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IDENTIFICATION AND DAMAGE BY WOOD BORERS OF *Pterocarpus indicus* TREES IN THE CENTRAL HIGHLANDS OF VIETNAM

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ABSTRACT

Pterocarpus indicus is a native hardwood that is widely planted in plantations in Vietnam as well as an ornamental tree on roadsides, parks, and in municipal gardens. In the Central Highlands the trees are often attacked by wood borers. This study identifies *Cnestus aterrimus* (Curculionidae: Scolytinae), *Hypothenemus birmanus* (Curculionidae: Scolytinae), *Sinoxylon anale* (Curculionidae: Bostrichinae), *Xylosandrus compactus*, and *X. discolor* (Curculionidae: Scolytinae) infesting *P. indicus* trees in Dak Lak and Gia Lai provinces. The most prevalent species is *S. anale*, comprising more than 90% of the damaged trees. Our study is prerequisite for further research on their biological and ecological characteristics necessary to design control solutions for effective pest management.

Keywords: Insect pest, *Pterocarpus indicus*, Scolytinae, wood borer

MỘT SỐ LOÀI MỌT GÂY HẠI CÂY GIÁNG HƯƠNG ẤN (*Pterocarpus indicus*) TẠI VÙNG TÂY NGUYÊN, VIỆT NAM

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TÓM TẮT

Giáng hương ấn (*Pterocarpus indicus*) phân bố tự nhiên ở Việt Nam và được trồng phổ biến ở vùng Tây Nguyên và nhiều địa phương khác. Cây Giáng hương ấn sinh trưởng khá nhanh, thân thẳng, tán lá và hoa đẹp. Loài cây này rất phù hợp để trồng phân tán và trồng cây cảnh quan trên các tuyến phố cũng như các công viên. Các cây trồng ở Tây nguyên thường bị mọt gây hại phổ biến. Nghiên cứu này đã ghi nhận các loài mọt *Cnestus aterrimus*, *Hypothenemus birmanus*, *Sinoxylon anale*, *Xylosandrus compactus* và *X. discolor* gây hại trên cây Giáng hương ấn tại tỉnh Đắk Lắk và Gia Lai. Loài mọt gây hại phổ biến nhất là *S. anale*, được ghi nhận trên hơn 90% số cây bị hại. Bài viết này cung cấp một số cơ sở khoa học cho các nghiên cứu tiếp theo về đặc điểm sinh học, sinh thái và phòng trừ các loài sâu hại này.

Từ khóa: Giáng hương, mọt đục thân, sâu hại, Scolytinae

1. INTRODUCTION

The genus *Pterocarpus* (Fabaceae) includes 41 species, some of which have been widely used for forest plantations such as *P. indicus*, *P. macrocarpus* and *P. santalinus*. *Pterocarpus indicus* is native to the southern provinces of China, Cambodia, Indonesia, Malaysia, Papua New Guinea, Philippines, Ryukyu Islands, Solomon Islands, Thailand, Timor-Leste and Vietnam (Thomson, 2006). The wood has excellent properties for producing high-quality furniture (Blantocas *et al.,* 2006), including a smooth texture, a rosy brown scent, aesthetically desirable grain due to prominent annual rings, small rays, and compact veins (Thomson, 2006). The tree grows well in many types of soil, has a straight trunk and a beautiful canopy of flowers. The tree is suitable for sawlog reforestation and as an ornamental tree on roadsides, parks, and in public construction's gardens (Thomson 2006; Helmanto *et al.,* 2022). It is widely grown in Vietnam both in plantations and urban areas, especially in the Central Highlands where it is often damaged by wood borers.

Over the years, dozens of insect pest and disease species have been recorded as dangerous pests on some major forest plants in Vietnam (Thu *et al.,* 2021; Chi *et al.,* 2022; Hung *et al.,* 2022; Thu *et al.,* 2024). Some wood borers are are recorded in Vietnam causing significant damage to commercial tree species, including *Euwallacea* sp. on *Dalbergia tonkinensis*, *E. fornicatus*, *E. similis*, *Xyleborus perforans*, and *Xylosandrus crassiusculus* on *Eucalyptus* and *Acacia* (Chi *et al.,* 2019; Thu *et al.,* 2021; Hung *et al.,* 2022). Forest owners and managers are very concerned about the negative impacts of the pests, while still applying some of the management solutions suggested.

Pterocarpus trees are often affected by pests and diseases when planted in forests or concentrated in urban areas (Thomson, 2006; Bumrungsri *et al.,* 2008; Tarno *et al.,* 2015). Insect pests recorded on *P. indicus* trees include the leaf miner *Hyloconis* sp. in the Solomon Islands and Vanuatu, the defoliator *Melipotis diversipennis* in Sumatra, Indonesia (Thomson, 2006), the ambrosia beetles *Euplatypus parallelus* (Bumrungsri *et al.,* 2008), *Treptoplatypus micrurus* (Tarno *et al.,* 2015) in Indonesia and Thailand, and longhorn beetle *Aristobia horridula* in Thailand (Bumrungsri *et al.,* 2008). Damage from pathogens include *Phomopsis* sp. on seeds, *Cyllindrocladium quinoseptatum* and *Colletotrichum gloeosporioides* on seedlings, and root and stem rots caused by *Fomes lamaoensis, Ganoderma lucidum,* and *Phellinus noxius* (Thomson, 2006). Meanwhile, longhorn beetle *Aristobia horridula* has been recorded as the most dangerous pest of *P. macrocarpus* (Hutacharern & Panya, 1996).

Forest planations represent a valuable, expanding, economic resource while tree plantings are used to improve the visual esthetics of urban environments. As there are no prevous studies on these pests we investigated the morphology, identification and damage characteristics of wood boring insects attacking *P. indicus* in the Central Highlands.

2. MATERIALS AND METHODS

2.1. Collection of wood borers from *Pterocarpus indicus* trees

Thirty 5 - year - old trees (stressed trees with wilted canopy, branch dieback or yellow leaves) with an excess of 100 exit holes/tree in Dak Lak and Gia Lai provinces, Vietnam were harvested in January 2024. Boles and branches with diameter of 5 - 15 cm, at a hight of 1.5 - 3.5 m were cut into 50 cm lengths and transported to the Forest Protection Research Centre (FPRC), Hanoi, Vietnam. The logs were split open and eggs, larvae, pupae and female adults manually removed.

2.2. Characterization and identification

Adult body length was measured along the midline from the anterior of the eye to the distal

apex of the elytra (15 samples for each species). Width was measured across the dorsal surface at the widest point. Fifteen adult voucher specimens of each species were deposited in the insect collections of the Tay Nguyen University, Buon Ma Thuot city, Dak Lak province and the FPRC, Hanoi, Vietnam. Identification of species was made using the keys of Hulcr & Smith (2010) for ambrosia beetles, Liu *et al.* (2006) for auger beetle and Vega *et al.* (2015) for bark beetle.

2.3. Damage symptoms

Damage characteristics were obtained from 30 tree samples (15 from each province). The number of adults of each species, number/position of exit holes and tunnel size were measured on boles and branches. The characteristics of frass in the tunnels of infested trees were described. The infested trees were cut and sectioned to characterize tunnels within.

3. RESULTS

3.1. *Cnestus aterrimus* Eggers, 1927 (Curculionidae, Scolytinae, Xyleborini)

3.1.1. Morphological description

Adult female brownish-grey or greyish-black, 1.8 - 2.3 long, 0.9 - 1.2 mm wide. Mesonotal mycangial tuft extends over the pronotal base. Elytral declivity rounded, with a lateral white pattern in the edges. In dorsal view, pronotum is sub-rectangular, with rounded front. Antenna clavate, two segmented. Striae of elytral declivity with punctures while interstriae 1 and 2 are clear and toward the apex of the elytral apex (Figure 1a, b).

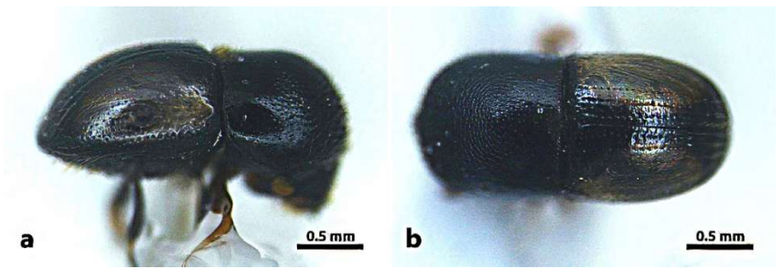

Figure 1. Morphological characteristics of *Cnestus aterrimus* adults:
a. lateral view; **b**. dorsal view.

3.1.2. Damage symptoms and frequency

Cnestus aterrimus excavates tunnels in the wood with a very small diameter of burrows and exit holes, about 0.8 - 0.9 mm diameter (Figure 2). This species was recorded at a low frequency, with the number of adult beetles comprising 2.8% of the total samples collected in this study.

Figure 2. Damage symptoms of *Cnestus aterrimus*

3.2. *Hypothenemus birmanus* Eichhoff, 1878 (Scolytidae: Scolytinae, Trypophloeini)

3.2.1. Morphological description

Similar to other *Hypothenemus* species, particularly *H. seriatus* and *H. eruditus*. The female adult dimension is 1.6 - 2.3 × 0.7 - 1.0 mm (length × width). The pronotum edge has four teeth, of which the median pair is wider. The upper anterior part of the head capsule is absent. The elytral declivity is steep (Figure 3a, b), and the interstrial setate are denser compared to *H. seriatus* and *H. eruditus* species.

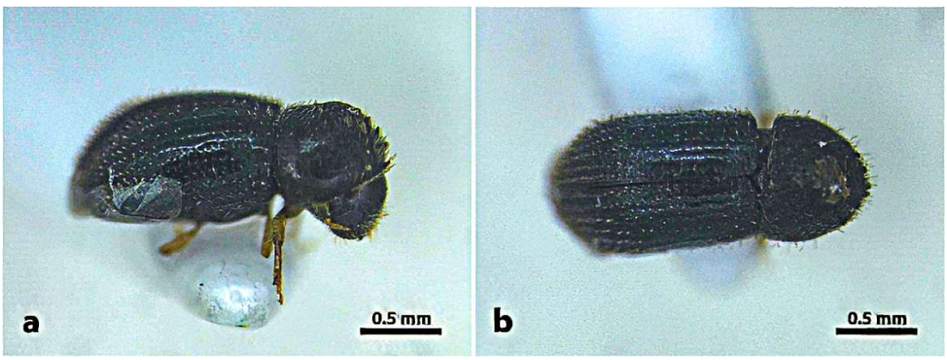

Figure 3. Morphological characteristics of *Hypothenemus birmanus* adults:
a. lateral view; **b**. dorsal view

3.2.2. Damage symptoms and frequency

Tunnels and exit holes are about 0.8 - 1.0 mm diameter (Figure 4), similar in size and shape to those of *C. aterrimus*. The occurrence frequency is 2.1% of the total wood borers samples.

Figure 4. Damage symptoms of *Hypothenemus birmanus*

3.3. *Sinoxylon anale* Lesne, 1897 (Bostrichidae: Bostrichinae)

3.3.1. Morphological description

Body is nearly four times longer than wide. The antennal club is flabellate. The posterior submarginal carina along the lateral margin of the elytra curve dorsally and join the carina forming lower margin of elytral declivity (Figure 5a-c). The anteriorly excavate pronotum with rounded anterior margin armed with a row of small teeth places this species in the Bostrichinae. The presence of two large spines medially, close to medial suture, places this species in the genus in *Sinoxylon*. It is distinguished from other *Sinoxylon* in northern Vietnam.

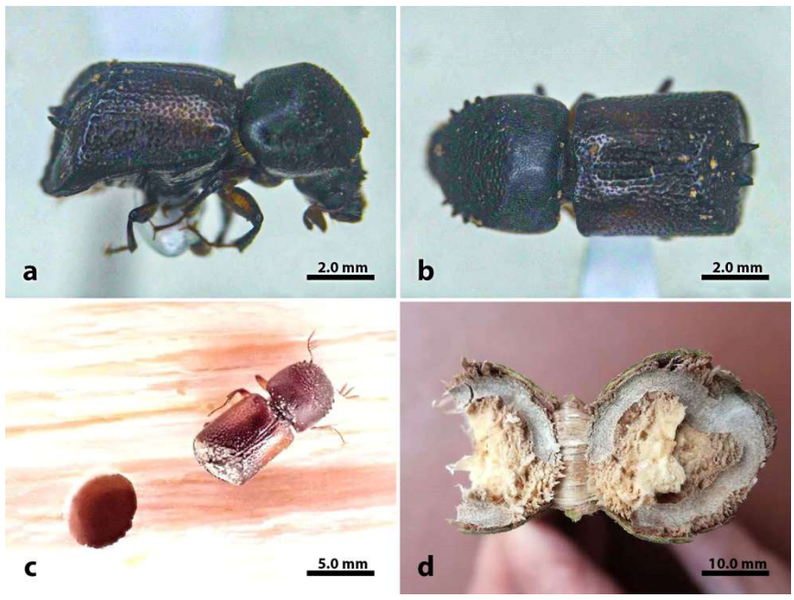

Figure 5. *Sinoxylon anale* in *Pterocarpus indicus* trees: **a**, **b**. female adults; **a**. lateral view; **b**. dorsal view; **c**. an adult and its hole in the stem; **d**. tunnel in branch.

3.3.2. Damage symptoms

Sinoxylon anale causes widespread damage to *P. indicus* trees in in Dak Lak and Gia Lai provinces, Vietnam, both on the trunks and branches. Tunnels are relatively large, about 3.3 - 4.5 mm in diameter. On tree trunks and large branches, they bore directly into the wood and excavate tunnels within (Figure 5c). With small branches, they often create encircling tunnels beneath the bark (Figure 5d), that effectively girdles the limb, resulting in breakage when exposed to wind. This species accounted for 85.1% of the total samples collected and on 90.2% of damaged trees.

3.4. *Xylosandrus compactus* Eichhoff, 1875 (Curculionidae: Scolytidae, Xyleborini)

3.4.1. Morphological description

Adult female is grey-black or black, with a polished surface when dry, and a body size of 1.6 - 2.0 × 0.8 - 1.1 mm (length × width). A sparse mycangial tuft on the pronotal base. The wide separation of the procoxae separate this *Xylosandrus* species from other *Xyleborini.* It is also small bodied comapred with other *Xylosandrus* species The pronotum is almost circular in dorsal view, and arc shape with two sides nearly perpendicular in lateral view. The elytral declivity has six striae, each with setae (Figure 6a, b).

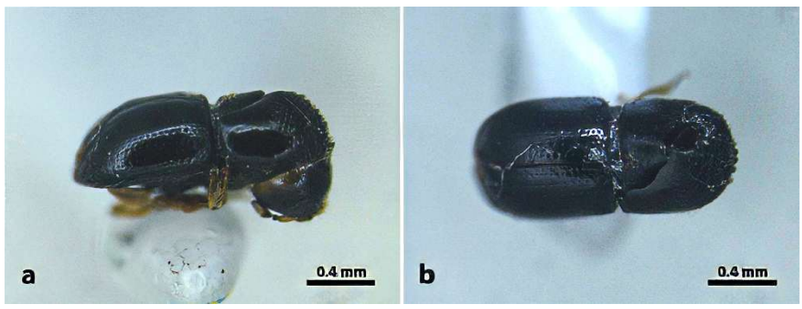

Figure 6. Morphological characteristics of *Xylosandrus compactus* female adults: **a**. lateral view; **b**. dorsal view

3.4.2. Damage symptoms

Xylosandrus compactus tunnels are 1.0 - 1.2 mm diameter on the branches (Figure 7). Tunnels initially extend into the branch and then branch into the sapwood. Initially, *X. compactus* extrude white frass that gradually turns dark black. This species had a low frequency of 5.8% of the samples collected. This pest was recorded simultaneously with four other wood borer species, and they often attack the branches after *P. indicus* trees have been attacked by other species.

Figure 7. Damage symptoms of *Xylosandrus compactus*

3.5. *Xylosanrus discolor* Blandford, 1898 (Scolytidae: Scolytinae, Xyleborini)

3.5.1. Morphological description

The female adult has a brownish or yellowish-brown pronotum, while the elytra is brownish-grey. Female beetles are 2.1 - 2.4 × 1.0 - 1.2 mm (length × width). A dense mycangial tuft which lays on the pronotal base. The pronotum is oval in dorsal view. The elytra is equal in length to the pronotum which is sub-square in shape with apex broadly rounded. The elytral declivity is very steep and convex on dorsal surface with small setae (Figure 8a, b). Striae have a granular texture instead of punctures as some of other *Xylosandrus* species. As other *Xylosandrus* species, this species is distinguished from other Scolytinae by the widely separated procoxae.

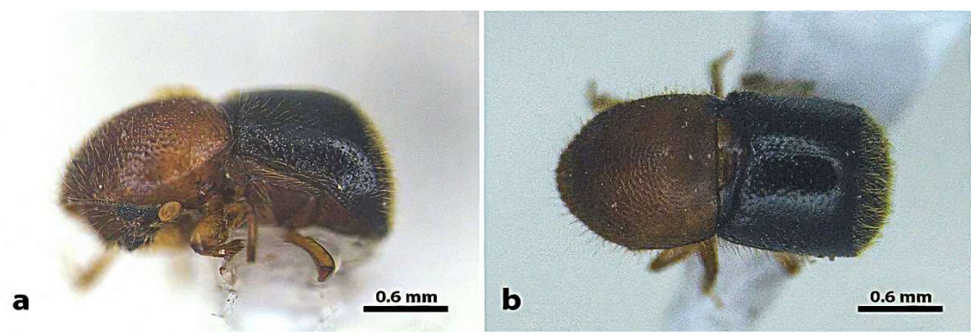

Figure 5. *Xylosandrus discolor* adult: **a**. lateral view; **b**. dorsal view

3.5.2. Damage symptoms

Damaged trees have exit holes and tunnels about 1.1 - 1.2 mm diameter (Figure 9). The tunnels run straight into the trunk, then branch into in the sapwood. Similar to *X. compactus*, the frequency of *X. discolor* is about 4.2% of the total samples. This symptom is similar with that of *X. compactus*.

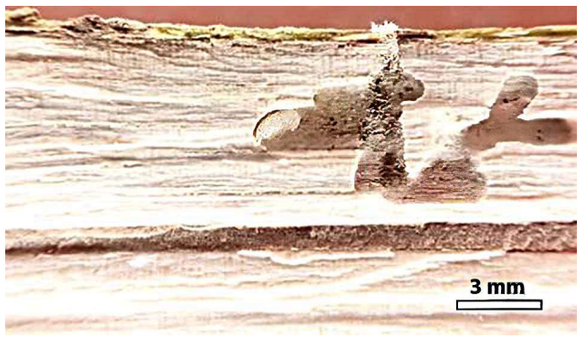

Figure 9. Damage symptoms of *Xylosandrus discolor*

4. DISCUSSION

Of the five pinhole borers recorded in our study, only *Sinoxylon anale* was previously recorded as a pest of *Pterocarpus indicus* trees (Lykidis *et al.,* 2016). A wide range of insect pests have been recorded on *P. indicus* trees, including *Hyloconis* sp. (Lepidoptera: Gracillariidae) and *Melipotis diversipennis* (Lepidoptera: Gracillariidae) (Thomson, 2006), *Euplatypus parallelus* (Coleoptera: Curculionidae) and *Aristobia horridula* (Coleoptera: Cerambycidae) (Bumrungsri *et al.,* 2008), and *Treptoplatypus micrurus* (Coleoptera: Curculionidae) (Tarno *et al.,* 2015; Tarno *et al.,* 2021). Of these, *E. parallelus* and *T. micrurus* are recognized as the most economically damaging ambrosia beetles of *P. indicus* in Indonesia (Tarno *et al.,* 2015). This finding with four additional pest species has further warned of potential harm to this important tree species in Southeast Asia, especially in *P. indicus* plantations and planted populations in urban areas.

Cnestus aterrimus is reported from China, Indonesia, Japan, South Korea, Laos, Malaysia, New Guinea, Taiwan, Thailand, and Vietnam (Smith *et al.,* 2018; Hulcr & Cognato, 2020; Park *et al.,* 2020). Adults have previously been collected in *Acacia* plantations in Vietnam using pheromone traps (Smith *et al.,* 2018), but the host tree has not been identified.

Hypothenemus birmanus is recorded from India, Sri Lanka, North America, Samoa and Vietnam (Beaver 1976; Peter *et al.,* 1984). It is recognized as a significant forest pest of many tree species including *Adenanthera pavonina*, *Albizia falcata*, *Bixa orellana*, *Bougainvillea spectabilis*, *Hibiscus rosa-sinensis*, *Leucaena* sp., *Macadamia ternifolia*, *Mangifera indica*, *Passiflora* sp., *Syzygium corynocarpus*, and *Theobroma cacao* in Samoa (Beaver, 1976), and *Manilkara zapota* in India (Peter *et al.,* 1984). It is a potential pest of stressed seedlings and transplants (Beaver, 1987).

Sinoxylon anale is a powder-post beetle found in Africa, America, Australasia, and Eurasia (Lykidis *et al.,* 2016; Zhang *et al.,* 2022; de Souza Covre *et al.,* 2023; Savaris *et al.,* 2023). Many woody plant species are host plants, including *Acacia* spp., *Albizia* spp., *Anacardium occidentale*, *Anogeissus acuminata*, *Cassia* spp., *Casuarina equisetifolia*, *Choerospondias axillaris*, *Dalbergia* spp., *Delonix* spp., *Hevea brasiliensis*, *Hura crepitans*, *Erythrina variegata*, *Koompassia malaccensis*, *Leucaena* spp., *Mangifera indica*, *Myroxylon* spp., *Persea americana*, *Prosopis* spp., *Pterocarpus* spp., *Plinia cauliflora*, *Shorea* spp., *Tectona grandis*, and *Terminalia* spp. (Kangkamanee *et al.,* 2011; Lykidis *et al.,* 2016). This pest has a strong ability to adapt and spread in many regions of the world and is a major threat to agriculture in many countries (Lykidis *et al.,* 2016; de Souza Covre *et al.,* 2023; Savaris *et al.,* 2023).

Xylosandrus compactus is widely distributed in many parts of the world from Asia to Eurasia,

Oceania, Africa, North America, Caribbean, and South America (Ngoan *et al.,* 1976; Hara & Beardsley, 1979; Garonna *et al.,* 2012; Urvois *et al.,* 2022). This pest has a very diverse range of host plant species (Hara and Beardsley, 1979; Urvois *et al.,* 2022), including many woody tree species such as *Acacia* spp., *Anacardium occident*, *Araucaria heterophylla*, *Cassia* spp., *Casuarina equisetifolia*, *Eucalyptus* spp., *Liquidambar formosana*, *Macadamia ternifolia*, *Magnolia grandiflora*, *Melia azedarach*, *Persea americana*, *Quercus ilex*, *Spondias purpurea*, *Swietenia mahogoni*, and *Tabebuia pentaphylla* (Hara & Beardsley, 1979; Chong *et al.,* 2009; Urvois *et al.,* 2022). *X. compactus* is recognized as a serious pest that often attacks live shoots and branches, especially if the trees have suffered stress through transplantation or drought (Hara & Beardsley, 1979).

Xylosandrus discolor is recorded in Australia, China, and Indonesia (Dole & Beaver, 2008; Tarno *et al.,* 2022; Pan *et al.,* 2023). This pest has received attention in quarantine and pest management activities because of its risk of invasion and damage to crops (Tarno *et al.,* 2022; Pan *et al.,* 2023). Although *X. compactus* and *X. discolor* occurred at low frequencies in this study, they are dangerous ambrosia beetles and can carry pathogens that cause damage to host plants (Li *et al.,* 2019). Therefore, monitoring these two pests is essential for timely and effective management.

Sinoxylon anale was recorded to be very common on *P. indicus* trees in Vietnam. Not only attacking dead trees or woody material, they also attack living trees (Lykidis *et al.,* 2016). Although more common in tropical areas, this pest has exhibited some adaptability to temperate climates, which may allow it to spread across the tropical and subtropical regions of Brazil and potentially to South America (de Souza Covre *et al.,* 2023; Savaris *et al.,* 2023). Similar to many other emerging pests in Vietnam such as *Batocera lineolata*, *Euwallacea fornicatus*, *Xyleborus perforans* on *Acacia* spp. and *Eucalyptus* spp. (Thu *et al.,* 2021; Hung *et al.,* 2022) or *Acanthoecia larminati* on chestnut trees (Chi *et al.,* 2024), *S. anale* is at risk of breaking out into an epidemic as the planted *P. indicus* area is increasing rapidly in Vietnam.

Table 1. The appearance of wood borer species in the damaged trees

Wood borer	The appearance of wood borers (%)		
	Dak Lak	Gia Lai	Average
Cnestus aterrimus	2.1	3.5	2.8
Hypothenemus birmanus	2.3	1.9	2.1
Sinoxylon anale	86.9	83.3	85.1
Xylosandrus compactus	5.1	6.5	5.8
Xylosanrus discolor	3.6	4.8	4.2
Total	**100**	**100**	**100**

Sinoxylon anale dominated the total wood borer samples collected in both provinces with a proportion of over 83% (Table 1). The damage symptoms of wood borers recorded and described in this study were similar to those previously described by Browne (1961), Beaver (1976), Beaver (1987), Hara & Beardsley (1979), Garonna *et al.* (2012) and Thu *et al.* (2021). There was no study confirming whether these five wood borer species are native or exotic in Vietnam but they are at risk of spreading and causing damage to crops in the country. *Xylosandrus compactus* and *X. discolor* have been identified as carrying *Fusarium* spp. and

other fungi, some of them are plant pathogens (Bateman *et al.,* 2016; Vitale *et al.,* 2022). However, we have not yet isolated fungi from the above mentioned pests as well as from their tunnels to check whether they carry pathogens that cause disease in the host plant. Further research needs to focus on monitoring, studying biological characteristics as well as management solutions for these pests in Vietnam.

5. CONCLUSION

Five species of wood borers (*Cnestus aterrimus*, *Hypothenemus birmanus*, *Sinoxylon anale*, *Xylosandrus compactus*, and *X. Discolor*) were recorded as pests of *Pterocarpus indicus* trees in Central Highlands of Vietnam. The abundant pest is *Sinoxylon anale* and commonly appears on damaged trees. Our study shows that there is potential for significant economic impacts on *P. indicus* forestry through wood degradation and tree mortality resulting from infestations by at least five pinhole borers. It is therefore desirable to carry out further surveys focusing on the extent of damage by pinhole borers to assess their economic significance and possible approaches to pest management should the need for premptive strategies or periodic monitoring of these insects be found necessary.

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Conflict of interest: On behalf of the authors, there are no conflicts of interest.

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