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Author(s): Daojian Yu, Alan V. Barak, Yi Jiao, Zhinan Chen, Guiming Zhang, Zhilin Chen, Lin Kang, and Weidong Yang

Source: Journal of Economic Entomology, 103(2):277-283.
Published By: Entomological Society of America
DOI: http://dx.doi.org/10.1603/EC09292
URL: http://www.bioone.org/doi/full/10.1603/EC09292

Sulfuryl Fluoride as a Quarantine Treatment for *Chlorophorus annularis* (Coleoptera: Cerambycidae) in Chinese Bamboo Poles

DAOJIAN YU,[1,2] ALAN V. BARAK,[3] YI JIAO,[1] ZHINAN CHEN,[1] GUIMING ZHANG,[1] ZHILIN CHEN,[1] LIN KANG,[1] AND WEIDONG YANG[1]

J. Econ. Entomol. 103(2): 277–283 (2010); DOI: 10.1603/EC09292

ABSTRACT Bamboo (genera *Bambusa* and *Phyllstachys*) is one of the fastest growing and economically important plants in the world, and it is cultivated widely throughout southern China. China annually exports to the United States significant quantities of bamboo garden stakes (*Bambusa* spp.). In recent years, Plant Protection and Quarantine officers of the U.S. Department of Agriculture–Animal and Plant Health Inspection Service have made numerous interceptions of the bamboo borer, *Chlorophorus annularis* Fairmaire (Coleoptera: Cerambycidae), in bamboo products from China. This species is considered to have high pest risk potential in the trade of bamboo products. As a fumigant, sulfuryl fluoride (SF) would be a practical alternative to methyl bromide (MeBr) fumigation. Here, we report the results of SF fumigation tests for *C. annularis* in bamboo poles at three doses—96 g/m^3 at 15.9°C, 80 g/m^3 at 21.5°C, and 64 g/m^3 at 26.0°C—in glass test chambers. Commercial standard fumigations were also conducted in a standard 6.1-m-long, 33.2-m^3 (standard height, 20-feet) marine general cargo container loaded to 80% (vol:vol) with similar bamboo poles, and sufficient levels of SF were obtained during the 24-h fumigations. During the course of these tests, 2,424 larvae, 90 pupae, and 23 adults in total were killed, with no survivors. A treatment schedule using SF is proposed for bamboo as an alternative to MeBr at several temperatures tested.

KEY WORDS *Chlorophorus annularis*, alternative fumigation, sulfuryl fluoride, *Bambusa*

Bamboo (genera *Bambusa* and *Phyllstachys*) are the fastest growing economically important plants in the world, and their importance worldwide is increasing. China is known as the Bamboo Kingdom due to its resources, the species, planting acreage, and yield of commercial bamboo. The total value of the Chinese bamboo industry is ≈60.0 billion RMB (US$8.78 billion at 6.83 RMB/USD exchange during July 2009) per anum (Ren 2008), and China is the largest producer, consumer, and exporter of bamboo materials in the world. Recently, the export trade of Chinese bamboo product has increased. Three species and nearly 2,000 varieties of bamboo products (e.g., flooring, fencing, poles, utensils, cups) are exported to the United States, Japan, Southeast Asia, and Europe with a value of >US$326 million per anum (Ma and Liu 2007, Anonymous 2008, Ren 2008), and it is expected to rise to US$802 million in 2010 (Chen et al. 2009). The bamboo borer, *Chlorophorus annularis* Fairmaire (Coleoptera: Cerambycidae), is widespread in Southeast Asia (Anonymous 1992, Xiao 1992). It can be found infesting live bamboo (*Bambusa spinosa, Bambusa spinosa chungii*, and *Phyllstachys pubescens;* Hill et al. 1982) and also damage and develop within postharvest stored bamboo products (Xiao 1992). Bamboo poles used for construction in China are the most important and widespread host material (Fig. 1A).

C. annularis is not the most serious pest of economic importance in its native range (Qian 1991), possibly due to a natural enemy. *Zombrus bicolor* (Enderlein) was reported as a wasp parasitoid of *Chlorophorus diadema* Motschulsky (Zang 1984). Still, *C. annularis* has been frequently intercepted in the United States in bamboo poles, garden/nursery stakes, and various bamboo products and baskets. Bamboo garden and nursery stakes would carry a significant risk of potentially aiding the spread of *C. annularis* as well as putting it in proximity to possibly susceptible host material (Auclair and Kubilis 2006). *C. annularis* has also been recorded in citrus and grapes (NAPPO 2005) and therefore deserves concern as a serious potential pest. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA–APHIS) had reported that at least 26 species of live insects of quarantine significance, including *C. annularis* were intercepted from 1985 to 2005 in dried bamboo garden stakes from China (Auclair and Kubilis 2006).

This article reports the result of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation by the USDA for its use.

[1] Animal and Plant Inspection and Quarantine Technical Center, Shenzhen Entry-Exit Inspection and Quarantine Bureau of People's Republic of China, China. 2049 Heping Rd., Shenzhen 518010, People's Republic of China.

[2] Corresponding author: State Key Laboratory for Biocontrol and Institute of Entomology, Sun Yat-Sen University, Guangzhou 510275, People's Republic of China (e-mail: yudj@szciq.gov.cn).

[3] USDA–APHIS–PPQ, CPHST Otis Laboratory, 1398 West Truck Rd., Otis ANGB, Buzzards Bay, MA 02542-1329.

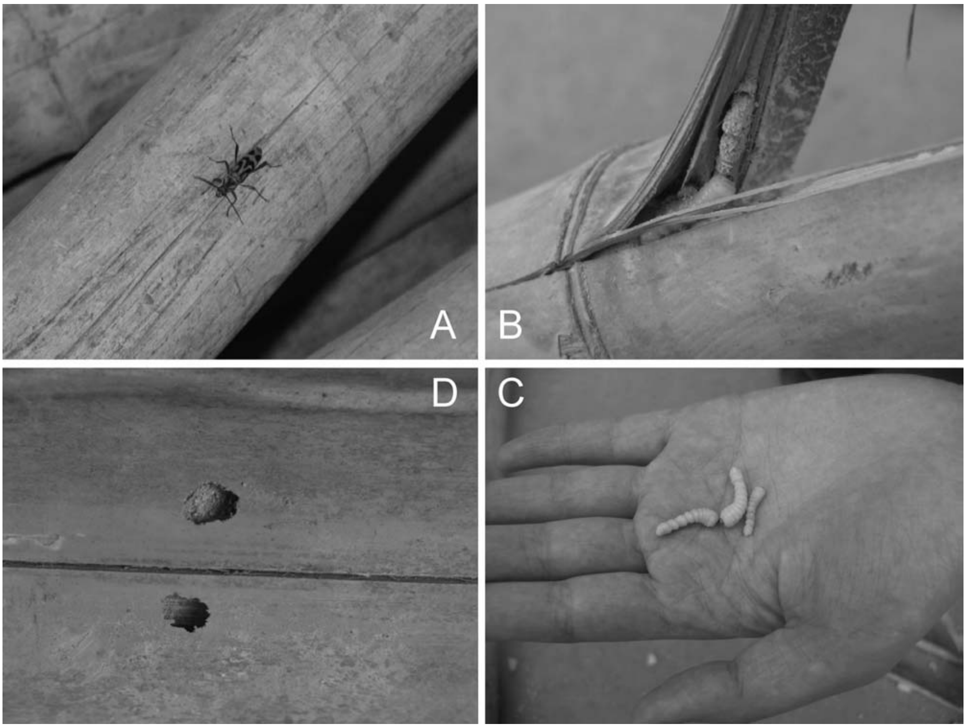

Fig. 1. Clockwise from top left. (A) Adult *C. annularis* on bamboo stem. (B) Larval boring within bamboo walls. (C) Several larvae, showing relative size. (D) Emergence hole, showing ragged opening.

The adult *C. annularis* will lay small clusters of eggs along splits and at the bamboo stem nodes. Eggs, being delicate and external, are unlikely to survive any handling and are therefore are not considered high risk. Free adults are rarely found associated with bamboo products in commerce, and larvae are considered the riskiest and most tolerant stage. The larvae hatch and bore deep into the bamboo, completing development within the immediate location on a stem (Fig. 1B). Larvae can tolerate low moisture content of the bamboo, and they are very difficult to detect, although very high infestation rates may produce evidentiary frass. Larvae bore longitudinally within the stem and in the center of infested bamboo poles in high density. More than 80 larvae have been found on one 100-cm length of bamboo pole (Fig. 1C). The adult emergence holes (Fig. 1D) are raggedly and round compared with the observed very neat, round hole of another found bamboo cerambycid *Purpuricenus temminckii* (Guerin-Meneville).

C. annularis may have one to two generations yearly in the natural environment of China but usually one generation in the cooler, main Chinese bamboo areas (Anonymous 1992, Xiao 1992). Weidner (1982) reports that *C. annularis* is normally univoltine and normally overwinters as a mature larva, whereas in southern China (Guangdong and Hong Kong) it can occur over the entire year, although greatest emergence occurs during May–June.

In 2007–2008, a series of MeBr fumigations for *C. annularis* and bamboo had been conducted at Shenzhen PRC, with cooperation between scientists from APHIS and China's General Administration for Quality Supervision, Inspection and Quarantine (AQSIQ). A new schedule at reduced rates of applied MeBr was recommended for bamboo materials (Barak et al. 2009). Currently, MeBr is an accepted treatment for regulated wood packing material under the International Standards for Phytosanitary Measures No. 15 (ISPM) known as "Rule 15," adopted by the Commission on Phytosanitary Measures, governed by the International Plant Protection Convention treaty (FAO 2002). However, acceptance of the Montreal Protocol of 1998 (UNEP 1998) calls for the reduction or elimination of MeBr unless emergency quarantine actions are approved due to its ozone depletion potential.

Sulfuryl fluoride (SF) has been evaluated internationally for control of other wood-destroying beetles (Soma et al. 1996, 1997; Mizobuti et al. 1996). SF is labeled as Vikane gas fumigant in the United States (Dow AgroSciences, Indianapolis, IN) and has been used since 1961 in the United States for the control of lyctid, anobiid, and cerambycid beetles infesting structural wood, furnishings, and artwork. As an alternative fumigant, SF may be an effective quarantine treatment for Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky) (Barak et al. 2006); and pine wood nematode, *Bursaphelenchus xylophilus* (Soma et al. 2001). A China–APHIS cooperative project presented data to support a recommended dose of 104-g/m^3 dose of SF for 24 h at 15.6°C and above for *A. glabripennis* in solid wood packing (Barak et al. 2006), and although that dose was 8 g/m^3 higher, it was tested with larvae deeper inside 10- by 10-cm square green *Populus* spp. timbers. It is noted that a successful quarantine treatment in this commodity must address the most tolerant condition or riskiest stage of the pest species present. Soma et al. (1996) reported that with SF, mature larvae of the cerambycid *Callidiellum rufipenne* Motschulsky were 2.5 and 2.8 times more tolerant than adults or pupae, respectively. Although eggs are most tolerant (although low risk), we point out that eggs also experience much higher CT exposure than internally infesting stages due to the time required for fumigant penetration and initially higher headspace concentration.

We report here the results of SF fumigation trials and a proposed quarantine fumigation schedule for bamboo that could result in an internationally accepted alternative to MeBr fumigation. For the 5 yr before 23 June 2009, 30,144 bamboo fumigations in total requiring 35,204 kg of MeBr were conducted in the United States (USDA–APHIS 2009).

Materials and Methods

Bamboo and Insects. According to the phenology of *C. annularis*, adults lay eggs in May through August near Shenzhen. Therefore, bamboo harvested during the fall season is at higher risk of carrying natural *C. annularis* populations. The test bamboo was collected and purchased from the Yongfeng Bamboo Market of Shenzhen (Guangdong province) in December and January where second-hand and fresh bamboo with instar II and III larvae was available. The bamboo was cut to length (≈116 cm) to fit the fumigation chambers.

Fumigation Chambers and Fumigant. Fumigation chambers were constructed of tempered glass of ≈8.0 mm in thickness and measured internally 0.56 by 0.6 by 1.2 m (long), with a volume of 403.2 liters. Each chamber end was fitted with two vacuum-tight brass 6.35-mm ball valves (Swagelok, Solon, OH) with hose barbs used to draw a vacuum, introduce the fumigants, and monitor concentrations. Three additional brass 6.35-mm Swagelok compression fittings were added to provide access for thermocouple wires and electricity to the small 220-V equipment ventilation fans placed inside to facilitate gas circulation.

Fumigations were conducted in four chambers simultaneously. All chambers were tested previously for tightness by drawing a differential pressure of approximately −50 mmHg and by observing that the pressure differential decrease to approximately one half took at least 1 min. The ability to hold a vacuum was essential to infuse the fumigant. The infested bamboo was added to each chamber to achieve typical load factors of ≈52% (vol:vol), which were essentially similar in weight (see Table 2). Internal bamboo temperatures for each replicate were monitored by inserting a type T thermocouple into the fiber portion of a heavy bamboo stem. Chamber temperatures were monitored by data loggers (Onset Computer Co., Bourne, MA) during the durations of all fumigations. Fumigation technique, chambers, and evaluation techniques were reported previously in studies with MeBr fumigation (Barak et al. 2009).

SF fumigant of 99.8% purity was produced by Linhai Limin Chemicals Co. Ltd. (People's Republic of China) and was used in all chamber and cargo container fumigations. Dosages were computed volumetrically by calculating the volume of the required grams of sulfuryl fluoride gas after compensating for ambient pressure and temperature according to the "ideal gas law" ($V = nRT/P$). The SF was then transferred to a reservoir bag (Calibrated Instruments, Inc., Hawthorne, NY) to a dose bag through a Swagelok 3-way valve and 2-liter air sampling syringe (Hamilton Co., Reno, NV). A slight vacuum was created with a vacuum pump and measured with a digital manometer (Dwyer Instruments, Michigan City, IN) until pressure was ≈20–32 mmHg below ambient, enough to accommodate the gas volume plus an additional 10 mmHg to speed gas infusion. The SF was introduced to the chambers directly using the 2-liter gastight syringe. The syringe was then attached and the valve was opened, allowing the gas to quickly flow into the chamber. After all gas was infused, the valve was left open only long enough to equalize the remaining pressure differential.

Chamber fumigant concentrations were measured with a calibrated, custom-made infrared analyzer, (Spectros Instruments, Hopedale, MA) and similar in design and function to the Spectros IR analyzer used in previous MeBr fumigation studies (Barak et al. 2009). The analyzer was purged and connected to the ball valves, and the headspace temperature was entered. A concentration was then measured. The analyzer self-purged and automatically re-zeroed and applied temperature compensation between each reading.

Initial Fumigation Trial with Sulfuryl Fluoride. Based on the result of previous MeBr fumigation for *C. annularis* (Barak et al. 2009) and with SF and *A. glabripennis* (Barak et al. 2006) four doses of SF (64, 80, 96, and 112 g/m^3) were selected for the initial fumigations of bamboo poles at ambient room temperatures (23.0 ± 0.42°C) for 24 h. These were conducted on 20 May 2008. The infested bamboo was removed from temporary cold storage (4–6°C) and allowed to naturally warm 1 wk before the test, because with *A. glabripennis* and SF, it was reported that cold-acclimated larvae were more tolerant of SF at temperatures below 15.6°C (Barak et al. 2006). Hand-selected pieces with high infestation were added to assure high numbers of stages, because numbers in commercially purchased bamboo were low. There was one replicate for each dose and control. The survival of *C. annularis* was evaluated 8 d postfumigation by hand splitting individual bamboo stems and recovering all stages found. Larvae that had any sign of movement were considered alive, whereas nonmoving and flaccid larvae were judged as dead. Many dead larvae were badly discolored. Larvae with any apparent movement were held for observation to confirm possible delayed death. Delayed mortality of life stages of numerous insects,

Table 1. Sulfuryl fluoride fumigation of bamboo poles infested with *C. annularis* at four doses and ambient temperatures for 24 h (Shenzhen PRC, 2008)

Fumigation parameter		Replicate *n*	Larvae		Pupae alive/dead	Adults[a] alive/dead	CT[b] (g-h/m³)
Dose (g/m³)	Temp (°C) ± SEM		Larvae killed (natural dead)	Larvae alive			
64	22.9 ± 0.13	1	177 (25)	0	0/38	0/2	1,050.6
80	23.0 ± 0.17	1	125 (12)	0	0/18	0/2	1,522.5
96	22.8 ± 0.16	1	159 (14)	0	0/10	0/10	1,619.0
112	23.3 ± 0.17	1	148 (24)	0	0/24	0/9	1,994.0
0	Ambient	1	92 (11)	92	31/0	27/0	

[a] Numbers of adults dead and naturally dead. At time of evaluation, these were desiccated and were from older infestation.
[b] CT, concentration × time product.

including forest beetles exposed to SF has been well documented (Su and Scheffrahn 1990).

Sulfuryl Fluoride Quarantine Fumigation. Based on results of the initial fumigation of SF, additional fumigations were conducted at the following doses/temperatures: 96 g/m³ at 15.9°C, 80 g/m³ at 21.5°C, and 64 g/m³ at 26.0°C. These fumigations were conducted as described above from 6 March to 11 April 2009 in the aforementioned chambers held within a 6.1-m refrigerated container capable of holding set point ±0.1°C. Four replications were done at each temperature and dose, with the control replicate held under similar conditions. As described above, replicates were augmented with hand-selected pieces to ensure high numbers of larvae. Mortality and 0.95 and 0.99 upper binomial confidence interval (CI) was computed (Sauro 2005).

Commercial Container Tests With Sulfuryl Fluoride Fumigant. To confirm that sufficient periodic concentrations and required CT could be maintained with actual commercial fumigation methods, three fumigation tests were conducted in a new 6.1-m (33.2-m³) marine cargo container filled with fresh and naturally dried bamboo poles (80% loading factor) during March 2009. This was conducted similarly to trials with MeBr reported recently (Barak et al. 2009). Fumigations were conducted at ambient temperature (22–27°C) at doses of 64, 80 96, and 112 g/m³. SF was applied from a pressurized cylinder using the methyl bromide carburetor; a microprocessor controlled digital fumigant applicator/scale combination (Guangzhou Import & Export Commodity Inspection Technology Institute, Guangzhou, China). The fumigation start time was considered the end of the introduction period. SF concentrations were monitored with three polyethylene sample lines after 5 min and at 0.5, 1, 2, 4, 8, and 24 h after introduction. Sample lines were placed to sample high-front headspace, the middle of the load, and just above the floor near doors. A large electric fan was placed on top of the load near the back doors to maximize SF circulation. A large, aluminized, reinforced polyethylene tarp was draped over the container to keep it cool. After 24 h, the container was aerated continually until the gas had dissipated and no detectable SF was found using the middle load gas sample line. The container was then readied for fumigation at the next higher dose one or more days later.

Data Analysis. The data of fumigant concentrations and temperature in the test chambers were monitored and recorded at intervals of 5 min and 0.5, 1, 2, 4, 8, and 24 h after gas introduction, by using an infrared SF monitor (Spectros Instruments, Hopewell, MA) and type T thermocouple. The concentration × time (CxT) product in g-h/m³ units (CT) was computed for each fumigation. Results were tabulated and displayed with Excel (Microsoft, Redmond, WA) in Anonymous (2000), and statistical analysis was performed using STATISTIX 9 (Analytical Software 2008) and online (Sauro 2005).

Results and Discussion

Initial Sulfuryl Fluoride Fumigation Trial. The result of initial SF fumigation of *C. annularis* is shown in Table 1. No survivors among 609 larvae, 90 pupae, and 98 adults were found in four doses treatments. Natural mortality totaled an additional 75 larvae. Although most of the total 133 *C. annularis* were alive in the control bamboo, only 11 of 38 adults had natural mortality. The probable cause of the high natural mortality of adults is that the infested bamboo had been stored

Table 2. Results of sulfuryl fluoride fumigation of bamboo poles infested with *C. annularis* at three doses and temperatures for 24 h (Shenzhen PRC, 2009)

Fumigation parameter		Replicate *n*	Larvae, total killed (mean ± SEM)	Total survivors	Upper CI (P = 0.95, P = 0.99)	Larval[a] natural death	Infested bamboo material	
Dose (g/m³)	Temp (°C) ± SEM min.-max.						No. pieces (avg. ± SEM)	Total kg (avg. ± SEM)
64	26.0 ± 0.15 24.7–27.2	4	457 (114.25 ± 6.85)	0	0.0065, 0.0100	11	64.25 ± 1.7	41.9 ± 1.19
80	21.5 ± 0.12 20.5–22.6	4	456 (114.0 ± 7.74)	0	0.0065, 0.0100	22	61.0 ± 1.58	45.7 ± 0.20
96	15.9 ± 0.15 14.5–17.3	4	479 (119.75 ± 17.77)	0	0.0062, 0.0096	20	56.3 ± 0.85	45.1 ± 0.23
0	Ambient	1	132	132	1.000	6	62	49.6

[a] Naturally dead stages were dried and discolored and easily determined, therefore not included in survivors or total killed.

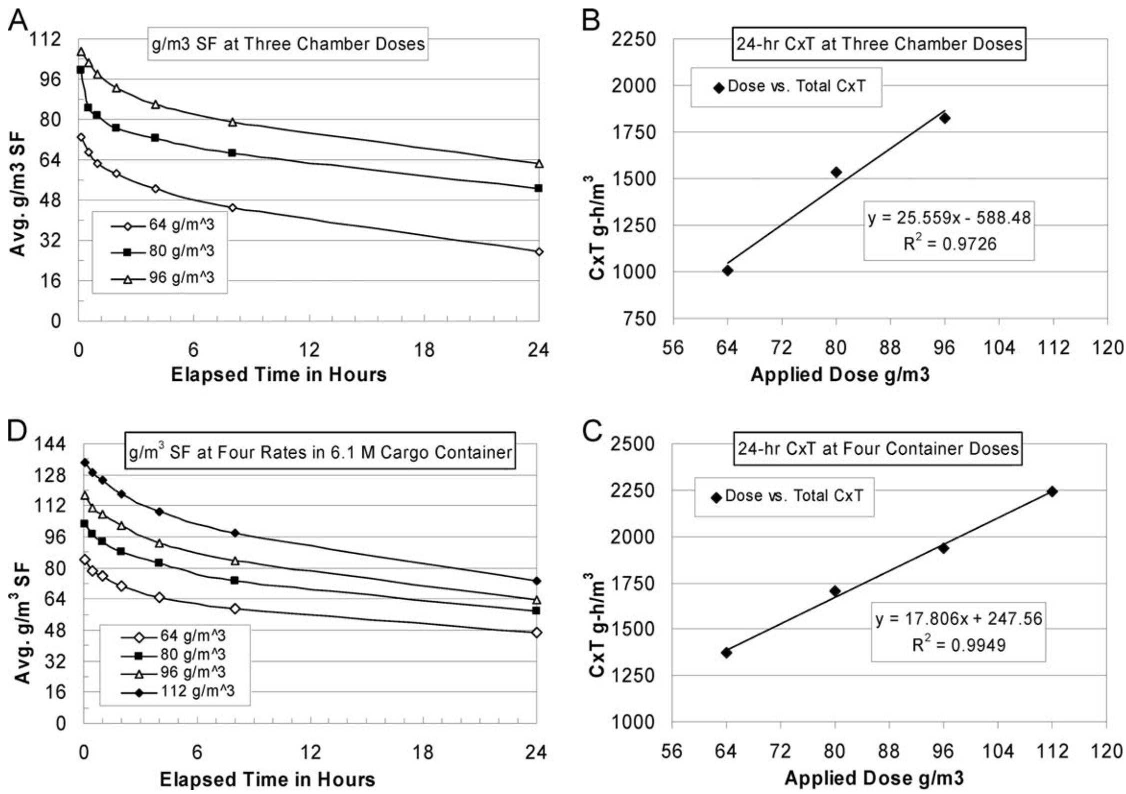

Fig. 2. Clockwise from top left. (A) Average sorption curves for bamboo at three temperature and dose combinations with a 52% loading factor. (B) Relation of final total CT products (concentration × time) to applied dose at three temperatures and dose combinations over a 24-h fumigation. (C) Relation of final total CT to applied dose in a 6.1-m cargo container. (D) Sorption curves for four applied doses in a 6.1-m cargo container during the 24-h fumigations.

in a cold room for 3 mo at ≈6.0°C. No larvae and pupal mortality was attributed to the cold temperature, which is normal for *C. annularis* in the primary bamboo production areas. The larvae can endure cold temperature more than the adults, as the larval stage is the overwintering stage in colder climates. A small number of another Cerambycidae, *P. temminckii* and the bostrichid beetle *Bostrychopsis parallela* (Lesne) were recorded in each test, in low numbers similar to that in previous MeBr fumigations (Barak et al. 2009), and all were dead. Six *B. parallela* were found alive in the control bamboo sample.

Sulfuryl Fluoride Quarantine Fumigation. The results of the quarantine fumigations at three temperature–dose combinations are presented in Table 2, as well as physical parameters for each test. All *C. annularis* larvae in the treatment were dead and in the control all were alive save minimal and clearly observed natural death, which was easily determined due to obvious desiccation and discoloration. All bamboo was carefully split by hand, and all larvae were taken to a laboratory to confirm for mortality. If mandible movements were observed under a microscope they were considered alive. No new adult emergence was observed in any treatment or control sample bamboo.

The sorption of SF by bamboo is illustrated in Fig. 2A. The sorption curve was similar at the three temperatures tested. The trend of fumigant sorption was quite different than the more sorptive MeBr sorption

Table 3. Periodic sulfuryl fluoride concentrations obtained at three temperatures and three doses during 24-h fumigations of bamboo poles in 403.2-liter glass chambers

Fumigation parameter		SF concn (g/m^3) at time from start, avg.± SEM						Concn time product
Temp (°C) ± SEM	Dose (g/m^3)	0.5 h	1 h	2 h	4 h	8 h	24 h	(avg. ± SEM, g-h/m^3)
26.0 ± 0.15	64	67.3 ± 1.59	62.5 ± 1.26	58.5 ± 1.62	52.4 ± 1.70	45.1 ± 1.60	27.6 ± 1.54	1,007.7 ± 36.7
21.5 ± 0.12	80	84.3 ± 1.35	81.5 ± 1.22	76.4 ± 1.39	72.3 ± 1.48	66.3 ± 1.69	52.8 ± 2.23	1,535.5 ± 42.2
15.9 ± 0.15	96	102.6 ± 1.07	98.0 ± 1.80	92.7 ± 1.17	86.2 ± 0.71	78.8 ± 0.57	62.4 ± 0.81	1,825.6 ± 9.00

There were four replicates at each concentration. Fumigations were conducted during March and April in Shenzhen, China. The CTs were calculated from the concentrations below. The loading factor was 52% (vol:vol).

Table 4. Measured concentrations and calculated CxT exposure of sulfuryl fluoride during 24-h fumigations of bamboo poles in a 6.1-m cargo container at 64, 80, 96, and 112 g/m^3

Applied dose (g/m^3)	SF concn (g/m^3), at time in hours,± SEM							Accumulated CT (g-h/m^3), Avg. ± SEM
	5 min	0.5	1	2	4	8	24	
64	84.0 ± 0.24	78.5 ± 0.09	75.8 ± 0.07	70.9 ± 0.03	65.1 ± 0.03	58.8 ± 0.00	46.6 ± 0.03	1,371.1 ± 0.31
80	102.7 ± 0.20	97.2 ± 0.10	93.4 ± 0.00	88.3 ± 0.09	82.4 ± 0.12	73.0 ± 0.03	57.9 ± 0.09	1,707.7 ± 1.45
96	117.3 ± 0.17	110.9 ± 0.19	107.4 ± 0.07	101.8 ± 0.03	92.9 ± 0.03	83.9 ± 0.03	63.6 ± 0.03	1,933.8 ± 0.64
112	134.5 ± 0.15	129.2 ± 0.09	125.2 ± 0.11	118.3 ± 0.09	109.0 ± 0.12	97.6 ± 0.09	73.2 ± 0.10	2,245.4 ± 1.13

The container was loaded to 80% of capacity. All values and CxT are the average of three sample lines.

in the bamboo (Barak et al. 2009). With SF, sorption took place more slowly over the first 4–8 h, and the values of the fumigant concentrations were higher than the applied dose in the first hour. SF concentrations at sample times starting at 0.5 h are shown in Table 3, along with the calculated CxT values and internal bamboo temperatures. The proportion of calculated CxT values and the relation as a proportion to applied doses of 64, 80, and 96 g/m^3 was 65.6, 80.0, and 77.4%, respectively, are shown in Fig. 2B.

Commercial Container Fumigations. The results of the fumigations in a commercial 6.1-m marine cargo container filled to ≈80% with commercial-sized load of bamboo poles at four doses is shown in Table 4. The sorption curves and CxT–dose relation in the cargo container were similar to that in the small glass chamber (Fig. 2C and D). Compared with the results of fumigation in the glass chambers, there were initially higher concentrations at the start times due to the higher high load factor (restricted free headspace). The same results were initially found with MeBr fumigation tests (Barak et al. 2009), although MeBr concentrations more quickly declined due to the greater sorption of the organic MeBr.

Proposed Quarantine Schedule. A proposed SF fumigation schedule for bamboo is shown in Table 5. The results in this study generated data to support recommended doses of 96, 80, and 64 g/m^3 SF at 15.6, 21.1, and 26.7°C or above, respectively. The minimum concentrations are based on the partially filled small chamber tests in which mortality was 100%, and periodic concentrations were lower than in a cargo container with a full load, where the concentrations and final CT were consistently exceeded. Lower temperatures were not recommended, because the distribution of bamboo and products in China are mainly in eastern and southern China (Zhejiang, Jiangxi, Fujian, Hunan, and Guangdong provinces; Xiao 1992), where annual average temperatures would be 15–22°C, and because bamboo products are mainly exported to Japan, the United States, and Germany from the warm-water ports close to the produce area, such as Shanghai, Ningbo, Fuzhou, Zhangjiagang, Guangzhou, and Shenzhen (Ma and Liu 2007, Ren 2008).

Table 5. Proposed treatment schedule for 24-h sulfuryl fluoride (SF) fumigation of *C. annularis* F. in bamboo poles

Temp (°C)	SF dose (g/m^3)	Min. concn at hour (g/m^3)				Min. target CT (g-h/m^3)
		0.5 h	2 h	4 h	24 h	
15.6–21.1	96	103	93	87	63	1,826
21.1–26.7	80	85	77	73	53	1,536
=26.7	64	68	59	53	28	1,008

In confirmatory treatment tests (including one extra trial at 26.7°C not detailed here), 1,815 larvae in total were killed, with 132 control larvae recovered alive. Landolt et al. 1984 conclude that mortality rates for quarantine "results in widely varying risks" and does not necessarily give meaningful levels of security, and further that the actual risk of introduction is "far less than the probability of a mated pair being in a shipment." Follett and McQuate (2001) further discuss situations where less than probit-9 levels of test insects (developed with high risk and abundant tropical fruit flies and large volumes of fruit) can be reduced due to lower risks. Between 1992 and 2005, only 310 *C. annularis* larvae in total (average, 24 per yr) were found in Chinese bamboo entering the United States (Auclair and Kubilis 2006), whereas fumigations for bamboo averaged 6,029 a year over the 5 yr preceding 23 July 2009. They further rate establishment potential as "medium (at best)" and state that this insect has apparently entered the United States on many occasions but is not yet established.

With respect to the above-mentioned information, and further that it is the more tolerant larval stage that is of concern that was tested and eliminated, we agree with those theories on the case of *C. annularis* in bamboo. Considering the numbers tabulated and the lower numbers in a natural infestation of a commercial product, this treatment meets the ISPM Rule 15 goal to "reduce the risk of introduction and/or spread of quarantine pests" and to "significantly reduce the risk of pest spread." Regulators of the various international regulatory bodies may consider these results as a suitable quarantine treatment.

Acknowledgments

We thank the following people in China for valuable support of this project: Chen Xinru, Dai Jianxiong, Yin Shaojuan, and Yang Haijun (Shenzhen Entry-Exit Inspection and Quarantine Bureau, Shenzhen CIQ); Lv Liping (South-China Cold Storage & Ice Co. Ltd.), and Xiewen from Wanyouliang (Shenzhen) container Co. Ltd. We also thank the following for commentary and review of the manuscript: Phil Lewis (PPQ, Otis Laboratory, Buzzards Bay, MA) and Ellen Thoms (Dow AgroSciences). This work was supported by AQSIQ (project 2009IK267), Shenzhen CIQ (project SZ2008020), and APHIS–PPQ–CPHST (project T7Q02).

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Received 31 August 2009; accepted 4 December 2009.