INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 19, No. 6, p. 103-109, 2021

RESEARCH PAPER OPEN ACCESS

Natural durability of commercially important bamboo species in the Philippines against powderpost beetle (*Dinoderus minutus* Fabricius)

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Key words: *Powderpost beetles, Dinoderus minutus, Bamboo, Bambusa vulgaris, Gigantochloa levis, Bambusa blumeana, Natural durability.*

http://dx.doi.org/10.12692/ijb/19.6.103-109 Article published on December 18, 2021

Abstract

Natural durability tests of freshly cut bamboo species commonly available in Bukidnon, Philippines were carried out to determine which species is most susceptible against Powderpost beetles (PPB) (*Dinoderus minutus* Fabricius) or "bokbok" as it is known locally. The Bamboo species used were Kawayan dilaw (*Bambusa vulgaris* Schrad ex Wendl var striata (Lodd. ex Lindl.) Gamble), Bolo *(Gigantochloa levis* (Blanco) Merrill), and Kawayan tinik (*Bambusa blumeana* J.A. & J.H. Schultes). Aside from species, the influence of bamboo section (basal, middle, top) and exposure (indoor and outdoor) were also among the factors considered. The three classifications of durability, namely, durable, moderately durable, and slightly durable, were based on the number of beetle holes in the samples. The experiment was laid out in a factorial experiment in a Completely Randomized Design. For the analysis, Two-way ANOVA was carried out to determine whether the factors influence the variation in beetle holes. Results have revealed a significant interaction between species and section. Exposure did not show a significant result. Both *G. levis* and *B. vulgaris* are moderately durable against PPB, while *B. blumeana* was not durable (highly susceptible) against PPB. Most abundant beetle holes were observed in the top section. The variation in the environment setting *i.e.* indoor or outdoor did not significantly affect the feeding preference and feeding behavior of PPB. The *G. levis* was found as the most durable species in outdoor and indoor settings among the bamboo species compared in this study.

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Introduction

There are around 200 species of bamboo species found in Southeast Asia belonging to approximately 20 genera (Roxas, 2012). In the Philippines, there are 62 species, 21 of which are endemic (13 climbers, 8 erect) and 41 introduced species (Virtucio, 2009). Only 12 species are considered as commercially important viz Anos [*Schizostachyum lima* (Blanco) Merrill], Bayog [*Bambusa merrilliana* (Elmer) Rojo & Roxas comb. nov.], Bolo [*Gigantochloa levis* (Blanco) Merrill], Buho [*Schizostachyum lumampao* (Blanco) Merrill], Giant bamboo [*Dendrocalamus asper* (Schultes et.) Backer ex Heyne], Kawayan kiling [*Bambusa vulgaris* Schrad ex. Wendl], Kawayan tinik [*Bambusa blumeana* J. A. and J. H. Schultes], Kayali [*Gigantochloa atter*], Laak [*Bambusa philippinensis* (Gamble) McClure], Machiku [*Dendrocalamus latiflorus* Munro], Oldham [*Bambusa oldhamii*], and Puser [*Cyrtochloa puser*] (ERDB, 2016).

Bamboo has been traditionally used in the Philippines for fences, furniture, and even as the main material in constructing houses. Razal *et al.* (2013) stressed that technology developments led to the use of bamboo for floors and ceilings, cabinetry, and modular furniture in modern construction and designer homes, furthermore, transforming bamboo poles to engineered-bamboo products or simply e-bamboo, enables the use of this natural material in applications previously restricted to solid wood.

One of the challenges in using bamboo is its susceptibility to boring insects, especially PPB or "bokbok" as it is known locally. PPB also attacks wood but severe damage is usually caused by termites (Rojo, 2018a; Rojo, 2018b; Rojo, 2017) Stored bamboo and finished products are susceptible to attack by boring insects, mainly shot-hole, powderpost, and long-horned beetles (Wang, 2002). The bamboo post-harvest pests are borers mainly from the families of Cerambycidae, Bostrychidae, and Lyctidae under order Coleoptera (beetles) (Haojie *et al*, 2002). There are about 50 insect pests reported to attack felled culms and products of bamboo timber. Haojie *et al.* (2002) enumerated these post-harvest pests with an illustration. The most common which is responsible for 90% of insect damage was from the genus *Dinoderus viz., D. japonicas* Lesne, *Dinoderus minutus* Fab., *D. ocellaris* stephens and *D. brevis* Horn.

Although bamboo has already been used by many, especially in remote areas for housing and furniture, its durability against Powderpost beetle needs to be investigated. Hence, this study was conducted in order to assess the durability of three commercially important species of bamboo in the Philippines. The result will provide recommendations on the choice of species for particular end-use. This study assessed the natural durability of bamboo species against Powderpost beetle or "bokbok".

Materials and methods

Collection of bamboo poles

Mature culms of Kawayan dilaw (*Bambusa vulgaris* Schrad ex Wendl var striata (Lodd. ex Lindl.) Gamble), Bolo *(Gigantochloa levis* (Blanco) Merrill), and Kawayan tinik (*Bambusa blumeana* J.A. & J.H. Schultes) were collected in Lantapan, Bukidnon, Philippines. The species identifications were authenticated by a taxonomy expert in Central Mindanao University. The culms were divided into three sections representing basal, middle, and top portions.

Preparation of samples

The semi-field testing protocol followed in this study was adopted from Febrianto *et al.* (2014). It was slightly modified since indoor testing was included. Samples for each species measuring 5 cm x 2.5 cm were obtained from each section. At least 10 freshly cut test specimens were prepared per section x species combination. For indoor testing, the test specimens were placed inside a shedded area, unexposed to the sunlight. For outdoor testing, the specimens were placed in an open area with maximum sunlight exposure.

Durability test

An infested bamboo was collected to obtain PPB

samples for the experiment. Test chambers which were plastic containers that can accommodate all the samples were then prepared. The test chambers were covered with fine mesh wire to prevent PPB from escaping. The samples were arranged randomly and horizontally on top of the PPB infested bamboo and each week the samples were observed for signs of infestation. The test specimens were monitored, and the number of beetle holes was counted every week for a period of 3 months. New batches of PPB infested bamboo slats were introduced after 7 weeks. The durability of the bamboo against PPB was classified as shown in table 1:

Statistical analysis

Two-way Analysis of Variance (ANOVA) was carried out to determine if there was a significant difference in the number of PPB holes as influenced by the species, section and exposure factor. To determine pairwise differences of means, Tukey's Honest Significant Difference (HSD) test ($\alpha = 0.05$) was also performed.

Results and discussion

Natural Durability of Bamboo

As shown in Figure 1, Both *G. levis* and *B. vulgaris* were found moderately durable, whereas *B. blumeana* was found not durable (highly susceptible) against PPB. Similar results were observed in both indoor and outdoor settings. Ludovico (2015), emphasized that amino acids, starch, and simple carbohydrates are essential for PPB development. In addition, Garcia (2005), concluded that beetle populations were highly correlated with bamboo starch content. Thus, the variation in the chemical and physical properties of the bamboo species tested in this study could potentially be one of the factors affecting the feeding preference of PPB. Since no prior seasoning nor preservation treatment was applied to the test specimens, it can be deduced that the variation of chemical properties among the three species influences the feeding preference. *B. blumeana* have shown high susceptibility to PPB attack while *B. vulgaris* and *G. levis* possess a better natural durability.

Table 1. Classification of durability of sample based on number of beetle holes. Modified from Alipon *et al* (2018).

Number of beetle holes	Classification
0 or no hole except for boring attempts	Durable
1–5 beetle holes	Moderately durable
6–10 beetle holes	Slightly durable

The starch content of the bamboos was not analyzed in this study, however, it is hypothesized that *B. blumeana* samples could have greater starch content than the two other species due to greater feeding preference of PBB. It is highly recommended that a study which determines the amount of starch content in commercially important bamboo species in the Philippines should be conducted. Liese (1985) stressed that the starch content reaches its maximum in the driest months before the rainy season and sprouting. The season was wet during the harvest of the sample specimen in this study. Bamboo possesses large amounts of sugars and starch which are the principal nutrients for parasites, borers, and fungi (Singha & Hassan, 2017). The rate of attack is fastest with fresh green bamboo (which is more susceptible), but even dry bamboo can be attacked in warm humid climates where the equilibrium moisture content of the bamboo outside (but under cover) is often high (Liese *et al*, 2002 & Kaminski *et al*, 2016).

In this study, all samples were collected at the same time, thus harvest time did not influence the variation of starch content. In the absence of the starch content data, it is still conclusive that among the test species, *B. blumeana* is the most preferred species by PPB in both indoor and outdoor.

As shown in figure 2, the number of holes started to notably increase after the 9th week. Preference

and/or activity of the PPB seemed to be similar in indoor and outdoor as observed in the trends of both graphs in figure 2. The susceptibility of bamboo to borer attacks depends on the species, its starch content, age of the culm, felling season, and the physical properties of the bamboo (Plank, 1950).

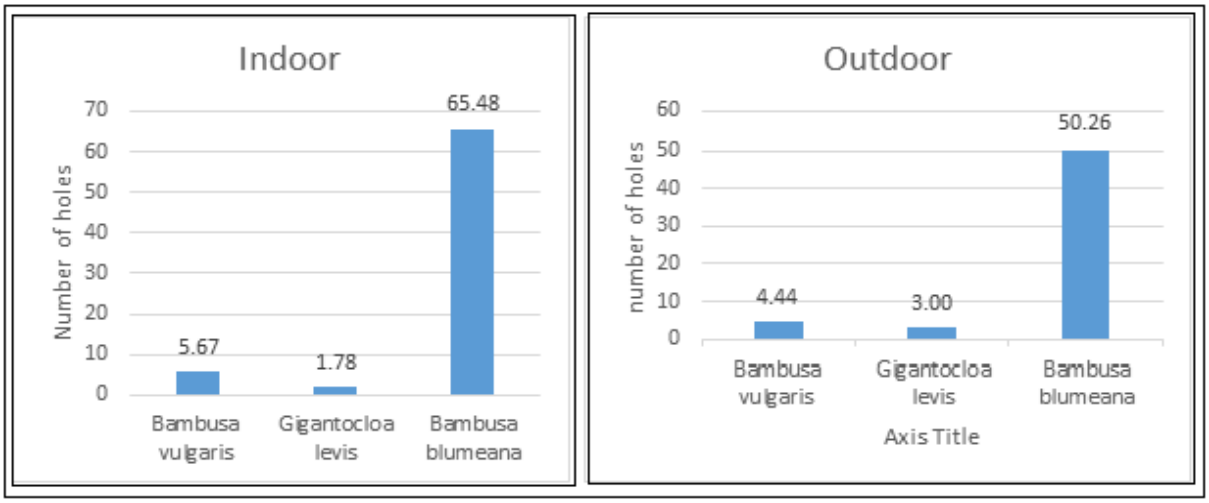

Fig. 1. Average number of beetle holes observed after 13 weeks of feeding test.

Section of the bamboo

Analysis has revealed the interaction between species and section factors in the feeding preference of PPB. In all of the bamboo species, the most abundant beetle holes were observed in the top section of the bamboo (figure 3) for test specimens exposed to the indoor environment. However, the variation in the number of holes for *G. levis and B. vulgaris* was not significant. The number of beetle holes observed in the top section of *B. blumeana* (p>.01) was significantly higher compared to the other two species. As discussed above, beetle holes in *B. blumeana* was significantly higher (p>.01) than the other two bamboo species in this study. Comparing the beetle holes in each section per species, the top and middle section of the bamboo was significantly higher compared to the bottom section in *B. blumeana* species.

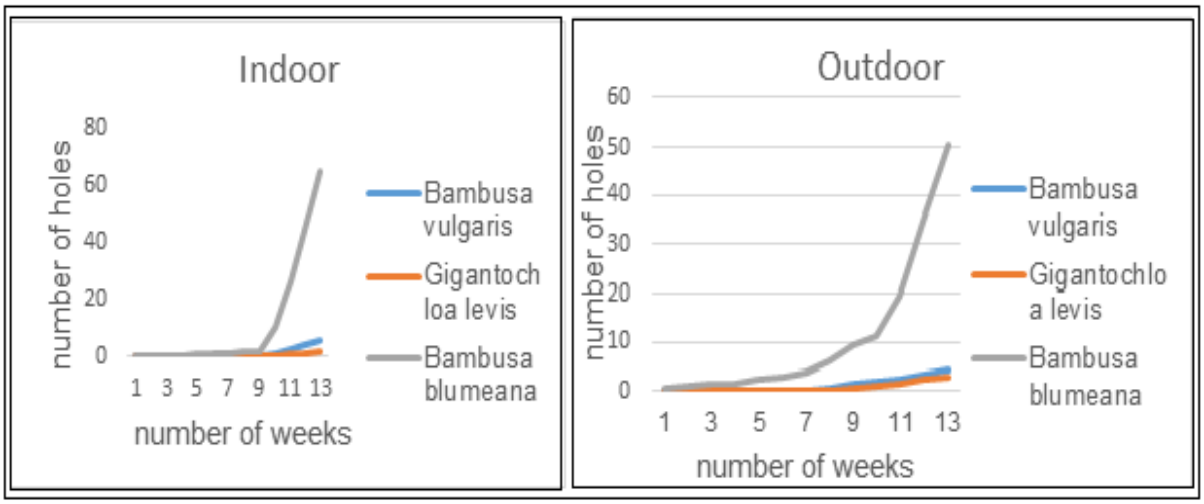

Fig. 2. Cumulative number of beetle holes after 13 weeks of feeding test.

It seems the bottom section of the bamboo is more resistant to PPB. In a similar study conducted by Wang *et al* (2016), their observation in *Fargesia yunnanensis* bamboo revealed that the starch content was higher in the top and middle portions than in the bottom ones at all age classes. Starch is an essential

nutrient for bostrichid beetles where PPB belongs (Jones 2008). Based on the classification of Alipon *et al* (2018) all sections of *G. levis* can be classified as moderately durable with only 0.78, 2 and 2.56 average beetle holes in bottom, middle and top section respectively. While *B. vulgaris* can be classified as moderate to slightly durable. But the variation in the beetle holes in *G. levis* and *B. vulgaris* is not significant. In the outdoor setting, the variation in the number of beetle holes in the different sections of bamboo was not significant ($p<.05$).

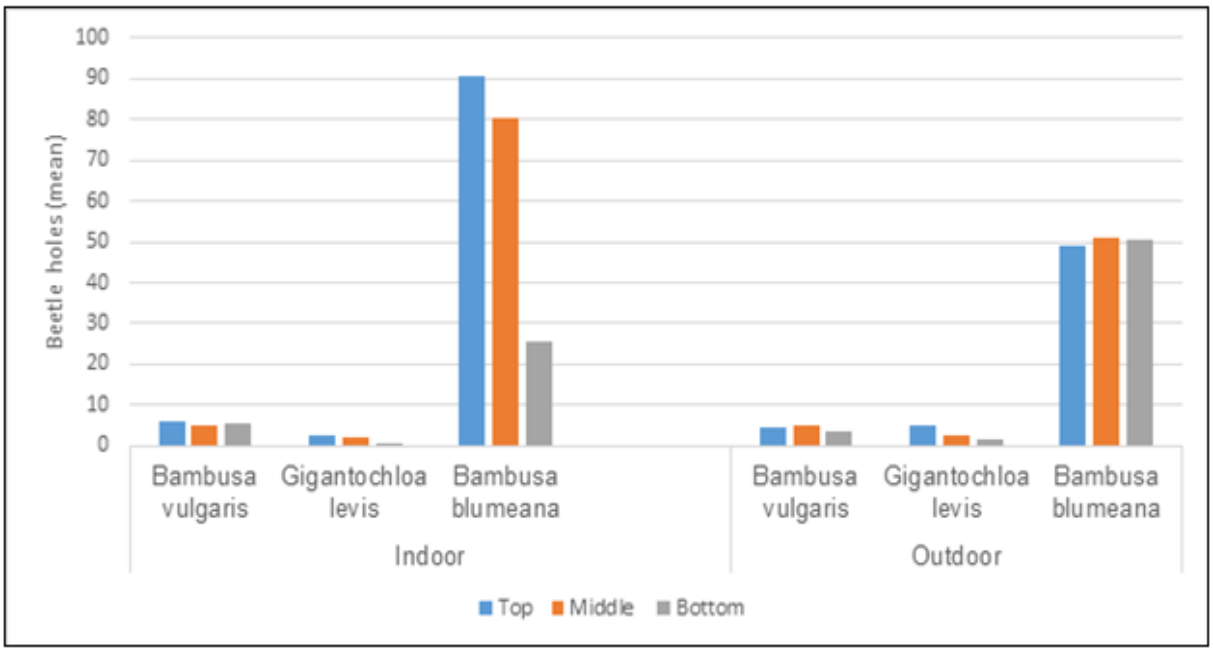

Fig. 3. Mean number of beetle holes per section per bamboo species exposed to indoor and outdoor environment after 13 weeks of feeding test.

The bamboo species highly infested with PPB was *B. blumeana* in all three sections. Furthermore, higher beetle holes can still be observed in the top and middle portion for *G. levis* and *B. vulgaris*.

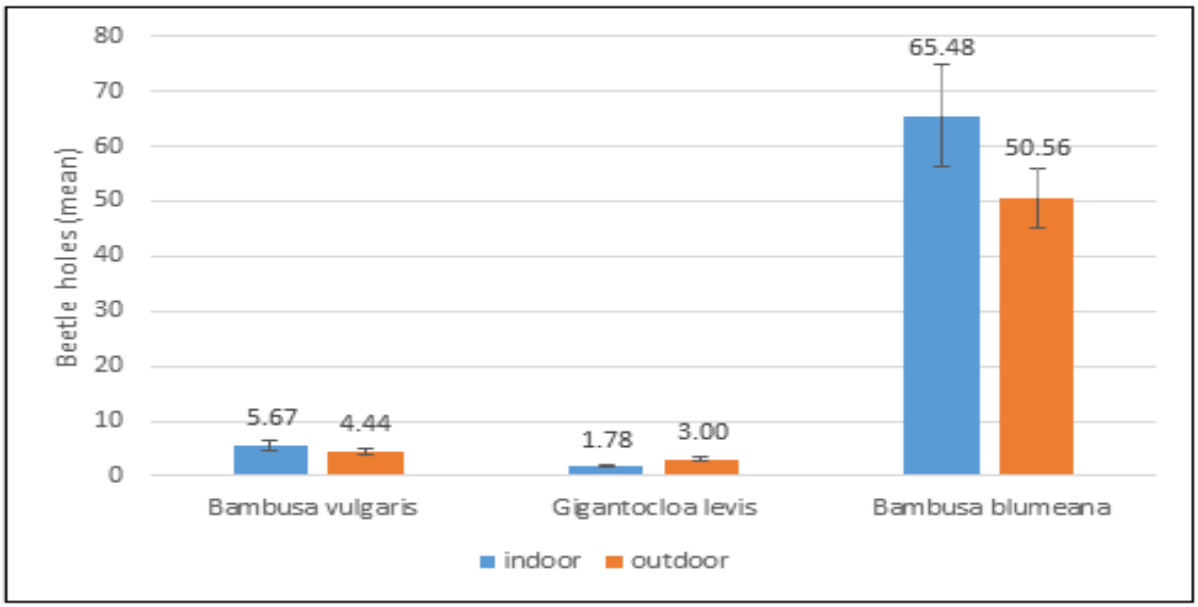

Fig. 4. Mean number of beetle holes as affected by the indoor and outdoor setting after 13 weeks of feeding test (mean ± SEM).

Indoor vs. Outdoor

Figure 4, shows the comparison of the average number of beetles per species when exposed to indoor and outdoor settings. Beetle holes were slightly higher indoors for both *Bambusa* species however the difference is not significant at p<.05. In *G. levis* outdoor beetle holes are significantly higher in outdoor than indoor (p>.01). Suggesting that the outdoor environment favors feeding preference of PPB to *G. levis* than indoors. The result is also consistent with the above observations. *B. blumeana* has significantly higher beetle holes than the other two bamboo species.

The result shows that variation in the environment setting *i.e.,* indoor or outdoor did not significantly affect the feeding preference and feeding behavior of PPB. Although the variation in the amount of starch in indoor and outdoor was not determined, feeding behavior were mostly similar. Variation in Temperature, Relative humidity, and other factors that might affect the feeding behavior of PPB were not significant to alter the feeding behavior of the PPB. As discussed by Potter (n.d) Moisture is the most crucial environmental factor affecting the destructive potential of this PPB and high humidity is essential for egg hatch.

Conclusions

This study found that *G. levis* is the most durable among the three species tested in both outdoor and indoor settings. With a significantly greater number of PPB holes, *B. blumeana* was found not durable, hence highly susceptible to PPB infestation. The top section of the bamboos had the greatest abundance of beetle holes. The variation in the environment setting *i.e.* indoor or outdoor did not significantly affect the feeding preference and feeding behavior of PPB.

Acknowledgment

This study is an offshoot of the DOST-PCAARRD funded project "S&T Intervention on Quality Standard and Drying Protocols for Locally Manufactured E-Bamboo. The authors also wished to thank Central Mindanao University through the University Research Office for facilitating this research project.

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