Communication

Damage Caused by Bacchisa medioviolacea Breuning (Coleoptera: Cerambycidae) in Wild Apple (Docynia indica) Orchards in Northwest Vietnam

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Abstract: The wood-borer Bacchisa medioviolacea Breuning (Coleoptera: Cerambycidae) is identified as a major new pest of Docynia indica (Rosales: Rosaceae) orchards in the northwest mountainous provinces of Vietnam. The life cycle extends over two years (721.7 days ± 17.6 days), with overwintering as larvae. Adults emerge and disperse in summer. Females lay 6–12 eggs during an oviposition period of 2–3 days, and the incubation period ranges from 27 to 38 days. The larval and pupal periods take 554–701 days and 40–59 days, respectively. Adults survive for 12–23 days. In 2019, the damage incidence (P%) and the damage index (DI) in Yen Bai, Lao Cai, Lai Chau, and Dien Bien provinces ranged from 43.5% to 71.6% and 0.80 to 1.78, respectively. Further research on the distribution and host range of B. medioviolacea is required to help formulate a management strategy for this new orchard pest.

Keywords: Docynia indica; insect pest; Bacchisa medioviolacea; fruit tree decline; upland horticulture; rural livelihood

1. Introduction

Docynia indica (Wall.) Decne. (Rosales: Rosaceae) is a wild edible fruit in Asia with a natural distribution from Nepal to China [1–3]. It is also a valuable ethnomedicinal plant [4]. In India, fruits of D. indica are used to treat digestive and infectious diseases [5–7]. In China, leaves of D. indica are used to treat a range of medical conditions [8,9]. In Vietnam, fruits of D. indica are a source of natural medicines to reduce cardiovascular disorders, high blood pressure, and high cholesterol levels [2,3].

Docynia indica is listed by the Vietnam Records Organization as one of the top 50 famous fruits of Vietnam [10]. Since 2014, D. indica has been promoted as one of the 20 major species for national reforestation and rehabilitation programs in Vietnam [11]. It is now propagated and widely cultivated for the commercial purpose of fruit production in the northwest mountainous provinces of the country [2,3,12]. Based on fruit quality and distance to market, local farmers sell fresh D. indica fruits directly to buyers with a farm gate price range of 0.2–0.7 USD/kg. The market price for fresh fruits at the end of the chain is between 0.7 and 1.2 USD/kg [13,14]. In 2018, the estimated area of D. indica orchards exceeded 15,000 ha [13], yielding about 6500 tons fruit/year [14]. The fruits are mainly used for the production of fruit juice and fruit wine. At present, D. indica fruits and their processed forms are consumed domestically. As processing facilities improve, the local authorities are hopeful that export will be possible to markets outside Vietnam.

In 2017, a new pest causing branch decline and tree mortality was reported locally in Son La province. Infestations were subsequently observed in wild apple orchards in Yen Bai, Lao Cai, Lai Chau, and Dien Bien provinces. The Forest Protection Research Centre (FPRC) of the Vietnamese Academy of Forest Sciences (VAFS) made a preliminary
identification of this pest as *Bacchisa* sp. (Coleoptera: Cerambycidae). Several species of *Bacchisa* are serious pests of horticultural crops *B. atritarsis* is a pest of tea, coffee, and cacao in China [15–17]; *B. fortunei* infests pear, apple, peach, pome, and stone fruit trees in Japan, China, and New Zealand [1,16,18], and *B. medioviolacea* has been reported to attack pear trees in China [19].

The objectives of this study were to identify the new borer attacking *D. indica* in northwest Vietnam, determine its life cycle, and quantify the extent of the damage. This information will assist orchardists and government authorities across the region in pest surveillance and in developing suitable management plans for this emerging pest.

2. Materials and Methods

2.1. Collection of Bacchisa from Orchards

Adults, eggs, larvae, and pupae were collected twelve times over two years (February, April, June, August, October, and December in 2019 and 2020) in heavily infested *D. indica* orchards in Son La, Yen Bai, Lao Cai, Lai Chau, and Dien Bien provinces (Figure 1). The land had been converted from degraded forests and used to cultivate maize and cassava for several rotations prior to the establishment of orchards in the last two decades. The landowners are small households of the Dao, Thai, and H‘Mong indigenous ethnic minority peoples. The study sites have a tropical monsoon climate with four distinct seasons, an altitudinal range of 1000–2000 m, terrain with a slope of 15–30%, and annual rainfall and temperature of 1500–3800 mm and 15–18 °C, respectively. The *D. indica* plantations were 10–20 ha in size with a density of 1100–1600 trees/ha, with no fixed spacing between trees (scattered plantings). Branches (8–10 cm diameter) with feeding/exit holes were removed from 5 *D. indica* trees in each province, cut into 80 cm lengths, and dissected to obtain eggs, larvae, and pupae. Sweep nets were used to catch flying adults. The collected material was transported to the FPRC laboratory in Hanoi.

![Figure 1. Geographic location of Docynia indica orchards found to be infested with Bacchisa medioviolacea in northwest Vietnam (A), D. indica orchard (B) in Yen Bai province, and fruit (C). The numbers in A are mentioned in Table 1.](image)
Table 1. Damage incidence and average damage index of *Bacchisa medioviolacea* in *Docynia indica* orchards in northwest Vietnam. The data are arranged by province according to the damage level.

<table>
<thead>
<tr>
<th>Province</th>
<th>Map Number (Coordinates)</th>
<th>10–15-Year-Old Trees</th>
<th>16–20-Year-Old Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P% DI</td>
<td>P% DI</td>
</tr>
<tr>
<td>Son La</td>
<td>1 (21°24′75.7″ N; 103°33′87.0″ E)</td>
<td>57.5 ± 4.11 1.23 ± 0.07</td>
<td>72.1 ± 5.05 1.77 ± 0.26</td>
</tr>
<tr>
<td></td>
<td>2 (21°24′81.5″ N; 103°33′93.5″ E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 (21°41′46.0″ N; 104°13′74.2″ E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yen Bai</td>
<td>4 (21°41′65.5″ N; 104°13′87.8″ E)</td>
<td>53.8 ± 3.18 1.08 ± 0.09</td>
<td>70.5 ± 3.24 1.75 ± 0.17</td>
</tr>
<tr>
<td></td>
<td>5 (22°33′00.8″ N; 104°20′24.6″ E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lao Cao</td>
<td>6 (22°31′90.8″ N; 104°18′16.1″ E)</td>
<td>40.9 ± 0.46 0.59 ± 0.04</td>
<td>65.7 ± 4.71 1.63 ± 0.17</td>
</tr>
<tr>
<td></td>
<td>7 (22°12′47.9″ N)</td>
<td></td>
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<tr>
<td>Lai Chau</td>
<td>8 (22°12′53.6″ N; 103°34′57.8″ E)</td>
<td>40.3 ± 2.56 0.61 ± 0.04</td>
<td>57.5 ± 3.72 1.30 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>9 (21°35′18.0″ N; 103°30′80.6″ E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dien Bien</td>
<td>10 (21°35′26.8″ N; 103°30′73.6″ E)</td>
<td>28.8 ± 1.82 0.48 ± 0.07</td>
<td>31.1 ± 1.53 0.74 ± 0.12</td>
</tr>
</tbody>
</table>

Note: P% is damage incidence (%), DI is mean damage index. Values are mean ± SE (n = 5).

2.2. Identification and Life Cycle

Identification was based on the external morphology of 50 adult specimens using the keys in Yang et al. [19] and a photograph of the holotype in the Bernice P. Bishop Museum, Honolulu, Hawaii, USA. Adult body length was measured along the midline from the anterior of the eye to the apex of the elytra. The width of adults was measured at the maximum width of the thorax. A further 90 samples (30 eggs, 30 larvae, and 30 pupae) were used to take measurements. Egg size and the width of the larval head capsule were measured using a Leica M165C microscope (Leica Microsystems, Wetzlar, Germany). Images were captured using a Nikon DS-Fi2 camera (Nikon Cooperation, Hanoi, Vietnam). Adult specimens examined were deposited in the insect collection of the FPRC with numbers coded from DI001 to DI050.

Bodies of 6 males (D001, D008, D013, D018, D024, D050) and 6 females (D004, D009, D015, D038, D045, D048) were softened in boiled water for 1–2 h. The adult genitalia were then detached from the abdomen with fine forceps. The genitalia were pretreated in a warm solution of 10% KOH for 10–20 min, then washed several times in water, transferred into glycerol on microscope slides, and observed under the microscope.

In 2019 and 2020, field surveys were conducted every month in Son La and Yen Bai provinces to determine the number of eggs laid per female, the egg incubation period, the developmental period of larvae, pupa, and adults, and adult longevity. After emergence, each adult was released into a netted cage (0.8 × 0.8 × 1.2 m) containing a one-year-old *D. indica* seedling (65–88 cm height) to record beetle longevity. The rearing cages were kept in a laboratory at 28–32 °C and relative humidity of 75–85%. In addition, further observations were undertaken to characterize the internal symptoms of the damaged stems/branches, such as feeding patterns, the location of larvae and pupae, and the distribution of cavities under the bark and in wood. The larval and pupal locations were determined by splitting open the infested trees from which wooden slivers and excreta were visible. The behavior of adults, including mating, feeding, time of emergence, and dispersal, was investigated daily.
2.3. Assessment of Damage and Severity

In May and June 2019, nine field surveys were carried out in 10–15-year-old and 16–20-year-old *D. indica* orchards in Son La, Yen Bai, Lao Cai, Lai Chau, and Dien Bien provinces (Figure 1). Six plots (25 × 40 m) were randomly established in each orchard. In total, 60 plots were established across the five provinces. In each sample plot, 30 trees were randomly selected, and they were assessed for damage symptoms (active holes on the bark surface of the main trunk and branches related to gallery extensions of larvae and foliage condition) from *B. medioviolacea* infestation. The damage was ranked into five levels, where: 0 = trees with no damage symptoms; 1 = trees with 1–10 active holes, yellowish-green canopy; 2 = trees with 11–20 active holes, yellow canopy; 3 = trees with 21–30 active holes, about 50% canopy senescence; 4 = trees with more than 30 active holes, full canopy senescence, some dead trees.

2.4. Data Analysis

Following the results of damage classification, the damage incidence and damage index were calculated after McMaugh [20] and Nguyen and Dao [21] using Equations (1) and (2), respectively, as follows:

\[
P\% = \left(\frac{n}{N}\right) \times 100
\]

where: \(P\%\) = damage incidence; \(n\) = the number of trees attacked by *B. medioviolacea*; \(N\) = total number of trees assessed.

\[
DI = \left(\frac{\sum n_i \times v_i}{N}\right)
\]

where: \(DI\) = damage index; \(n_i\) = the number of trees infested at damage index \(i\); \(v_i\) = the damage index at level \(i\); and \(N\) = total number of trees assessed. Based on the average damage index, the level of damage severity was ranked as 5 levels: \(DI = 0\), no damage; \(0 < DI \leq 1\), light damage; \(1 < DI \leq 2\), moderate damage; \(2 < DI \leq 3\), high damage; \(3 < DI \leq 4\), very high damage.

3. Results

3.1. Identification and Description

Based on the morphological characteristics of adults given by Breuning and a photograph of the holotype, the wood-boring beetle infesting *D. indica* plantations in this study is *Bacchisa medioviolacea* Breuning, 1965 (Coleoptera: Cerambycidae) (former name *Bacchisa guerryi apicalis* Pic). As very little descriptive information is available for this pest species, we provide the following data for our collections from northern Vietnam.

Adults (Figure 2A–F): abdomen black and yellow. Head and pronotum covered with yellowish pubescence. Antennae 11-segmented, covered with sparse hairs, segments 1 to 3 yellowish brown, segments 4 to 11 black (Figure 2B,E). Thorax yellowish brown (Figure 2B,C,E,F). Elytra proximal 2/5th metallic-black, distal 3/5th light orange yellow. Abdomen ventral surface yellow brown, with black on the third segment and two black spots on the sixth and seventh segments (Figure 2C,F). The last abdominal segment of females with a longitudinal, straight central groove (Figure 2C). Males smaller than females. Male body length 11.9–13.1 mm and width 3.9–6.1 mm. Female body length 13.9–15.8 mm and width 5.0–6.1 mm. Male antenna subequal to the body length (Figure 2E), female antenna about 2/3 times as long as the body length (Figure 2B).
Figure 2. Morphological and genital characteristics of *Bacchisa medioviolacea*. (A) Female dorsal view. (B) Female lateral view. (C) Female ventral view. (D) Male dorsal view. (E) Male lateral view. (F) Male ventral view. (G) Egg. (H) Third instar larva. (I) Pupa. (A–I) scale bars = 3.0 mm. (J–L) male genitalia. (M,N) female genitalia. (J) Tegmen in dorsal view. (K) Median lobe in dorsal view. (L) The 8th abdominal segment in ventral view. (M) Sternite. (N) Ovipositor in dorsal view. (J–N) scale bars = 0.3 mm.
Eggs (Figure 2G): cylindrical, creamy white initially but gradually become pale yellow, 3.7–3.9 mm long, 0.98–1.00 mm wide.

Larvae (Figure 2H): cylindrical, segmented, elongated, light to dark orange, sparsely covered with fine hairs, without legs. Head with a large pair of heavily sclerotized, black mandibles. Larvae up to 50 mm in length, head capsule up to 5 mm in width.

Pupae (Figure 2I): milky white to dark orange, 17.8–20.1 mm in length, in pupal chambers in sapwood about 1 cm below the bark in spring. Larvae pack wood shavings and frass behind themselves to block the larval tunnel and the partially excavated exit hole in front of them. Female pupae longer than males. Eyes light brown to black, pupal legs and wings free from the body, upper jaw dark brown, pupal abdomen with nine segments, of which the seventh segment is the longest.

Male genitalia: Tegmen (Figure 2J) approximately 3.9 times as long as broad, sub-oval in shape. Lateral lobes short, about 1/28 times as long as tegmen, 0.8 times as long as broad with dehiscent apex, slightly fishtail in shape, covered with dense short hairs. Median lobe (Figure 2K) moderately curved, rhombic in shape, approximately 6.9 times as long as broad, longer than tegmen in lateral view. The eighth abdominal segment (Figure 2L) 0.9 times longer than its width, square in shape. Apex slightly concave, covered with dense, long hairs.

Female genitalia: Sternite (Figure 2M) large, apex covered with sparse hairs. Ovipositor (Figure 2N) about 3.5 times as long as broad, elongated in shape, and gradually narrows down to a posterior portion. Two palps located near the apex.

3.2. Life Cycle

The life cycle of *B. medioviolacea* takes several years, and overwintering occurs as the larval stage in infested *D. indica* trees. Females lay 6–12 eggs during an oviposition period of 2–3 days (2–4 eggs per day). It takes 23–39 days for eggs to hatch (mean 27.9 ± 1.8 days). The larval and pupal periods take 554–701 days (mean 627.3 ± 12.0 days) and 40–59 days (48.9 ± 2.8 days), respectively. Adult longevity under laboratory conditions is 12–23 days (mean 17.6 ± 0.9 days).

Adults emerge from pupal chambers via exit holes (1.5 ± 0.1 mm in diameter) (Figure 3B) from late April to early May. Adults often perch on the undersides of leaves and feed on the leaf veins of *D. indica* (Figure 3D). Adults commence flying in the early morning (07:00–08:00 h). Mating takes place from 12:00 to 14:00 h on the leaves and stems of *D. indica* (Figure 3F). During copulation, the female’s antennae are curved sideways, whereas those of the males are V-shaped (Figure 3F). Two to three hours after mating, females chew oviposition pits in the bark and lay eggs (Figure 3E). Recently hatched larvae feed on the inner bark and then the sapwood before tunneling deep into the heartwood. Frass containing undigested wooden slivers and excreta is ejected from the trees (Figure 3A). Larval chambers are oval (Figure 3B). Larvae tunnel inside the trunk and main branches producing galleries 60–92 cm in length and up to 3 cm in width. Mature larvae construct rounded pupal chambers, 18.5–24.2 mm in length, at tunnel ends.

3.3. Damage Incidence and Severity

The damage incidence (P%) and damage index (DI) of *Bacchisa* infestation in *D. indica* plantations in Son La, Yen Bai, Dien Bien, Lao Cai, and Lai Chau provinces ranged from 43.5% to 71.6% and 0.80 to 1.78, respectively. The greatest P% and DI were observed in Son La (72.1% and 1.77), followed by Yen Bai, Dien Bien, Lao Cai, and Lai Chau. Furthermore, damage increased with tree age (Table 1).

Larval chambers and exit holes occurred in the main trunk >1 m (mostly 1.5–2.5 m) above the ground and in the main branches >1.5 m (mostly 2–4 m) above the ground. The diameter of trunks and branches in which pupation occurred and exit holes were present ranged from 7.5 to 11.5 cm (mean 8.8 ± 0.2 cm, number of samples = 30). Infestation led to foliage wilt, leaf loss, and branch dieback. Infested branches often broke off in strong winds. About 5% of tree mortality occurred in heavily infested orchards.
Figure 3. Characteristic symptoms of Bacchisa medioviolacea infestation in Docynia indica (A) Frass. (B) Exit hole. (C) Larval chambers. (D) Adult feeding on leaf vein. (E) A female making an egg chamber. (F) Mating on lower leaf surface. Scale bars = 3.0 mm.

4. Discussion

In this study, the wood-boring insect attacking D. indica orchards in Vietnam was confirmed as Bacchisa medioviolacea. This is the first time that B. medioviolacea has been recorded in Vietnam. Previous collections have been made in Laos [19,20] and China [16]. Two other species of Bacchisa are recorded for Vietnam: Saito [22] collected B. kusamai adults in a natural forest in Son La province but did not identify its host, and collections of B. pallidiventris are reported for Vietnam as well as Laos and southwest China [23].

The greatest damage level and damage index were found in Son La and Yen Bai provinces, which have the largest area of D. indica orchards in Vietnam. The pest attacks the main trunk and branches. Infested trees exhibit wilting, defoliation, branch death, and circular exit holes covered with wood slivers and frass. These symptoms are similar to those observed for B. guerryi, B. atritarsis, and B. fortunei, which attack domesticated apple and pear trees in China and Japan [14,17]. Life cycle characteristics of B. medioviolacea are similar to B. atritarsis and B. fortunei [14,16], which take two years to complete their life cycles and overwinter as larvae [24,25].

Nearly four decades ago, D. indica occurred in small, isolated populations in natural forests in the northern mountains of Vietnam, and villagers would go into the forest to collect fruit. Then, when the fruit of this species became more popular, villagers supplemented their income by growing D. indica in their home gardens. More recently, D. indica has been grown in commercial orchards and has become one of the main tree crops for improving the livelihood of rural upland communities. The presence of B. medioviolacea across all five provinces in the northwest poses a great risk to people’s livelihoods. The first symptom of B. medioviolacea damage occurred around 5 years ago, and since then, the pest
has become a serious problem for orchardists. We do not know whether *B. medioviolacea* is resident in the remaining wild population of *D. indica* in Vietnam and has spread into nearby orchards or whether it is an exotic pest. The distance between natural forests and orchards is relatively short, ranging from 500 to 2000 m. Further studies should be carried out to determine the likely origin and spread of this longhorn beetle epidemic in Vietnam.

Outside Vietnam, domestication of *D. indica* is at an early stage with the recent establishment of small commercial orchards in the north of Thailand and Laos. So far, there have been no reports of damage from longicorn beetles in these trees. The report of damage to pears in China [19] lacks detail. However, as some communities in northwest Vietnam are beginning to grow temperate apples and pears, we will continue to monitor upland orchards for alternative hosts.

At present, there is no approved protocol for the management of this new pest in Vietnam. Studies on the management of *B. fortunei* provide some useful insight. Guan [24] and She et al. [25] suggested trimming and pruning damaged branches of pear trees as well as the manual removal of eggs and larvae from infestation sites. Furthermore, several entomopathogenic pesticides killed *B. fortunei* larvae inside tunnels of infested trees [24–26], and a parasitic wasp (*Scleroderma guani*) had a moderate effect on the control of this pest [27]. Research is now underway to assess biological and other control options for *B. medioviolacea* in Vietnam.

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**Data Availability Statement:** Datasets presented in this study are available to the user on request.

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**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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