# Damage of Agrilus mali Matsumura to Wild Apple Forests and Its Assessment Postprint

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## Abstract

The apple tree borer (Agrilus mali Matsumura) has posed a significant threat to wild apple forests on the northern slopes of the Tianshan Mountains in Xinjiang since its invasion in 1995, yet systematic assessment of the damage at the regional scale is lacking. Experimental observations were conducted in typical distribution areas of wild apple forests—Xinyuan County (Xinyuan Improved Farm, Balian, Saha) and Gongliu County (Jiaolesai, Xiaomohe, Damohe, Erxiang)—to record indicators such as damage grade, fruit yield, and density of old emergence holes on damaged branches for each wild apple tree within the sample plots. The results showed that Xinyuan Improved Farm suffered the most severe damage, while Jiaolesai, Erxiang, and Damohe experienced the lightest damage; fruit yield and density of old emergence holes of Agrilus mali differed significantly among the survey sites; damage from Agrilus mali was less severe in intensively managed cultivated orchards. It is recommended to adopt manual pruning measures in severely damaged areas (such as Xinyuan); aerial control in areas suitable for aircraft operation (such as Xiaomohe and Damohe); establishment of fencing protection measures in high mountain regions (such as Erxiang and Balian); and application of biological control and manual pruning measures in locations easily accessible to humans or suitable for manual operations (Jiaolesai and Saha).

## Full Text

### Damage of *Agrilus mali* Matsumura in Wild Apple Forest and Its Assessment

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**Abstract:** *Agrilus mali* Matsumura causes severe damage to the wild apple forests in the north Tianshan Mountains in Xinjiang since an invasion of insect pests from 1995. However, an assessment on the regional damage of insect pests is missed. In this study, the damage level of *A. mali* and its impacts on the wild apple forests, fruit yield, old emergence hole density, etc. of wild apple trees in Xinyuan and Gongliu counties, where the wild apple trees grow widely, Xinjiang, were investigated. It was found that the damage of insect pests was the most serious in the Agricultural Improvement Farm in Xinyuan County, but it was the lightest in Jiaolesay, Second Township and Damohe. There was a significant difference in the old emergence hole density because of the difference of *A. mali* density and of fruit yield among seven sites. In apple orchards with the enhanced management, the infestation level was much lower. Therefore, it was suggested to extensively carry out the pruning at the sites with serious damage of insect pests. Insecticide spray by aircraft is thus recommended in the regions suitable for aircraft flight. Protected areas should be delimited and the pruning and bio-control programs could be applicable in the regions where local people cannot get easy access in the wild apple forests.

**Keywords:** wild apple forest; *Agrilus mali* Matsumura; damage level; fruit yield; emergence hole density; north Tianshan Mountains; Xinjiang

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### 1.2 Study Sites

During 2016–2017, investigations were conducted at seven sites in Gongliu and Xinyuan counties where *Agrilus mali* infestation was prevalent [19]. Three fixed plots were established at each site, with each plot measuring 50 m × 50 m. Within each plot, eight subplots were randomly selected for sampling. In each subplot, 60 trees were surveyed, with two trees selected per plot for detailed measurements of old emergence hole density.

The distance between plots was maintained at approximately 20 m, resulting in a total of 21 subplots across all sites. Old emergence holes were counted on each sampled tree to assess infestation levels.

### 1.3 Data Collection

Old emergence hole density was calculated as the number of holes per square meter of bark surface area. The formula used was:

$$\text{Old emergence hole density} = \frac{\text{Number of old emergence holes}}{\text{Bark surface area } (\text{m}^2)}$$

Statistical analysis was performed using SAS 9.2 software. A General Linear Model (GLM) was applied to analyze differences in fruit yield and old emergence hole density among sites and years, with significance determined at $P < 0.05$. When significant differences were detected, Duncan' s multiple range test was used for post-hoc comparisons. Data visualization was conducted using OriginPro 8.0.

## 2. Classification of Insect Pests

**2.1 Damage Level Classification** Damage levels were classified into five categories based on the percentage of damaged trees:

| Damage Level | Percentage of Damaged Trees |
|---|---|
| 1 | 0–10% |
| 2 | 11%–25% |
| 3 | 26%–50% |
| 4 | 51%–75% |
| 5 | 76%–100% |

The classification was applied to assess infestation severity across the seven study sites in both 2016 and 2017. The calculation formula was:

$$\text{Damage percentage} = \frac{\text{Number of damaged trees}}{\text{Total number of surveyed trees}} \times 100\%$$

Results indicated that Level 1 damage accounted for approximately 60% of the surveyed areas, while Level 2 and Level 3 each represented about 50% of the sites. Level 4 and Level 5 damage showed higher severity, with Level 5 reaching approximately 70% in severely affected areas.

**2.2 Fruit Yield Analysis** In 2016, fruit yield varied significantly among the seven sites ($F = 7.55$, $df = 6$, $P < 0.0001$). The highest yields were observed at sites with lower infestation levels, while severely damaged sites showed substantially reduced productivity. Specific differences were detected between: (1) high-yield sites and low-yield sites, (2) moderately affected sites and severely affected sites, and (3) sites with different management intensities.

In 2017, fruit yield again showed significant variation among sites ($F = 2.40$, $df = 6$, $P < 0.05$), though the differences were less pronounced than in 2016. The overall yield pattern remained consistent with 2016, with better-managed orchards maintaining higher productivity despite pest pressure.

[Figure 2: see original paper] shows the fruit yields across the seven study sites.

[Figure 3: see original paper] illustrates the relationship between damage levels and fruit yield.

**2.3 Old Emergence Hole Density** In 2016, old emergence hole density averaged 3 holes per square meter across all sites, with significant differences detected among locations ($F = 20.41$, $df = 6$, $P < 0.0001$). The highest densities were recorded at sites with severe historical infestations, particularly in areas with poor management practices.

In 2017, old emergence hole density decreased compared to 2016 levels, but significant differences among sites persisted ($F = 8.83$, $df = 6$, $P < 0.0001$). The reduction was most notable at sites where control measures had been implemented.

[Figure 4: see original paper] presents the old emergence hole densities at the seven study sites.

[Figure 5: see original paper] shows the distribution of old emergence holes in wild apple forests planted in 2017 and in mountainous regions.

### 2.5 Discussion and Management Implications

The study demonstrates that *Agrilus mali* infestation levels vary significantly across different sites and management regimes. Enhanced management practices, including regular pruning and sanitation, substantially reduce pest damage and improve fruit yield.

**Management Recommendations:**

1. **Pruning:** Extensive pruning should be implemented at sites with serious pest damage. This practice removes infested branches and reduces pest populations.
2. **Aerial Spraying:** In regions accessible to aircraft, aerial insecticide application is recommended for large-scale control. Historical data show that aerial spraying can achieve 90% control efficiency [1].
3. **Protected Areas:** Delimitation of protected areas is essential for conservation of wild apple forest ecosystems. In remote areas where local communities have limited access, biological control programs should be prioritized.
4. **Integrated Pest Management:** The combination of cultural practices (pruning), chemical control (aerial spraying), and biological control offers the most sustainable approach. Studies indicate that orchards under enhanced management maintain significantly lower infestation levels [8, 24-25].

The damage assessment reveals that the Agricultural Improvement Farm in Xinyuan County experienced the most severe infestations, while Jiaolesay, Second Township, and Damohe showed the lightest damage. This spatial variation underscores the importance of site-specific management strategies tailored to local conditions and accessibility.

**References:** [References are preserved as in the original text]

*Note: Figure translations are in progress. See original paper for figures.*