Advanced Lecture on Geospatial Information Science

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A review of Aromia *bungi*; biology, invaded history, and spatial dispersal globally and local.

**Abstract**

The monitoring of pest invasive species Aromia *bungii* a bit challenge due to the size of the insect and their capability of flying is still unknown. The recent research is developing the simulation of spreading as a preliminary guideline for eradication plan. In order to understand this invasive species, it including to study their life cycle including their native habitat including biological characteristics, invasive spread and impact, including what simulation model has been applied, host tree characteristic, and the history of their spreading from their native area. Therefore, this paper presents a systematic review considering multiple digital research database in collecting the related research or website about this invasive species: Consensus; Elicit; Epsilon; Semantic Scholar; Paper Digest; and Connected Paper. We found amount of paper almost 60 published between years ’80 until recently 2024 and a few of them were discuss in detail based on the eligible criteria from the keyword that has been set. Result shows that various research has been published after it invaded across country in 2012. More research conducted in biology and chemical perspective rather than focus on the spatial factor. However, all those finding in biology, chemical and climate variables are useful parameter that can be include in the spatial modelling.

**Keywords**: Aromia *bungii*; potential host tree; dispersal ecology; distribution.

**Key message**

* Aromia bungii is an invasive species that highly impact the economical regarding to Prunus species.
* It has been invaded Italy and Germany in Europe as well as Japan around 2012.
* Understanding the life cycle; behaviour; suitable climate condition together with chronology history of invasion leads to design the model for potential distribution, simulation, and eradication plan action.
* Much research from each country invaded that written their research using own mother tongue language, a bit challenging to find the journal which is randomly can filter English version only.

**Introduction**

The taxanomy of Aromia *bungii* is under the class insecta and its order is Coleoptera while Cerambycide is its family. Their current scientific name is Aromia *bungii* Faldermann1835. It was known as the red-necked longhorn beetle. The common name of this invasive pest can be redneck longhorn beetle, peach red-necked longhorn, plum and peach longhorn beetle, peach borer, peach musk beetle.Searches were conducted in the China National Knowledge Infrastructure and J-STAGE databases to obtain relevant Chinese and Japanese literature, respectively, whereas Google Scholar and Web of Science were used to obtain English literature. We also discuss the potential global distribution of Aromia.*bungii* through the development of a bioclimatic MaxEnt (Phillips et al. 2006) model. Reviewing these elements will provide scientists, industry, and policy makers the current state of information regarding Aromia *bungii.*

**1.0 Life cycle of Aromia *bungii***

Life cycle of Aromia *bungii* can be divided into two (i) general cycle and (ii) development stages and duration. In the development stage of eggs and larva the oviposition period for Aromia *bungii* last about three weeks. The female can laying egg in average of 587.5 eggs during the first week after emergence. In early July the eggs will hatch and the peak is at the end of July or early August. The larvae begin to destroy the host tree by mid of September. The larvae continue to spend their winter in the tree and resume their activity in the March of the following year. The pupa stage is approximately 17.3 days before becoming an adult and it emerge late June to early August . Their peak activity is mid June. Meanwhile the general cycle of Aromia bungii complete cycle is over four years but it also depend on the region. Based on the Gui (2005) Aromia bungii has one generation two years in Yixian County and Shexian County of Anhui Province. When we were checking the map location, these two province is next to each other, so that the climate condition does not differ so much. The life cycle is different based on climate condition was also supported by European Food Safety Authority (EFSA). Why this life cycle is so important? Since this species is invasive, it is important to know what is the similar climate condition between their own native pest versus non-native that makes them survive and at the same time gives the threat to the trees. Another reason also for planning and managing the eradication effectively. Many countries maybe can applied the same approach however the perfect timeline when it should be done was different.

### A diagram of a tree with a magnifying glass Description automatically generated

Figure 1 : Time span of Aromia bungii

(Source: Pest Survey Card on Aromia bungii (2019)

### A diagram of life cycle of insects Description automatically generated

Figure 2 : Life cycle of Aromia bungii reviewed from Chinese and Japanese literature

(Source : Horrock et al.(2024))

**2.0 Native habitat of Aromia bungii**

Aromia *bungii* is native to south-eastern Paleartic and Oriental regions. This region covered in south-eastern Paleartic are part of eastern Asia; area around Russian Far East, northern China, Korea and Japan. Meanwhile the Oriental region refer to the tropical and subtropical Southest Asia. The climate condition between these two region are different. Paleartic is characterized by temperate and boreal climates, while Oriental has tropical and subtropical climate. Therefore, Aromia *bungii* can be survive with two different climate conditions. Since the Aromia *bungii* was called “wood boring” its gives alarm to most of the country that has been economically affected by them such as Germany, Italy, small part of UK, Spain and Japan. This red necked longhorn beetle primary infest in genus Prunus family species such as cherries, plums, apricots and peaches. Based on European Food Safety Authority (EFSA) female tend to choose the healthy tree for oviposition and it was supported by research in Canada about the Coleoptera Cerambycide where Aromia *bungii* was categorized. The research that was carried out in Japan from Tsukuba University found Aromia *bungii* prefer the peach tree, apricot compared to cherry blossom. However there is no concrete more evidence on that due to limition of the research being carried out.

A close-up of a network

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Figure 3: Graphical node shows the connected research paper that discussed about the characteristic of tree and potential host tree Aromia bungii, including any related factors that influence the infected area including the eradication and monitoring. Each node is an academic paper related to origin paper where the papers are arranged according to their similarity work. Node size represents the number of citation and node colour is the publishing year. However, there is one paper is not available to download which is in year 1992.

Based on the connected paper above, we downloaded the papers and analyze the time publish, what type of journal publish and the simple summary about the researchs. From the Table (1) we noticed that the trend of the research much focus on biology perspective and very less exposure on spatial explicit yet even though it is very important to design the eradication plan based on the buffering distance.

Table 1 : Summary about the papers from graphical node on Figure (3) were describe below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Title | Author | Year | Type of Journal | Description |
| Biology, impact, management and potential distribution of Aromia bungii, a major threat to fruit crops around the world | K. Horrocks and Jinping Zhang and T. Haye and M. L. Seehausen and R. Maggini and Xiaoqing Xian and Juhong Chen and F. Nugnes and J. Collatz and Angela Gruber and T. Gariepy | 2024 | Journal of Pest Science | A review of Aromia bungii in biology, history of invaded across the country and potential distribution. |
| PM 7/156 (1) Aromia bungii |  | 2024 | EPPO Buletion | The buletin describe the protocol of Aromia bungii |
| Identification and potential application of a putative allomone component in the defensive secretion of a destructive invasive species: the red-necked longhorn beetle, Aromia bungii | Ruixu Chen and Cong Chen and Xudong Zhao and Li Chen and Tian Xu and D. Hao | 2023 | Journal of Pest Scienve | Introducing the chemical element as defencive strategy. |
| Field trials of pheromone blends of longhorned beetles in South Korea | Seunghyun Lee and Jocelyn G. Millar and L. M. Hanks and S. Spichiger and Kyeong Sik Kang and Bai Ming | 2023 | Journal of Asia-Pacific Entomology | Evaluate the effectiveness of pheromoen trap in South Korea. |
| Detection of invasive and native beetle species within trees by chemical | N. Fujiwara-Tsujii, H. Yasui | 2023 | Scientific Report | Analysis of hydrocarbons in frass could allow definitive detection of invasive wood-boring pests, and indicates that analysis of hydrocarbons in frass could allow definitive detection of invasive wood-boring pests. |
| Effects of neonicotinoid insecticide trunk injections on non-target arboreal ants, potential biological control agents for invasive longhorn beetle Aromia bungii on cherry trees  Cont .. | E. Sunamura, Shigeaki Tamura, Hisatomo Taki, Grzegorz Buczkowski, E. Shoda‐Kagaya | 2023 | Applied Zoology and Entamology | The preliminary short-term survey suggests the possibility that chemical control by trunk injection and biological control by arboreal ants are compatible in A. bungii management. |
| Seasonal Prevalence of the Invasive Longhorn Beetle Aromia bungii in Osaka Prefecture, Japan | Yu Yamamoto, S. Kaneko | 2022 | Insect | Determine the optimal timing for pest control. |
| Comparison of the Ecological Traits and Boring Densities of Aromia bungii (Faldermann, 1835) (Coleoptera: Cerambycidae) in Two Host Tree Species | T. Urano, Hisatomo Taki, E. Shoda‐Kagaya | 2022 | Insect | This study elucidated that peach trees are more suitable hosts than cherry trees for A. bungii larvae however risk in the long term is to P. persica, an agricultural species in the main producing areas surrounding the Kanto region. |
| Effects of dinotefuran trunk injection against the red-necked longhorn beetle Aromia bungii (Coleoptera: Cerambycidae) in Japanese flowering cherry trees | Yu Yamamoto, S. Kaneko, T. Yoshimura | 2022 | Journal of Forest Research | Introducing the chemical effect in active frass hole for treated and untreated tree. |
| Genetic Differences among Established Populations of Aromia bungii (Faldermann, 1835) (Coleoptera: Cerambycidae) in Japan: Suggestion of Multiple Introductions | Shigeaki Tamura, E. Shoda‐Kagaya | 2022 | Insects | DNA research was conducted and identify many intriduction of Aromia bungii not solely on normal dispersal spreading. |
| Establishment of an expansion-predicting model for invasive alien cerambycid beetle Aromia bungii based on a virtual ecology approach | T.Osawa | 2022 | Management Biological Invasion | Introduce the CA model simulation to predict the expansion in Saitama area. |
| Chemical Compounds Emitted from Mentha spicata Repel Aromia bungii Females | Dan‐dan Cao, Jianfeng Liu, Zhengping Zhao, Xuewu Yan, Wei-Chao Wang, Jianrong Wei | 2022 | Insect | Repellent chemical myrcene, (S)-(+)-carvone, (E)-β-caryophylle was introduce for control method. |
| サクラ並木におけるクビアカツヤカミキリ（コウチュウ目：カミキリムシ科）幼虫によるフラス排出孔数の季節変化 | Shigeaki Tamura, E. Sunamura, E. Shoda‐Kagaya | 2021 | Japanese Journal of Applied Entomology and Zoology | Study about the pest control seasonal changes in it larva injection. |
| Efficacy of Two Neonicotinoid Insecticides against Invasive Wood Borer Aromia bungii Larvae in Dietary Toxicity Test | E. Sunamura, Shigeaki Tamura, Hisatomo Taki, Hiroki Sato, E. Shoda‐Kagaya, T. Urano | 2021 | Insect | Chemical element was introduced for injection as control method. |
| Seasonal Changes in Frass Ejection by Larval Red-necked Longicorn Beetles, Aromia bungii（Coleoptera: Cerambycidae）, Infesting Cherry Trees | Shigeaki Tamura, E. Sunamura, E. Shoda‐Kagaya | 2021 | Nihon oyo dobutsu konchu gakkaishi | Assess seasonal changes in its larval frass after injection. |
| Field Trials With Blends of Pheromones of Native and Invasive Cerambycid Beetle Species | J. Millar, Y. Zou, L. Barringer, L. M. Hanks | 2021 | Environmental Entomology | Tested the pheromone of two invasive species and one of them is Aromia bungii. |
| Extension of sustained pheromone release for monitoring an emerging invader, red-necked longicorn beetle Aromia bungii (Coleoptera: Cerambycidae) | H. Yasui, N. Fujiwara-Tsujii, S. Kugimiya, N. Haruyama | 2021 | Applied Entomology and Zoology | Study the chemical retention material for pheromone to lure the species for longevity. |
| Feeding locations of the red-necked longhorn beetle Aromia bungii larvae inside trees of Rosaceae family | 優一 山本 | 2021 | Biology and Environment Science | Investigating feeding location in inner part for every stages. |
| Biological and molecular characterization of Aromia bungii (Faldermann, 1835) (Coleoptera: Cerambycidae), an emerging pest of stone fruits in Europe | E. Russo, F. Nugnes, Francesco Vicinanza, A. Garonna, U. Bernardo | 2020 | Scientific Reports | Molecular analyses of recovered specimen in Italy and compare with Germany area. |
| Predation of invasive red-necked longhorn beetle Aromia bungii (Coleoptera: Cerambycidae) eggs and hatchlings by native ants in Japan | E. Sunamura, Shigeaki Tamura, T. Urano, E. Shoda‐Kagaya | 2020 | Applied Entomology and Zoology | Japanese native ants play as biotic resistance of Aromia bungii. |
| Identification of the Red-Necked Longhorn Beetle Aromia bungii (Faldermann, 1835) (Coleoptera: Cerambycidae) with Real-Time PCR on Frass | D. Rizzo, Andrea Taddei, Daniele Da Lio, F. Nugnes, E. Barra, L. Stefani, L. Bartolini, R. Griffo, P. Spigno, L. Cozzolino, E. Rossi, A. Garonna | 2020 | Sustainability | Discuss about diagnotic protocal based on frass analysis with real time PCR that can implement in phytosanitary survey. |
| Pest survey card on Aromia bungii | E. Peña, G. Schrader, S. Vos | 2019 | EFSA | Prunus species that has grown surround port, packhouses and house risk area of detection. |
| Electroantennographic Responses of Aromia bungii (Faldermann, 1835) (Coleoptera, Cerambycidae) to a Range of Volatile Compounds | G. Germinara, Marco Pistillo, R. Griffo, A. Garonna, A. Di Palma | 2019 | Insect | This study demonstrates the capability of A. bungii males and females to detect and discriminate among a wide range of VOCs in field trapping experiments aimed at identifying behaviorally- semiochemical-based control strategies for this pest. |
| Optimizing pheromone-based lures for the invasive red-necked longhorn beetle, Aromia bungii | Y. Zou, Laura L. Hansen, Tian Xu, S. Teale, D. Hao, J. Millar | 2019 | Journal of Pest Science | Introduce the pheromoen trapping operational |
| Scanning Electron Microscopy of the Antennal Sensilla and Their Secretion Analysis in Adults of Aromia bungii (Faldermann, 1835) (Coleoptera, Cerambycidae) | Antonella Di PalmaMarco PistilloMarco PistilloRaffaele GriffoRaffaele GriffoShow all 5 authorsGiacinto Salvatore GerminaraGiacinto Salvatore Germinara | 2019 | Insect | Chemical signal play important role in mating location |
| Do visual cues associated with larger diameter trees influence host selection by Tetropium fuscum (Coleoptera: Cerambycidae)? | T. Nelson, J. Sweeney, N. Kirk Hillier | 2017 | Canadian Entomologist | High the diameter of the host tree, Coleoptera Cerambycidae (Aromia bungii class) more prefer. |

**3.0 Dispersal ecology of Aromia bungii.**

The research that was carried out by Fukuya et al.(2017) in the lab demontrated the flying capability inside the wind tunnel. The main research finding in this paper is the factor of flying location is halfly influenced by mating partner. Therefore, we can conclude that the the pheromone trap can be one of the method to study the flying pattern movement. Even though (Huang 20009; Chen et al.2023) said female can fly 10-60 m away when feel threated but there is no scientific evidence on that since it is very hard to measure. Based on Liu (1982) adult can fly 40 -70 m but it does not mentioned clearly the what are the drift factors of flying instead of pheromone. We can assume the pheromone right now is the significant method to measure their flying pattern based on the research that was carried out in Europe too. The only different is the device to capture their movement. There is pro and cons; if we are controlling the enviroment such as in laboratory, it is easy to monitor closely but the environment will be different from their nature. However, if we set them free, it required powerful device and manpower to monitor in nature environment. Maybe the financial contraint is crucial in this part because it is require the most powerful technology high resolution camera and enough power supply.

One of the report in Europe found that this species can travel up to almost 3 km in their region. The only different was the host of the tree there was plum and apricot, while in Japan they were attacked cherry blossom most of the time. Tamura and Shoda-Kaguya (2022) highlight there were multiple introduction after performing the bioloigcal research that involve the genetic. They believed the spreading of Aromia *bungii* was quiet aggressive in Japan was not soley depend on the natural disperse, maybe we need to consider about the hitch-hiking factors as well. However the most challenging part is how can we measure the hitch hiking factor? There is less research was conducted on potential region expansion threat from Aromia *bungii.* The only research we can rely on is Osawa et al. (2022) model where they used the cellular automata (CA) model to simulate the expansion and the research was conducted in Saitama region. They decided to use the CA model based on the similar behaviour of Aromia *bungii* with mirid bug. They considered the geographical parameters like river, road and tree density. So far there is no one have publish the research on the simulation yet, so their model can become the baseline to any other research on simulation.

There is a quite number of research that discussed about the potential distribution of Aromia *bungii.* We can found it in Europe and also in China. Most of the research findings were using MaxEnt model to observe the potential distribution around the world. However there were none of them discussed about the hitch hiking event as a factor transferable method of movement. Since this invasive species is consider a new threat, there is a lot of researchs can be done to fill the research gap especially on the local expansion prediction. However we still need to think on how to measure the hitch hiking event either considering road network only or incudling the real world data or transporting and exporting wood industry. So far there is no simulation research has been made except the Osawa model that consider the region level. Many researches has been published only focus on the potential distribution Aromia *bungi* by Maxent model. However there is no model has been developed yet that consider about the transferable how the Aromia *bungii* distribute to different country and even across the continental.

The host plant range of Aromia *bungii* predominantly within Rosaceae family in invaded country based on table (1) below shows the list of the complication research that discussed about the potential host of the tree for Aromia *bungii* across the world. However in their native area we can see multiple of family not only Rosaceae. So we can conclude that this species have multiple choice of species family tree in their native country but not in non-native country. However the similar common trait of this pest prefers are young, matured tree and healthy tree.

Aromia *bungii* can easily transported long distance through human-mediated pathway during trasnportation either wood industry or nursery stock. European Union insert this invasive species inside pest control database by European and Mediterranean Plant Protection Organization (EPPO) which is one of the international organization which responsible for cooperation and harmonization in plant protection with European and Mediterranean region. In order to control the outbreak of this species, they implimented the regulation of quarantine procedure to any wood packaging or industry especially for high risk of Prunus species.

Table (2) : Potential host of Aromia bungii across country from native to invaded.

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Family | Species | References |
| China | Rosacaea | *Eriobotrya japonica (loquat)* | Peng et al. (2010) |
|  |  | *Malus sp. (crabapple)* | Song et al. (2010); Gui et al. (2019) |
|  |  | *Malus domestica (apple)* | Lu (2017); Gao (2018); Song et al. (2010); |
|  |  | *Prunus armeniaca (apricot)* | Fang (2001) |
|  |  | *Prunus avium (cherry)* | Fu et al. (2007); Zhang et al. (2009); Song et al. (2010) |
|  |  | *Prunus japonica (Japanese bush cherry)* | Hong (2011); Gao (2018) |
|  |  | *Prunus mume (Chinese plum)* | Si and Hu (2002); Lu (2017) |
|  |  | *Prunus persica (peach)* | Chen and Jia (2006); Deng and Wang (2013); Jin et al. (2014) |
|  |  | *Prunus pseudocerasus (Chinese sour cherry)* | Tian et al. (2008) |
|  |  | *Prunus salicina (Japanese plum)* | Liu (1982); Wang et al. (2007); Zhao et al. (2019) |
|  |  | *Pyrus spp. (pear)* | Hong (2011) |
|  |  | *Rubus corchorifoius (raspberry)* | Bai et al. (2017) |
|  | Aquifoliaceae | *Ilex chinensis (holly)* | Song et al. (2010) |
|  | Ebenaceae | *Diospyros kaki (persimmon)* | Hong (2011) |
|  | Fabaceae | *Albizia julibrissin (Persian silk tree)* | Song et al. (2010) |
|  |  | *Robinia pseudoacacia (black locust)* | Song et al. (2010) |
|  | Fagaceae | *Castanea mollissima (Chinese chestnut)* | Tang et al. (1988) |
|  | Juglandaceae | *Juglans regia (walnut)* | Hong (2011) |
|  | Lythraceae | *Punica granatum (pomegranate)* | Wang et al. (2002) |
|  | Moraceae | *Morus alba (mulberry)* | Zhang et al. (1995) |
|  | Rutaceae | *Zanthoxylum bungeanum* | Ma et al. (2001) |
|  | Salicaceae | *Populus spp. (poplar)* | Song et al. (2010) |
|  |  | *Salix babylonica (weeping willow)* | Song et al. (2010); Lu (2017) |
|  |  | *Xylosma racemosum (oak wood)* | Bai et al. (2017) |
|  | Sapindaceae | *Koelreuteria spp. (Chinese lantern tree)* | Kang (2017); Liu and Liu (2018) |
|  | Theaceae | *Camellia sinensis (tea)* | Peng et al. (2010) |
|  | Ulmaceae | *Ulmus pumila (elm)* | Song et al. (2010); Mou et al. (2013) |
| Japan | Rosaceae | *Prunus mume (Chinese plum)* | Urano et al. (2022) |
|  |  | *Prunus persica (peach)* | Urano et al. (2022) |
|  |  | *Prunus salicina (Japanese plum)* | Urano et al. (2022) |
|  |  | *Prunus yedoensis* | Urano et al. (2022) |
| Germany | Rosaceae | *Prunus avium (cherry)* | LfL (2023) |
|  |  | *Prunus cerasifera 'Nigra' (cherry plum)* | LfL (2023) |
|  |  | *Prunus cerasus (sour cherry)* | LfL (2023) |
|  |  | *Prunus domestica (plum)* | LfL (2023) |
|  |  | *Prunus domestica subsp. domestica (prune plum)* | LfL (2023) |
|  |  | *Prunus domestica subsp. insititia (damson plum)* | LfL (2023) |
|  |  | *Prunus domestica subsp. italica (greengage)* | LfL (2023) |
|  |  | *Prunus domestica subsp. syriaca (mirabelle plum)* | LfL (2023) |
|  |  | *Prunus padus (bird cherry)* | LfL (2023) |
|  |  | *Prunus persica (peach)* | LfL (2023) |
|  |  | *Prunus serrulata (Japanese cherry)* | LfL (2023) |
| Italy | Rosaceae | *Prunus armeniaca (apricot)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus avium (cherry)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus cerasifera (cherry plum)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus cerasus (sour cherry)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus domestica (plum)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus laurocerasus (cherry laurel)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus persica (peach)* | EPPO (2012a, 2012b, 2019, 2021) |
|  |  | *Prunus serotina (black cherry)* | EPPO (2012a, 2012b, 2019, 2021) |

**4.0 History of Aromia bungii in invaded country and eradication plan.**

4.1 Italy

In Italy, the initial outbreak was in 2012 (EPPO 2012b) and it was extend untill the Compania region and Lombardy, Northern Italy (EPPO 2013a). The reason behind why it spread from South to North area was not solely on Aromia bungii capacity of dispersal or hitch-hiking event but one of the factor was the private garden infested. This case was also the problem in Japan. Once the infested area is the private land or garden, it is become a challeging not only for monitoring but also for eradication plan action. It is possible to enter this authority area with government and management intervention. In order to control many introduction from this species, what EU did was followed the EU Decision 2018/1503 (EU 2018) which a comprehensive framework that has been designed since the outbreak by establishing demarcation area. The area was determined by sum of the both infested zone either infested or display symptoms where they made a buffer zone at least 2km and increase 4km after still positive in surveys. It was obligatory to remove the infested tree or the tree that already showed the symptoms within 100m radius surrounding host plant. So during the insect active flight period, the confirmed infested plant should be cutting down to prevent the spreading. The buffer zone up to 4km was based on the conducted research in Italy where they conclude the natural dispersal up to 4km. For the monitoring part, they followed what China did by trapping using plastic traps bited with sweet and sour liquid and for the visual sign is by the presence of the frass.

4.2 Germany

While in Germany (EPPO 2012a) reported officially the first confirmed Aromia *bungii* was in Kolbermoor, Rosenheim, Bavaria, Germany. Rosenheim area has many factories and it is a bit sub urban area. Germany also followed the framework that had been introduced by EU Decision same as Italy. It was suprisingly, in Kolbermoor Rosenheim reported no longer existance of Aromia *bungii* since 2016 and the total of demarcation area was decreasing from time. According to the regulation, the delimited area just cover 100km square as 2023 (Lombardia 2019). For the visual monitoring, the efficacy of pheromone that has been newly developed in China was tested in Kolbermoor. They setted up the pheromone trap in an even grid, however in 2022 no bettles were caught. Surprisingly, in 2023 five beetles were recorded in three different locations between July and October.

4.3 Japan

Japan is one of the country that highly economical impact by Aromia bungii especially in cherry blossom. The history of invasion spread in Japan begin in Saitama Prefecture in 2011 recorded as the first incident. However the following year which is 2012, it was found in Aichi Prefecture. It rapidly spread from 2013 -2017 was confirmed cases in Saitama, Gunma, Tokyo, Osaka and Tokushima between 2013-2015. Currently, the Aromia *bungii* continue to expand their range with no successful eradication so far based on the paper by Shoda-Kagaya(2018). Japan also treated this case was seriously impact on their economical untill in January 2018 Aromia *bungii* or “kubiakatsuya kamikiri” (name in Japanese) was put under Japan Invasive Alien Species Act. Based on the regulation it is prohibiting the breeding, transport and trade the species. Fines for violation up to 3 years in prison or 3 million yen for individual and 100 million yen for corporations, and special permission requited for research institution to handle live specimens. However there is no designated action or framework based on the distance or buffering yet.

**5.0 Global distribution by MaxEnt model and local simulation by CA model.**

Global distribution of Aromia bungii was estimated by MaxEnt model and the data was collected from China National Knowledge Infrastructure (CNKI 2022) Wanfang Data (2022) Chongqing VIP (CQVIP 2022) databases from relevant article, reports and theses. The data were also combined by retrieving from EPPO global database and EPPO reporting services (EPPO 2012a, 2012b,2013a, 2013b, 2017, 2019, 2020, 2021, 2022) the CABI compedium, regional decrees available online (Regione Lombardia 2019; Servizio fitosanitario Lombardia 2019; Giunta Regionale delle Campania 2022), journal article literature review (Byun et al. 2009; Iwata 2018; Lee et al.2021; Tamura and Shoda-Kagaya 2022) Final dataset compilation shows the current distribution of occurrence in global in total 896 points as (Figure 4).

Later the data were used to develop the model potential distribution by applied MaxEnt model (Philips et.al 2006) using R package with using the bioclimatic variables:

Bio 2 – mean diurnal mean temperature,

Bio 3 – isothermality,

Bio 7 – temperature annual range,

Bio 11 – mean temperature of coldest quarter,

Bio 15 – precipitation seasonality,

Bio 7 -precipitation of driest quarter,

Bio 18 -precipitation of warmest quarter and

Bio 19 – precipitation of coldest quarter.

70 percent of the data were use and remaining 30 percent as evaluation. The evaluation statistically show excellent overall accuracy Area Under Curve (AUC) 0.994 is model train and the remaining 30 percent data test achieved AUC 0.991. The most significant variable was Bio 18 – precipitation which 50.5% contribution, and from the Osawa model used Celular Automata (CA) (Osawa et al. 2022) river gave the highest correlation on the expansion simulation. Bio 11 – mean temperature (28.5%), Bio 15 – precipitation season (11.2%) . Spatial pattern of the prediction Aromia *bungii* from this model show high probabilities occurrence in China and Korea as native range and Japan as invaded range.

A map of the world

Description automatically generated

Figure 4 : Map of potential distribution where A is global occurrence probabilities, B occurrence probabilities in Europe and C occurrence probabilities in its native range and including Japan(invaded) . Cross black depicts the original occurrence used for modelling by MaxEnt.

Source : Horrock et al.(2024)

The only research that discussed about the simulation by local is Osawa model. The study was carried out in Saitama region and the data collection was by citizen science but had been verified by Center of Environmental Science of Saitama (CESS). The model show the river density gave higher correlation compared to road and density of tree. The AUC of model river achieved 0.6 and it still considered better since there is no other research yet has been conducted about the simulation of Aromia *bungii*. High river density supported the MaxEnt model of global distribution which has the almost similar parameter in precipitation and high humidity. At this rate, we can conclude the precipitation, humidity have significant factor of distribution of spreading. Based on (Iwata 2019) climate change also influence the distribution of Aromia *bungii* because warmer temperature enable Aromia bungii to spread to unsuitable area and mild winter improve the larvae survival rate and increasing the populations in area where it was cold before that restricted for them to survive. Warmer the temperature shorten this species development period consequently, leads to frequently generations. In addition, faster metabolism in larvae due to increase temperature makes the severe damage to host trees. There is still a few of research gap in simulation that has not been discussed yet, including the extreme wind speed that might increase the capability of flying but at the same time might influence the smell of pheromone. All the environmental factors has never been imply yet for simulation.

A map of the country

Description automatically generatedFigure 5 :Simulation map of river model by applied CA model in Saitama region with 1km grid and the parameter considered is only river density which is achieve the highest accuracy AUC 0.65.

Source : Osawa (2022)

**Conclusion**

Since this species travel to any other countries in around 2012 that leads to economically impact to invaded country, it alarm everyone. Everyone here start from individual farmers, environmental society, government including policy untill the species regulation has been established to control this issue. However, to fill the research gap requires a lot of research in many aspect including its behaviour toward climate, biological, dispersal pattern, monitoring method because from all this findings it lead to enhance the existing policy to make it better. Since the climate change sign show how severe from time to time, but at the same time, the development of technology getting better and advance giving the opportunity to help in research industries. Even though, this invasive Aromia *bungii* is almost a decade invaded to any Europe continental and quite severe spread in Japan, many research were conducted in their own native language. Therefore, the translation option of AI aid can help to understand the research finding and for literature review purpose.

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