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| **Table S1.** Summary of the treatment conditions and efficacy of phosphine (PH3) fumigations against forestry pests in empty chambers (i.e., in vitro) | | | | | | | | | | | | | |
| **Type** | **Family** | **Species** | **Life stage** | **Number of replicates** | **Insect numbers/repa** | **Treatment temperature (°C)** | **Atmosphere** | **PH3 doses (ppm)** | **Fumigation time (h)** | **Fumigation volume** | **Effective dose and duration for 100% control** | **Comments** | **Reference** |
| Insect | Bostrichidae | *Dinoderus minutus* | Eggs | 4 | Not reported | Not reported | Air | 350, 700 and 1,400b | 96 | 2.85 L chamber | ≥ 350 ppm  for 96 h | Zero control mortality. | Remadevi et al. [1] |
| Larvae |
| Adults |
| *Sinoxylon anale* | Adults | 3 | 20 | Not reported | Air | 25, 50, 100, 150 and 200 | 24 | 6 L chamber | 200 ppm for 96 h | Mortality of 75, 85 and 100% was reported for doses of 100, 150 and 200 ppm, respectively. Control mortality was not reported. | Remadevi and Deepthi [2] |
| Cerambycidae | *Anoplophora chinensis* | Eggs | 3 | 10 | 25 to 28 | Air | 1,400b | 24 | 125 L chamber | 1,400 ppm  for 24 h | Control mortality was 25.9%. | Lee et al. [3]c |
| Larvae | 3 | 10 | 20 | 1,400 and 2,800b | 168 | 12 L chamber | ≥ 1,400 ppm  for 168 h | Zero control mortality. |
| 1 | 5 to 20 | 20 to 25 | 1,400b | 24 and 48 | 125 L chamber | 1,400 ppm  for ≥ 24 h | Zero control mortality. |
| 53 | -1.3 | 72 | 1,250 L chamber | 1,400 ppm for 72h | - |
| *Anoplophora glabripennis* | Eggs | 4 | 10 | 25 to 28 | Air | 1,400b | 24, 48 and 72 | 125 L chamber | 1,400 ppm  for ≥ 24 h | Control mortality was 15%. |
| Larvae | 1 | 5 to 16 | 20 to 25 | 24 and 48 | 1,400 ppm  for ≥ 24 h | Zero control mortality. |
| 41 | -1.3 | 72 | 1,250 L chamber | ≥ 1,400 ppm  for 72 h | - |
| 47 | 1.5 | 48 | Not achieved | - |
| *Arhopalus ferus* | Eggs | 3 | 50 | 20 ± 1 | Air | 200 | 12, 24, 36, 48, 60, 72, 96 and 120 | 28 L chamber | Not achieved | The longest duration of 120 h resulted in an average mortality of 99.9%. Average control mortality of 19.0%, with a range of 15.1 to 25.5%. | Armstrong et al. [4] |
| Larvae | 6, 12, 24, 36, 48 and 72 | 200 ppm  for ≥ 72 h | Average control mortality of 54.7%, with a range of 44.4 to 62.8%. |
| Adults | 200 ppm  for ≥ 72 h | Average control mortality of 42.0%, with a range of 14.1 to 71.8%. |
| Eggs | 5 | 50 to 70 | 20 | ≤ 1.6% oxygen | Zero | 240 | 28 L chamber | n/a | Average mortality of 78.7 ± 6.8% was reported for zero phosphine and low oxygen (≤ 1.6%). Control mortality was 4.8 ± 0.9%. |
| ≤ 1.6% oxygen | 1,000 | Not achieved | Average mortality of 90.4 ± 5.7% was reported for low oxygen (≤ 1.6%) + 1,000 ppm phosphine. Control mortality was 4.8 ± 0.9%. |
| Air | 1,000 ppm for 240 h | Control mortality was 4.8 ± 0.9%. |
| Eggs | 4 | 95 to 253 | 15 | Air | 700, 2,100 and 3,500 | 72 | 1 L chamber | 3,500 ppm  for 72 h | Control mortality was 14%. | Brash et al. [5] |
| 350, 700 and 2,100 | 120 | 2,100 ppm for 120 h | Inconsistent results, i.e., 350 ppm provided complete control, but eggs hatched in the 700 ppm treatment. Control mortality was 26%. |
| 350 and 700 | 168 | ≥ 350 ppm  for 168 h | Control mortality was 47%. |
| Eggs | 4 | 35 to 42 | Described as no less than 16 | Air | 200, 700 and 2,000 | 240 | 92 L chamber | ≥ 200 ppm  for 240 h | Control mortality was 74%. | Zhang [6]e |
| Adults | 10 | 200 and 2,000 | 24 | ≥ 200 ppm  for 24 h | Control mortality was 27%. |
| Eggs | 4 | 96 to 108 | 15 to 18 | Air | 100 and 200 | 120 | 1 L chamber | 200 ppm  for 120 h | Control mortality was 35%. | Zhang [7]e |
| Eggs | 94 to 107 | 240 | ≥ 100 ppm for 240 h | Control mortality was 4%. |
| Eggs | 4 | 100 ± 5 | 15 to 18 | Air | 100 and 200 | 240 | 1 L chamber | ≥ 100 ppm  for 240 h | Control mortality was 3%. | Zhang et al. [8] |
| Adults | 9 to 12 | 700 and 2,000 | 92 L chamber | ≥ 700 ppm  for 240 h | Control mortality was 27%. |
| Eggs | 4 | 50 to 100 | Not reported | Air | 50 and 150 | 120 and 240 | 1 L chamber | Not achieved | The highest dose of 150 ppm and the longest duration of 240 h resulted in an average mortality of 96.0%. Control mortality 40.8%. | Zhang and van Epenhuijsen [9]e |
| *Callidiellum rufipenne* | Eggs | Not reported | 306 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | Not achieved | The highest mortality of 78.2% was achieved for a dose of 1,400 ppm for 48 h. Control mortality was not reported. | Oogita et al. [10]c |
| Pupae | 158 | 1,400b | Not achieved | The highest mortality of 88.2% was achieved for a dose of 1,400 ppm for 48 h. Control mortality was not reported. | Oogita et al. [10]c |
| Insect | Cerambycidae | *Monochamus alternatus* | Eggs | 3 | 10 | 25 to 28 | Air | 1,400b | 120 and 168 | 125 L chamber | 1,400 ppm  for ≥ 120 h | Control mortality was 23.3%. | Lee et al. [3]c |
| Larvae | 15 to 20 | 20 to 24 | Zero control mortality. |
| Eggs | Not reported | 291 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | ≥ 700 ppm  for ≥ 24 h | Control mortality was not reported. | Oogita et al. [10]c |
| *Semanotus japonicus* | Eggs | Not reported | 354 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | Not achieved | The highest mortality of 46.6% was achieved for a dose of 1,400 ppm for 48 h. Control mortality was not reported. | Oogita et al. [10]c |
| Curculionidae | *Cryphalus fulvus* | Eggs | Not reported | 600 | 15 | Air | 700b | 24 and 48 | 30 L chamber | 700 ppm for 48 h | Control mortality was not reported. | Oogita et al. [10]c |
| Larvae | 587 | 700 and 1,400b | Not achieved | The highest mortality of 97.4% was achieved for a dose of 700 ppm for 48 h. However, the 1,400 ppm dose for 48 h achieved a lower mortality of 76.4%. Control mortality was not reported. |
| Pupae | 337 | Not achieved | The highest mortality of 75.0% was achieved for a dose of 700 ppm for 48 h. However, the 1,400 ppm dose for 48 h achieved a lower mortality of 67.2%. Control mortality was not reported. |
| Adults | 827 | Not achieved | The highest mortality of 99.0% was achieved for a dose of 1,400 ppm for 48 h. Control mortality was not reported. |
| Eggs | Not reported | 530 | 25 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | ≥ 700 ppm  for ≥ 24 h | Control mortality was not reported. |
| Larvae | 442 | Not achieved | The highest mortality of 96.5% was achieved for a dose of 700 ppm for 48 h. However, the 1,400 ppm dose for 48 h achieved a lower mortality of 95.0%. Control mortality was not reported. |
| Pupae | 198 | ≥ 700 ppm for 48 h | Control mortality was not reported. |
| Adults | 206 | 1,400 ppm for ≥ 24 h or ≥ 700 ppm for 48 h | Control mortality was not reported. |
| Adults | 3 | 15 | 20 | Air | 14, 35, 49, 105 and 350b | 24 | 12 L chamber | 350 ppm for 24 h | Control mortality was not reported. | Cho et al. [11]c |
| *Hylastes ater* | Larvaed | 4 | 10 | 15 | Air | 700, 2,100 and 3,500 | 72 | 1 L chamber | ≥ 2,100 ppm  for 72 h | Control mortality was 63%. | Brash et al. [5] |
| 350, 700 and 2,100 | 120 | ≥ 350 ppm  for 120 h | Control mortality was 57%. |
| 350 and 700 | 168 | 700 ppm  for 168 h | Control mortality was 76%. |
| Larvae | 4 | 10 | Described as no less than 16 | Air | 200, 700 and 2,000 | 240 | 92 L chamber | ≥ 200 ppm for  240 h | Control mortality was 12%. | Zhang [6]e |
| Adults | ≥ 200 ppm for  240 h | Control mortality was 19%. |
| Larvae | 4 | 9 to 12 | 15 to 18 | Air | 200, 700 & 2,000 | 240 | 92 L chamber | ≥ 200 ppm for  240 h | Control mortality was 12%. | Zhang et al. [8] |
| Adult | ≥ 200 ppm for  240 h | Control mortality was 19%. |
| *Hylurgus ligniperda* | Eggs | 3 | 25 | 20 ± 1 | Air | 200 | 12, 24, 36, 48, 72 and 96 | 28 L chamber | Not achieved | The longest duration of 96 h resulted in an average mortality of 94.0%. Average control mortality of 10.3%, with a range of 5.3 to 16.0%. | Armstrong et al. [4] |
| Larvae | 50 | 6, 12, 24, 36, 48 and 72 | Not achieved | The longest duration of 72 h resulted in an average mortality of 99.4%. Average control mortality of 45.3%, with a range of 42.9 to 47.0%. |
| Pupae | Not achieved | The longest duration of 72 h resulted in an average mortality of 94.4%. Average control mortality of 15.7%, with a range of 10.0 to 19.3%. |
| Adults | 200 ppm  for ≥ 36 h | Average control mortality of 5.1%, with a range of 3.3 to 7.1%. |
| Larvae | 5 | 60 to 70 | 20 | ≤ 1.6% oxygen | 200 | 72 | 28 L chamber | Not achieved | Average mortality of 45.6 ± 6.1% was reported for low oxygen (≤ 1.6%) + 200 ppm phosphine. Control mortality was 14.5 ± 12.6%. |
| Air | 200 ppm  for 72 h | Control mortality was 14.5 ± 12.6%. |
| Insect | Curculionidae | *Hylurgus ligniperda* | Larvae | 5 | 60 to 70 | 20 | ≤ 1.6% oxygen | Zero | 240 | 28 L chamber | n/a | Average mortality of 89.5 ± 8.2% was reported for zero phosphine and low oxygen (≤ 1.6%). Control mortality was 30.4 ± 6.7%. | Armstrong et al. [4] |
| ≤ 1.6% oxygen | 1,000 | Not achieved | Average mortality of 99.0 ± 0.9% was reported for low oxygen (≤ 1.6%) + 1,000 ppm phosphine. Control mortality was 30.4 ± 6.7%. |
| Air | 1,000 ppm for 240 h | Control mortality was 30.4 ± 6.7%. |
| Adults | ≤ 1.6% oxygen | Zero | n/a | Average mortality of 52.6 ± 5.6% was reported for zero phosphine and low oxygen (≤ 1.6%). Control mortality was 16.1 ± 4.1%. |
| ≤ 1.6% oxygen | 1,000 | Not achieved | Average mortality of 54.5 ± 5.6% was reported for low oxygen (≤ 1.6%) + 1,000 ppm phosphine. Control mortality was 16.1 ± 4.1%. |
| Air | 1,000 ppm for 240 h | Control mortality was 16.1 ± 4.1%. |
| Larvaed | 4 | 10 | 15 | Air | 700, 2,100 and 3,500 | 72 | 1 L chamber | ≥ 2,100 ppm  for 72 h | Control mortality was 63%. | Brash et al. [5] |
| 350, 700 and 2,100 | 120 | ≥ 350 ppm  for 120 h | Control mortality was 57%. |
| 350 and 700 | 168 | 700 ppm  for 168 h | Control mortality was 76%. |
| Eggs | 1 | 50 | 10 ± 1 | Air | 25, 100, 150, 200, 250, 300 and 350 | 72 | 28 L chamber | ≥ 300 ppm  for 72 h | Very low control mortality. | Devitt [12] |
| Larvae | 25 to 50 | 25, 50, 100, 150 and 200 | Not achieved | Very low control mortality. |
| Pupae | 25, 100, 150, 200, 250, 300 and 350 | Not achieved | For the highest dose of 350 ppm, a mortality of 28.0 ± 9.0% was reported. Very low control mortality. |
| Adults | 100, 150, 200, 250, 300 and 350 | Not achieved | For the highest dose of 350 ppm, a mortality of 60.0 ± 6.9% was reported. Very low control mortality. |
| Eggs | 1 | 50 | 20 ± 1 | 150, 200, 250, 300, 350 and 400 | ≥ 350 ppm  for 72 h | Low control mortality. |
| Larvae | 25 to 50 | 25, 50, 75, 100, 130 and 160 | Not achieved | For the highest dose of 160 ppm, a mortality of 80.0 ± 8.0% was reported. |
| Adults | 25, 50, 75, 100, 130 and 160 | Not achieved | The second-highest dose of 130 ppm recorded the highest mortality of 84.0 ± 7.3%. Low control mortality. |
| Pupae | 1 | 25 | 10 ± 1 | 0 to 1,400 | 120 | Not achieved | The highest mortality of 56.0 ± 9.9% was reported for a dose of 1,200 ppm. Individual doses and control mortality were not reported. |
| Pupae | 3 | 50 | 200, 350, 500, 750, 950, 1,200 and 1,400 | 240 | Not achieved | For the highest dose of 1,400 ppm, a mortality of 98.0 ± 2.0% was achieved. |
| Larvae | 1 | 0 to 160 | Not achieved | The highest mortality of 86.0 ± 4.9% was reported for a dose of 100 ppm. Individual doses and control mortality were not reported. |
| Adults | 0 to 160 | ≥ 25 ppm  for 240 h | Individual doses and control mortality were not reported. |
| *Phloeosinus perlatus* | Eggs | Not reported | 335 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | 1,400 ppm  for 24 h | Control mortality was not reported. | Oogita et al. [10]c |
| Larvae | 964 | Not achieved | The highest mortality of 98.6% was achieved for a dose of 1,400 ppm for 48 h. Control mortality was not reported. |
| *Phloeosinus perlatus* | Pupae | Not reported | 535 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | Not achieved | The highest mortality of 98.1% was achieved for a dose of 700 ppm for 24 h. However, the 1,400 ppm dose for 48 h achieved a lower mortality of 94.6%. Control mortality was not reported. | Oogita et al. [10]c |
| Adults | 809 | 700 ppm  for 24 h | Control mortality was not reported. |
| Insect | Curculionidae | *Platypus calamus* | Larvae | Not reported | 129 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | Not achieved | For the highest dose of 1,400 ppm for 48 h, a mortality of 96.2% was reported. Control mortality was not reported. | Oogita et al. [10]c |
| Adults | 344 | 700 ppm for 24 h | Control mortality was not reported. |
| *Platypus koryoensis* | Adults | 3 | 15 | 20 | Air | 140, 210, 280, 490, 700 and 854b | 24 | 12 L chamber | 854 ppm for 24 h | Control mortality was not reported. | Cho et al. [11]c |
| *Platypus quercivorus* | Larvae | Not reported | 207 | 15 | Air | 700 and 1,400b | 24 and 48 | 30 L chamber | Not achieved | For the highest dose of 1,400 ppm for 48 h, a mortality of 83.7% was reported. Control mortality was not reported. | Oogita et al. [10]c |
| Adults | 88 | 1,400 ppm  for 48 h | Control mortality was not reported. |
| *Xyleborus pfeili* | Eggs | Not reported | 268 | 15 | Air | 700 and 1,400b | 48 | 30 L chamber | Not achieved | For the highest dose of 1,400 ppm for 48 h, a mortality of 97.2% was reported. Control mortality was not reported. | Oogita et al. [10]c |
| Larvae | 1,160 | Not achieved | For the highest dose of 1,400 ppm for 48 h, a mortality of 97.3% was reported. Control mortality was not reported. | Oogita et al. [10]c |
| Pupae | 206 | Not achieved | For the highest dose of 1,400 ppm for 48 h, a mortality of 93.3% was reported. Control mortality was not reported. |
| Adults | 2,239 | 1,400 ppm  for 48 h | Control mortality was not reported. |
| Eggs | Not reported | 184 | 25 | Air | 700 and 1,400b | 48 | 30 L chamber | ≥ 700 ppm  for 48 h | Control mortality was not reported. | Oogita et al. [10]c |
| Larvae | 276 | 1,400 ppm  for 48 h |
| Pupae | 104 | 1,400 ppm  for 48 h |
| Adults | 115 | ≥ 700 ppm  for 48 h |
| *Xyleborus mutilatus* | Adults | 3 | 15 | 20 | Air | 7, 11, 14, 18, 21 and 35b | 24 | 12 L chamber | 35 ppm for 24 h | Control mortality was not reported. | Cho et al. [11]c |
| Dryophthoridae | *Rhynchophorus ferrugineus* | Eggs | 4 | 10 | 25 ± 2 | Air | 140, 700, 1,120 and 1,400b | 72 | 1 m3 chamber | ≥ 700 ppm  for 72 h | Control mortality was 26.6%. | Llácer and Jacas [13] |
| Young larvae  (15 d) | ≥ 140 ppm  for 72 h | Zero control mortality. |
| Old larvae (60 d) | ≥ 1,120 ppm  for 72 h |
| Pupae | 1,400 ppm  for 72 h |
| Adults | ≥ 700 ppm  for 72 h |
| Erebidae | *Hyphantria cunea* | Pupae | 3 | Not reported | 24 to 32 | Air | 10,500, 14,000 and 17,500b | 72 | Not reported | ≥ 10,500 ppm  for 72 h | Control mortality was 12%. | Shu and Yu [14]c |
| 96 | ≥ 10,500 ppm  for 96 h | Control mortality was 6%. |
| Kalotermitidae | *Kalotermes brouni* | Nymph | 4 | 15 to 54 | Not reported | Air | 50, 100 and 200 | 240 | 1 L chamber | 200 ppm for 240 h | Control mortality was 10.2%. | Zhang and van Epenhuijsen [9]e |
| 1,200 ppm for 48 h, followed by a top-up of 200 ppm for 192 h | 1,200 ppm for 48 h, followed by a top-up of 200 ppm for 192 h |
| Insect | Pseudococcidae | *Planococcus citri* | Eggs | 3 | 30 | 20 ± 1 | Air | 35, 70, 210, 350, 700, 1,050, 1,400, 1,750 and 2,100b | 24 | 6.8 L chamber | LCt99 17,640 ppm‧h/m3 | All 13 tested nursery plants had no phytotoxic damage. Control mortality was not reported. | Kwon et al. [15]c |
| Eggs | 5 | 533  (total) | 1,400b | 24 | 1 m3 chamber | 1,400 ppm for 24 h | All 13 tested nursery plants had no phytotoxic damage, except *Hoya carnosa* and *Hedera helix*. Control mortality was 1.4 ± 0.6%. |
| Eggs | 5 | 1,204 (total) | 1,400b | 24 | 10 m3 chamber | 1,400 ppm for 24 h | All 13 tested nursery plants had no phytotoxic damage, except *Hoya carnosa* and *Hedera helix*. Control mortality was 0.9 ± 0.3%. |
| Adults | 3 | 30 | 35, 70, 210, 350, 700, 1,050, 1,400, 1,750 and 2,100b | 24 | 6.8 L chamber | LCt99 770 ppm ppm‧h/m3 | All 13 tested nursery plants had no phytotoxic damage. Control mortality was not reported. |
| Rhinotermitidae | *Reticulitermes speratus* | Adults | 3 | 50 | 5 | Air | Not reported | 24 | 12 L chamber | LCT99 18,182 ppm‧h/m3b | PH3 toxicity was 7.8-fold higher at 15°C than at 5°C. Control mortality was not reported. | Choi et al. [16] |
| 15 | LCT99 2,109 ppm‧h/m3b |
| 20 | LCT99 1,655 ppm‧h/m3b |
| 20 | 24, 48, 72, 96, 120, 144 and 168 | ≥ 5 days for all doses tested | Control mortality was not reported. |
| Fungi | Polyporaceae | *Oligoporus placentus* | Fungal isolates | 6 | Isolate grown on malt agar petri dishes | Not reported | Air | 1,000, 3,000, 5,000, 7,000, 10,000 and 13,000f | 24 | Not reported | 13,000 ppm for 24 h | Zero control mortality. | Pant and Tripathi [17] |
| *Trametes versicolor* | Fungal isolates | 1,000, 3,000, 5,000, 7,000 and 10,000f | 10,000 ppm for 24 h |
| aIf 60 insects per replicate are tested per organism and controlled by the treatment, then the statistical reliability is 0.95 at the 95% confidence level (i.e., LD95; Haack et al. [42]). | | | | | | | | | | | | | |
| bConversion of units from g/m3 (or mg/L) to ppm was based on 1 g/m3 = 700 ppm. | | | | | | | | | | | | | |
| cManuscript translated to English using Google Translate, <https://translate.google.com/?hl=en&tab=TT>. Where possible, authors were contacted to ensure the accuracy of the details provided in the table. | | | | | | | | | | | | | |
| dThe authors did not differentiate between the larval stage of *Hylastes ater* and *Hylurgus ligniperda*. Therefore, the results for both species have been included in the table. | | | | | | | | | | | | | |
| eInformation from secondary sources (Armstrong et al. [4], Brash and Page [43] and/or MAF [44]). | | | | | | | | | | | | | |
| fConversion of units from % to ppm was based on 1% = 10,000 ppm. | | | | | | | | | | | | | |

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| **Table S2.** Summary of the treatment conditions and efficacy of phosphine (PH3) fumigations against forestry pests in chambers containing wood (i.e., in vivo) | | | | | | | | | | | | | | |
| **Type** | **Family** | **Species** | **Life stage** | **Number of replicates** | **Insect numbers/repa** | **Treatment temperature (°C)** | **Atmosphere** | **PH3 doses (ppm)** | **Fumigation time (h)** | **Fumigation volume** | **Effective dose and duration for 100% control** | **Comments** | **Reference** |
| Insect | Bostrichidae | *Dinoderus ocellaris* | Not reported | 2 | Insects in naturally infested wood | 31 ± 8 | 70 to 120 wooden pallets | 1,400b | 96 | 33 m3 shipping container | ≥ 1,400 ppm  for 96 h | No dust from boring insects was observed from fumigated wood, but 2.3 g was measured from the control. New wooden pallets were used with a moisture content of 25%. Control mortality was not reported. | Rajendran and Kumar [18] |
| 1 | 2,100b |
| *Sinoxylon* sp. | Not reported | 2 | Insects in naturally infested wood | 31 ± 8 | 70 to 120 wooden pallets | 1,400b | 96 | 33 m3 shipping container | ≥ 1,400 ppm  for 96 h | No dust from boring insects was observed from fumigated wood, but 2.3 g was measured from the control. New wooden pallets were used with a moisture content of 25%. Control mortality was not reported. | Rajendran and Kumar [18] |
| 1 | 2,100b |
| *Sinoxylon anale* | Mixed life stages (larvae, pupae and adults) | Not reported | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | Not reported (24 quickphos tablets, 56% purity) | 72 | 1.8 m3 tarpaulin covered stack | Not achieved | One month after fumigation, powder from insect boring was found underneath treated logs in one or two places. Indicating that the treatment was not completely effective. Control mortality was not reported. | Remadevi and Deepthi [2] |
| Cerambycidae | *Anoplophora nobilis* | Larvae | - | - | 15.5 and 21.1 | Atmosphere modified by infested logs | - | 96 | - | - | The concentration of phosphine dropped to below 3% of the initial concentration after 96 h. Insects were only completely controlled at temperatures of ≥ 15.5°C. | Wang et al. [19]c |
| 4.4 and 10.0 | 120 |
| Pupae | - | - | - | - | - | - | - |
| *Arhopalus ferus* | Mixed life stages | 4 | Insects in naturally infested wood | 8 to 53 | Atmosphere modified by infested logs | 350, 700, 1,050 & 1,400b | 240 | 230 L chamber | Not achieved | Mortality of the control was estimated at 20%, while the mortality of all treatments was estimated at 80%. | Baker et al. [20]d |
| Mixed life stages | 4 | Insects in naturally infested wood | 17 to 41 | Atmosphere modified by infested logs | 3,500, 3,850, 4,200 & 5,250b | 240 | 230 L chamber | ≥ 3,500 ppm  for 240 h | All insects in the controls were reported as alive, while all treated insects were reported as dead. | Baker et al. [21]d |
| Larvae | 1 | 189 | Not reported | Atmosphere modified by infested logs | 200 to 300 | 240 | 3.4 m3 chamber | ≥ 200 ppm  for 240 h | All insects in treated logs were dead. There was no untreated control. | Frontline Biosecurity [22]d |
| Larvae | 1 | 6 | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 3.4 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | No live insects were found in infested logs after fumigation. There was no untreated control. | Frontline Biosecurity [23]d |
| Adults | 1 | 101 | 15 to 28 | Sawn timber commercial stack | 300 ppm was reached after 1 h, 80 ppm remained at 17 h | 17 | 220 m3 sawn timber stack covered with a tarpaulin | Not achieved | A mortality of 97% was reported for fumigated insects. Control mortality was 19%. | Hosking [24]d |
| Adults | 1 | 40 | Not reported | Sawn timber commercial stack | 352 ppm initial conc., 52 ppm remained at 24 h | 24 | 220 m3 sawn timber stack covered with a tarpaulin | The treatment provided complete control | Control mortality was 10%. |
| Larvae | 1 | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 2 m3 chamber | 1,400 ppm initial dose for 120 h followed by a top-up dose of 1,050 ppm | The treatment did not maintain phosphine concentrations of ≥ 200 ppm for 10 days. No live insects were observed. Chambers were not vented until 18 days after treatment. There was no untreated control. | Hosking and Goss [25]d |
| Insect | Cerambycidae | *Arhopalus ferus* | Larvae | 1 | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | 2,800b | 240 | 2 m3 chamber | 2,800 ppm for 240 h | The treatment did not maintain phosphine concentrations of ≥ 200 ppm for 10 days. No live insects were observed. Chambers were not vented until 18 days after treatment. There was no untreated control. | Hosking and Goss [25]d |
| Adults | 3 | 30 | 20 to 30 | Sawn timber | Initial dose of 1,050 to 1,330b | 16 | Timber stack covered with a tarpaulin | The treatment provided complete control | Control mortality was 12%. | Hosking and Burridge [26]d |
| 24 |
| Adults | 2 | 3 to 5 | Minimum temperature of 18 to 19. Maximum temperature not reported. | Sawn timber | 1,400b | 16 | Timber stack covered with a tarpaulin | The treatment provided complete control | Very low insect numbers. | Tumambing [27]d |
| 3 | Shipping container | The treatment provided complete control |
| 1 | 24 |
| Adults | 3 | 24 to 25 | 16 to 18 | Sawn timber | 196b | 12 | Timber stack covered with a tarpaulin | Not achieved | Mortality of 79 to 96% was reported for treated insects. Control mortality was 76%. | Tumambing [28]d |
| Eggs | 3 | 83 to 191 | 15 to 20 | Atmosphere modified by infested logs | 1400b | 72 | 92 L chamber | Not achieved | The highest mortality of 94% was achieved for a dose of 2,100 ppm for 72 h. Control mortality was 56%. | Zhang et al. [29]d |
| 2100b |
| 1,400 ppm initial dose and a top-up dose of 700 ppm after 24 hb |
| Adults | 20 | 1400b | ≥ 1,400 ppm  for 72 h | Control mortality was 70%. |
| 2100b |
| 1,400 ppm initial dose and a top-up dose of 700 ppm after 24 hb |
| Eggs | 4 | 200 to 300 | 15 | Atmosphere modified by infested logs | 2,100b | 120 | 92 L chamber | All treatments provided complete control | Control mortality was 38%. | Zhang et al. [30]d |
| 2,450b | 96 |
| 2,800b | 72 |
| *Monochamus sutor* | - | - | - | - | - | - | - | - | The treatment was effective | - | Li et al. [31] |
| *Prionoplus reticularis* | Eggs | 1 | 4 (rafts) | Not reported | Atmosphere modified by infested logs | 1,400ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 3.4 m3 chamber | 1,400ppm initial dose and a top-up dose of 1,050ppm after 120 h | No live insects were found in infested logs after fumigation. There was no untreated control. | Frontline Biosecurity [23]d |
| Insect | Cerambycidae | *Prionoplus reticularis* | Eggs | 1 | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 2 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | The treatment did not maintain phosphine concentrations of ≥ 200 ppm for 10 days. No live insects were observed. Chambers were not vented until 18 days after treatment. There was no untreated control. | Hosking and Goss [25]d |
| 2,800b | 2,800 ppm for 240 h |
| Larvae | 3 | 7 to 15 | 15 to 20 | Atmosphere modified by infested logs | 1400b | 72 | 92 L chamber | ≥ 1,400 ppm  for 72 h | Control mortality was 40%. | Zhang et al. [29]d |
| 2100b |
| 1,400 ppm initial dose and a top-up dose of 700 ppm after 24 hb |
| Curculionidae | *Hylastes ater* | Larvaee | 1 | 229 | Not reported | Atmosphere modified by infested logs | 200 to 300 | 240 | 3.4 m3 chamber | ≥ 200 ppm  for 240 h | All insects in treated logs were dead. There was no untreated control. | Frontline Biosecurity [22]d |
| Pupaee | 125 |
| Adults | 4 |
| Larvaee | 1 | 188 | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 3.4 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | No live insects were found in infested logs after fumigation. There was no untreated control. | Frontline Biosecurity [23]d |
| Pupaee | 14 |
| Adults | 15 |
| Larvae | 1 | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 2 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | The treatment did not maintain phosphine concentrations of ≥ 200 ppm for 10 days. No live insects were observed. Chambers were not vented until 18 days after treatment. There was no untreated control. | Hosking and Goss [25]d |
| Pupae |
| Adults |
| Larvae | 2,800b | 2,800 ppm for 240 h |
| Pupae |
| Adults |
| Larvae | 3 | 13 to 18 | 15 to 20 | Atmosphere modified by infested logs | 1400b | 72 | 92 L chamber | Not achieved | The highest mortality of 81% was achieved for a dose of 2,100 ppm for 72 h. Control mortality was 15%. | Zhang et al. [29]d |
| 2100b |
| 1,400 ppm initial dose and a top-up dose of 700 ppm after 24 hb |
| Larvaee | 4 | 22 to 31 | 15 | Atmosphere modified by infested logs | 2,100b | 120 | 92 L chamber | All treatments provided complete control | Multiple fumigated insects were classified as moribund, between 2 and 32%. Control mortality was 23%. | Zhang et al. [30]d |
| 2,450b | 96 |
| 2,800b | 72 |
| *Hylurgus ligniperda* | Mixed life stages | 4 | Insects in naturally infested wood | 8 to 53 | Atmosphere modified by infested logs | 350, 700, 1,050 and 1,400b | 240 | 230 L chamber | Not achieved | Mortality of the control was estimated at 20%, while the mortality of all treatments was estimated at 80%. | Baker et al. [20]d |
| Mixed life stages | 4 | Insects in naturally infested wood | 17 to 41 | Atmosphere modified by infested logs | 3,500, 3,850, 4,200 and 5,250b | 240 | 230 L chamber | ≥ 3,500 ppm  for 240 h | All insects in the controls were reported as alive, while all treated insects were reported as dead. | Baker et al. [21]d |
| Insect | Curculionidae | *Hylurgus ligniperda* | Adults | - | - | - | Atmosphere modified by infested logs | - | - | 28 L chamber | Not achieved | Zero phosphine was measured in the treated space after 100 h. This resulted in low insect mortality of 55 to 75%. The load factor was 43%. | Esfandi et al. [32] |
| Larvae | - | - | - | Atmosphere modified by infested logs | 1,400, 2,800 and 4,200b | 240 and 360 | 500 L chamber | - | The load factor was very low at 5%. |
| Pupae | - | The load factor was very low at 5%. |
| Adults | Not achieved | Adults survived a dose of 4,200 ppm for 360 h. |
| Pupae | - | - | - | Bark sandwiches were used as a proxy for infested logs | 1,400, 2,800 and 4,200b | 240 and 360 | 500 L chamber | 4,200 ppm  for ≥ 240 h | - |
| Adults | Not achieved | Adults survived a dose of 4,200 ppm for 360 h. |
| Eggs | - | - | - | Atmosphere modified by infested logs | 2,450b | 240 | Shipping container (unknown size) | - | All life stages achieved mortality rates of ≥ 99%. A total of 50,151 insects were used across experiments. | Esfandi et al. [33] |
| Larvae |
| Pupae |
| Adults |
| Larvaee | 1 | 229 | Not reported | Atmosphere modified by infested logs | 200 to 300 | 240 | 3.4 m3 chamber | ≥ 200 ppm  for 240 h | All insects in treated logs were dead. There was no untreated control. | Frontline Biosecurity [22]d |
| Pupaee | 125 |
| Adults | 70 |
| Larvaee | 1 | 188 | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 3.4 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | No live insects were found in infested logs after fumigation. There was no untreated control. | Frontline Biosecurity [23]d |
| Pupaee | 1 | 14 | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 3.4 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | No live insects were found in infested logs after fumigation. There was no untreated control. | Frontline Biosecurity [23]d |
| Adults | 44 |
| Larvae | 1 | Insects in naturally infested wood | Not reported | Atmosphere modified by infested logs | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 hb | 240 | 2 m3 chamber | 1,400 ppm initial dose and a top-up dose of 1,050ppm after 120 h | The treatment did not maintain phosphine concentrations of ≥ 200 ppm for 10 days. No live insects were observed. Chambers were not vented until 18 days after treatment. There was no untreated control. | Hosking and Goss [25]d |
| Pupae |
| Adults |
| Larvae | 2,800b | 2,800 ppm for 240 h |
| Pupae |
| Adults |
| Larvae | 1 | 314 | 10 | Atmosphere modified by infested logs | 50, 100, 150, 175, 200, 225 and 250 | 240 | 28 L chamber | 100 ppm for  240 h | Although 100 ppm for 240 h provided complete control, insect survival was reported at doses of 150, 175, 200, 225 and 250 ppm. Control mortality was ~10% (based on Fig. 8). | Devitt [12] |
| Pupae | 125 | 25, 50, 150, 200 and 250 | Not achieved | The highest mortality of 72.0 ± 10.6% was achieved for a dose of 250 ppm. Control mortality was ~35% (based on Fig. 8). |
| Adults | 1,242 | 25, 50, 75, 100, 125, 150, 175, 200, 225, 250 and 300 | Not achieved | The highest mortality of 84.0 ± 1.9% was achieved for a dose of 175 ppm. However, insect survival was reported at doses of 200, 225, 250 and 300 ppm. Control mortality was ~3% (based on Fig. 8). |
| Insect | Curculionidae | *Hylurgus ligniperda* | Larvae | 1 | 900 | 10 | Atmosphere modified by infested logs | 25, 50, 75, 100, 150, 500, 700, 1,000 and 1,400 | 240 | 28 L chamber | ≥ 700 ppm for  240 h | Although 700 ppm for 240 h provided complete control, insect survival was reported at doses of 1,000 and 1,400 ppm. Control mortality was ~30% (based on Fig. 8). | Devitt [12] |
| Pupae | 1,082 | 25, 50, 75, 100, 150, 200, 500, 700, 1,000 and 1,400 | Not achieved | The highest mortality of 49.0 ± 5.9% was achieved for a dose of 1,400 ppm. Control mortality was ~5% (based on Fig. 8). |
| Adults | 2,139 | 25, 50, 75, 100, 150, 200, 350, 500, 700, 1,000 and 1,400 | Not achieved | A mortality of 43.0 ± 4.7% was achieved for the highest dose of 1,400 ppm. Control mortality was ~3% (based on Fig. 8). |
| Adults | 3 | 443 | 20 | Atmosphere modified by infested logs | 1,400b | 120 | 28 L chamber | Not achieved | Average mortality of 95% was reported. Control mortality was < 5% (based on Fig. 9). |
| Adults | 270 | 1,400ppm initial dose and a top-up dose of 1,050 ppm after 120 hb | 240 | Not achieved | Average mortality of 83% was reported. Control mortality was < 5% (based on Fig. 9). |
| Larvaee | 4 | 22 to 31 | 15 | Atmosphere modified by infested logs | 2,100b | 120 | 92 L chamber | All treatments provided complete control | Multiple fumigated insects were classified as moribund, between 2 and 32%. Control mortality was 23%. | Zhang et al. [30]d |
| 2,450b | 96 |
| 2,800b | 72 |
| Dryophthoridae | *Rhynchophorus ferrugineus* | Larvae | 8 | 78.00 ± 37.19 | 27.5 ± 2.5 | Atmosphere modified by infested palm | 1,400b | 72 | 33.2 m3 chamber | 1,400 ppm for  72 h | All insects in fumigated palms were dead after the treatment. Control mortality was 15.3 ± 10.8%. A total of 714 insects were recovered from treated palms and 1,203 insects from the control. | Llácer and Jacas [13] |
| Pupae | 28.88 ± 10.72 |
| Adults | 12.94 ± 7.25 |
| Lyctidae | *Lyctus africanus* | Larvae | 6 | 9 | 20 ± 5 | Insects located within a wooden block - *Mangifera indica* (hardwood) | 500, 1,000, 2,000, 4,000, 8,000 and 16,000f | 72 | Not reported | ≥ 2,000 ppm  for 72 h | Control mortality was zero. | Pant and Tripathi [34] |
| Insects located within a wooden block - *Pinus*  *Roxburghii* (softwood) | 500, 1,000, 2,000, 4,000, 8,000 and 16,000f | ≥ 2,000 ppm  for 72 h | Control mortality was 1.85% |
| Not reported | 2 | Insects in naturally infested wood | 31 ± 8 | 70 to 120 wooden pallets | 1,400b | 96 | 33 m3 shipping container | ≥ 1,400 ppm  for 96 h | No dust from boring insects was observed from fumigated wood, but 2.3 g was measured from the control. New wooden pallets were used with a moisture content of 25%. Control mortality was not reported. | Rajendran and Kumar [18] |
| 1 | 2,100b |
| Rhinotermitidae | *Reticulitermes speratus* | Adults | 3 | 50 | 5 | Insects within a wooden cube | Not reported | 24 | 12 L chamber | Complete control was achieved, but the initial dose required to provide control was not reported | PH3 toxicity was 7.9-fold higher at 15°C than at 5°C. Control mortality was not reported. | Choi et al. [16] |
| 15 |
| 20 |
| Insect | Rhinotermitidae | *Reticulitermes speratus* | Adults | 3 | 50 | Not reported | Atmosphere modified by infested logs with a moisture content of 10% | Not reported | 24, 48, 72, 96, 120, 144 and 168 | 12 L chamber | ≥ 120 h (dose not provided) | Control mortality was not reported. | Choi et al. [16] |
| Atmosphere modified by infested logs with a moisture content of 40% | Not reported | ≥ 120 h (dose not provided) | Control mortality was not reported. |
| Siricidae | *Sirex noctilio* | - | - | - | - | - | - | - | - | Not achieved | - | Wimalaratne et al. [35]d |
| Fungi | Bondarzewiaceae | *Heterobasidion annosum* | Mixed life stages | Not reported | 10 inoculated wood samples | 20 | Atmosphere modified by inoculated wood blocks | 300, 600, 1,000, 1,500, 2,000, 2,500 and 3,000 | 120 | 10 L chamber | Not achieved | After treatment, fungal growth was observed on fumigated wooden pieces from all phosphine concentrations. | Uzunovic and Coelho [36] |
| 25 |
| *Spiniger* sp. | Mixed life stages | 4 | Not reported | 15 | Atmosphere modified by 10 inoculated wood blocks | 100, 300, 600 and 1,000 | 120 | 10 L chamber | Not achieved | The fungus survived in 10 out of 10 test blocks under all fumigation scenarios. | Uzunovic et al. [37] |
| 20 |
| Ceratocystidaceae | *Bretziella fagacearum* | Mixed life stages | 1 | Not reported | Not reported | Atmosphere modified by inoculated logs | 38,500 and 77,700b | 72 | Not reported | Not achieved | Treatments had no effect on parenchtma viability. No evidence of sapwood penetrations was observed. | Schmidt and Christopherson [38] |
| Hymenochaetaceae | *Phellinus chrysoloma* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Ophiostomataceae | *Leptographium longiclavatum* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Mixed life stages | 4 | Not reported | 15 | Atmosphere modified by 10 inoculated wood blocks | 100, 300, 600 and 1,000 | 120 | 10 L chamber | Not achieved | The fungus survived in 10 out of 10 test blocks under all fumigation scenarios. | Uzunovic et al. [37] |
| 20 |
| Mixed life stages | Not reported | 10 inoculated wood samples | 20 | Atmosphere modified by inoculated wood blocks | 300, 600, 1,000, 1,500, 2,000, 2,500 and 3,000 | 120 | 10 L chamber | Not achieved | After treatment, fungal growth was observed on fumigated wooden pieces from all phosphine concentrations. | Uzunovic and Coelho [36] |
| 25 |
| *Leptographium terebrantis* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| *Ophiostoma clavigerum* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Fungi | Ophiostomataceae | *Ophiostoma montium* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Mixed life stages | 4 | Not reported | 15 | Atmosphere modified by 10 inoculated wood blocks | 100, 300, 600 and 1,000 | 120 | 10 L chamber | Not achieved | The fungus survived in 10 out of 10 test blocks under all fumigation scenarios. | Uzunovic et al. [37] |
| 20 |
| Mixed life stages | Not reported | 10 inoculated wood samples | 20 | Atmosphere modified by inoculated wood blocks | 300, 600, 1,000, 1,500, 2,000, 2,500 and 3,000 | 120 | 10 L chamber | Not achieved | After treatment, fungal growth was observed on fumigated wooden pieces from all phosphine concentrations. | Uzunovic and Coelho [36] |
| 25 |
| Polyporaceae | *Trichaptum abietinum* | Mixed life stages | Not reported | Not reported | 15 | Atmosphere modified by inoculated wood | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Nematode | Aphelenchoididae | *Bursaphelenchus xylophilus* | Mixed life stages | 5 holds | Average of 3.18 nematodes per gram of wood chips | 10 to 48 | Wood chips | 2,800b | 600  (holds were closed for the 25-day voyage) | Commercial vessel – all five holds with a total capacity of 48,442 m3 | Not achieved | The percentage of infested samples was reduced from 79 to 6% during the 25-day voyage from the USA to Sweden. Three out of five holds contained live nematodes. One day after application, concentrations ranged from 45 to 1,500 ppm in different locations of the holds.  After 7 days, all concentrations were ≤ 40 ppm. | Leesch et al. [40] |
| Mixed life stages | Not reported | Average of 283 nematodes per gram | 20.0 ± 0.5 | Wood chips | 1,000 | 240, 264, 288, 312, 336, 384, 432 and 480 | 10 L chamber | Not achieved | Phosphine concentrations in the treated space during the 480 h fumigation decreased by 50% to 80%. Indicating a good chamber seal. | Seabright et al. [41] |
| 1,500 | 288, 336, 384, 432 and 480 | 1,500 ppm for 480 h | The only treatment which controlled nematodes was a dose of 1,500 ppm for 480 h. All other treatments had surviving nematodes. PH3 concentrations in the treated space during the 480 h fumigation decreased by 50 to 80%. Indicating a good chamber seal. |
| Mixed life stages | Not reported | Average of 283 nematodes per gram | Wood blocks | 1,500 | 480 | Not achieved | After fumigation, 11 out of 13 samples contained live nematodes. | Seabright et al. [41] |
| Isolates of Q52A, Q1426 and Nel 5/03 | Not reported | Average of 162 nematodes per gram | 15 | Atmosphere modified by inoculated wood – wood blocks | 200 and 600 | 120 and 360 | 25.5 m3 chamber | Not achieved | Target concentrations were not achieved. For the 200 ppm dose, the maximum concentration was 60 ppm; while for the 600 ppm dose, it was 300 ppm. For the 600 ppm chamber, the temperature dropped < 0°C after four days due to heater failure. | Uzunovic et al. [39] |
| Average of 280 nematodes per gram | Atmosphere modified by inoculated wood – small log segments |
| Average of 52 nematodes per gram | Atmosphere modified by inoculated wood – large logs |
| Mixed life stages | 4 | Average of 2,020 nematodes per block | 15 | Atmosphere modified by 10 inoculated wood blocks | 100, 300, 600 and 1,000 | 120 | 10 L chamber | Not achieved | After 9 days, live nematodes were reported under all fumigation scenarios. | Uzunovic et al. [37] |
| Average of 725 nematodes per block | 20 |
| Nematode | Aphelenchoididae | *Bursaphelenchus xylophilus* | Mixed life stages | Not reported | 10 inoculated wood samples | 20 | Atmosphere modified by inoculated wood blocks | 300, 600, 1,000, 1,500, 2,000, 2,500 and 3,000 | 120 | 10 L chamber | 2,500 ppm for 120 h | Although no live nematodes were present in the 2,500 ppm dose, they were recovered from all other doses, including 3,000 ppm. | Uzunovic and Coelho [36] |
| 25 | Not achieved | All wooden blocks in the control had live nematodes (10/10), while all wooden blocks in the highest dose of 3,000 ppm also contained live nematodes. |
| aIf 60 insects per replicate are tested per organism and controlled by the treatment, then the statistical reliability is 0.95 at the 95% confidence level (i.e., LD95; Haack et al. [42]). | | | | | | | | | | | | | |
| bConversion of units from g/m3 (or mg/L) to ppm was based on 1 g/m3 = 700 ppm. | | | | | | | | | | | | | |
| cManuscript translated to English using Google Translate, <https://translate.google.com/?hl=en&tab=TT>. Where possible, authors were contacted to ensure the accuracy of the details provided in the table. | | | | | | | | | | | | | |
| dInformation from secondary sources (Armstrong et al. [4], Brash and Page [43] and/or MAF [44]). | | | | | | | | | | | | | |
| eThe authors did not differentiate between the larval and pupal stages of *Hylastes ater* and *Hylurgus ligniperda*. Therefore, the results for both species have been included in the table. | | | | | | | | | | | | | |
| fConversion of units from % to ppm was based on 1% = 10,000 ppm. | | | | | | | | | | | | | |

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