The Citrus Longhorned Beetle (*Anoplophora chinensis*): A Comprehensive Review of Biology, Impact, Management, and Data Resources

I. Executive Summary

The citrus longhorned beetle (CLB) is a large wood-boring insect that threatens citrus production worldwide by damaging trunks and branches of more than 100 tree species. In contrast to most Cerambycid beetles, CLB attacks on healthy, vigorous trees. The beetle is named for the damage it caused to citrus trees, especially in China where it is native. It is also native to eastern Asia, including Korea and Japan and has been introduced to other regions via the movement of wood packaging materials used in the shipment of goods like steel, ceramics, and stone, as well as through the trade of live woody plants such as bonsai and nursery stock.

Effective management of citrus longhorned beetle (CLB) requires a long-term, coordinated strategy grounded in integrated pest management (IPM) approach. Early detection remains critical and should be implemented through systematic surveys. While insecticides may assist in reducing the adult population, chemical control is not sufficient alone. Robust regulatory measures, including restrictions on plant imports, quarantine enforcement, and removal of infested plant material, are essential to prevent establishment and spread. Public education and strict oversight of plant movement further contribute to risk reduction. Continued research into the beetle's biology and diagnostic tools is vital for improving surveillance systems and developing long-term, sustainable management practices.

II. Introduction

The citrus sector plays a critical role in global agriculture, significantly contributing to national economies and providing employment for millions of people worldwide. For example, the value of California citrus production in the 2020-21 marketing year was $3.63 billion. The total economic impact of the industry on California's economy in 2020-21 was $7.6 billion. The California citrus industry added $1.9 billion to California's state GDP and sustained 24,247 full-time equivalent jobs.[2] This immense economic significance underscores the critical imperative to safeguard citrus crops from pervasive threats.

The citrus longhorned beetle (CLB) is a large wood-boring insect, typically ranging from 20 to 35 millimeters in length. This beetle poses a serious threat to woody plants by boring into the trunk, main branches, and root collar of host trees. After eggs are laid in bark crevices, the emerging larvae tunnel deep into the xylem tissue, disrupting the transport of water and nutrients. Over time, this internal damage leads to symptoms such as canopy thinning, dieback, and ultimately, the death of the tree.

Although the citrus longhorned beetle (CLB) poses a serious threat to North American hardwoods, current data indicate that CLB remains non-established in the United States. Isolated detections—such as the 2001 case where five adult CLB emerged from *Acer* bonsai trees imported from South Korea and held outdoors at a nursery near Tukwila, Washington—have been eradicated with no stable populations documented. The state of Washington's rapid response included destroying all 369 bonsai trees, removing over 1,000 host trees within 200 meters, treating 1,500 trees within 200 to 400 meters with systemic insecticides, and conducting annual surveys within 800 meters through 2006. The quarantine was lifted in January 2007. This five-year eradication effort cost approximately $2.2 million but successfully prevented CLB from establishing in the United States.[5]

This comprehensive report aims to provide an expert-level review of the citrus longhorned beetle (CLB), covering its life cycle, host range, ecological impacts, and management strategies, as well as summarizing essential datasets and resources for ongoing surveillance and research.

III. Biology and Identification of the Citrus Longhorned Beetle (*Anoplophora chinensis*)

The citrus longhorned beetle, scientifically designated as *Anoplophora chinensis* (Coleoptera: Cerambycidae), is widely recognized by its common name, CLB. While occasionally confused with *Anoplophora glabripennis*, the Asian longhorned beetle (ALB), the two species differ in host preference and geographic distribution. CLB poses a distinct threat due to its broader host range and ability to infest healthy trees.[5]

Life Cycle: Egg, Larvae, Pupae and Adult Stages

The life cycle of citrus longhorned beetle follows 4 morphological steps: egg, larvae, pupae and adult.[3] Citrus longhorn beetles' life cycle generally takes one year although two years is common.[5] In summer, female beetles cut slits in the bark with their mandibles and lay their eggs in them.[4] One female can lay about 200 eggs.[4] The eggs are laid singly, and are about 6 mm (0.25 in) long. The larvae emerge from the eggs between one and three weeks later.[4] They are cylindrical, about 56 mm (2.2 in) long, 10 mm (0.4 in) wide at the widest point, without obvious legs, and pale yellowish white with a dark head. When the larvae near maturity, which can be between one and four years after emergence from the eggs, they pupate for about four to six weeks before emerging from the tree as adult beetles.[4] The pupae are found under the bark, and have legs and long, coiled antennae.[4] The adults emerge from pupation from April to August, mate, lay eggs and die.[4]

Physical Description and Distinguishing Features

The citrus longhorned beetle exhibits distinct morphological characteristics across its life stages, which are crucial for accurate identification.

- **Adults:** The beetle is large, stout, and approximately 21 to 37 mm long with shiny black elytra marked with 10 to 20 white round spots.[11] Generally males are smaller than females, and have their abdomen tip entirely covered by the elytra, in contrast to the partially exposed abdomen of females.[11] Males also possess antennae that are approximately 1.7 to 2 times their body length, whereas females have approximately 1.2 times body length.[3] The head is held vertically downwards, with maxillary palpi tapering apically.[3] The pronotum is transverse, with a stout lateral spine at each side and a raised area medially in the basal half. The legs appear to have four segments excluding the claws, but with the third segment strongly bilobed and almost concealing the very small fourth segment at the base of the true fifth, claw-bearing segment.[3]
- **Eggs:** The egg is elongate, sub cylindrical and tapers at each end. It is about 6 mm long.[4] The chorion is off-white, turning yellowish-brown closer to hatching.[4]
- **Larvae:** The larva is elongate, cylindrical, up to 56 mm long and 10 mm at its broadest point across the prothorax; it lacks obvious legs.[4] It tapers gradually behind the prothorax towards the end of the abdomen, but is then slightly broadened apically.[4] It is pale yellowish-white, with the anterior part of the head pitchy-black.[4] There are some yellow, chitinized patterns on the prothorax.[4] The pronotum has a narrow orange transverse band near the anterior margin and a large, orange, raised area posteriorly.[4c]
- **Pupae:** The pupa is light yellow, 24 to 38 mm long, with legs and long, coiled antennae.[3]

The citrus longhorned beetle (CLB) and the Asian longhorned beetle (ALB) are similar in appearance and name but differ in several ways. Unlike the ALB, which is glossy black with irregular white splotches on its wings, black and gray banded antennae, and slate-blue hairs on its legs and feet, the CLB is large, stout, about 1 to 1.5 inches long, with shiny black wings marked by 10 to 12 white round dots.[10] Male CLB are generally smaller than females, with wings fully covering the abdomen tip, whereas females have partially exposed abdomens. Males also have antennae longer relative to their body size compared to females.[10] CLB has a few native lookalikes, including the banded alder borer (*Rosalia funebris*) and several species in the genus Monochamus.[10] Monochamus species have smaller white spots, small white triangles on their upper backs, and visibly rougher, bumpier, and less glossy exoskeletons.[10]

Host Plants and Feeding Behavior

Unlike many cerambycids that primarily attack dead trees, this beetle attacks apparently healthy trees and sever tissues that carry nutrients, water, and subsequently kill the host tree.[11] Attacks numerous species of hardwood trees including *Acer spp., Aesculus hippocastanum, Alnus spp., Betula spp., Carpinus spp., Citrus spp., Cornus spp., Corylus spp., Cotoneaster spp., Crataegus spp., Fagus spp., Lagerstroemia spp., Malus spp., Platanus spp., Populus spp., Prunus laurocerasus, Pyrus spp., Rosa spp., Salix spp., Ulmus spp., Casuarina spp., Cryptomeria spp., Ficus spp., Hibiscus spp., Litchi spp., Mallotus spp., Melia spp., Morus spp.*[11]

Severe damage is caused by the larval feeding galleries, which extend deep into woody tissues. These tunnels not only compromise the mechanical stability of the tree by hollowing the lower trunk but also disrupt the flow of sap and nutrients, often resulting in the host's death. Furthermore, the exit holes serve as potential entry points for wood-decaying fungi, accelerating tree decline.[1]

Geographical Distribution (Global and United States)

This citrus longhorned beetle is a wood-boring beetle native to Eastern Asia.[11] The citrus longhorned beetle has moved to Europe on several occasions. It was first discovered in Europe in 2000 at Italy and respectively, recorded in Netherlands and France (2003) and Switzerland (2006) according to FAO (2009).[11] Based on the USDA's 2009 report, CLB is present and not under official control in Afghanistan, China, Japan, Indonesia, Republic of Korea, Democratic People's Republic of Korea, Madagascar, Malaysia, Myanmar, Philippines, Taiwan, and Vietnam.[8]

In North America, except for interceptions at various ports of entry, there were no records of established populations until local infestations were detected for the first time in Tukwila, Washington on maple trees imported from Korea in 2001.[7] Since then, eradication measures were taken and quarantine regulations imposed. As of 2005 there were no reports of new infestation.[7]

Table 1: Key Characteristics of Citrus Longhorned Beetle Life Stages

Life Stage	Size (approx.)	Color/Appearance	Typical Location
Eggs	5.5 mm (0.22 inch)	White but gradually turns yellowish brown when ready to hatch[6c]	Under the bark through a T-shaped oviposition slit made at the base of the trunk or exposed roots
Larvae	5 mm (0.2 inch)	Creamy white with some yellow, chitinized patterns on the prothorax	Green, sappy portion of the inner bark
Pupae	27 to 38 mm	It has elytra that only partially covers the membranous hind wings and curves around to the ventral surface of the body	The pre-adult is inactive and takes about one to two weeks to mature and emerge out of the tunnel
Adult	21 to 37 mm (~1–1.5 inch)	Shiny black elytra marked with 10 to 12 white round spots	On leaves, petioles, and bark of twigs of preferred host plants

Adult Comparison (Asian Longhorned Beetle)	20–35 mm	Glossy black with irregular white blotches; antennae distinctly black and white banded	On trunks and branches of hardwood trees, especially *Acer* spp.; invasive and established in parts of North America

IV. Management and Control Strategies

Effective management of citrus longhorned beetle (CLB) requires a long-term, coordinated strategy grounded in integrated pest management (IPM) approach.

Integrated Pest Management (IPM) Principles for CLB

An IPM approach is essential for managing citrus longhorned beetle (CLB), which poses serious risks to both natural and cultivated hardwood species.[9] The process involves proper identification of the beetle, routine monitoring of adult emergence and larval damage, and setting clear management objectives such as containment or eradication.[5] Control efforts often integrate regulatory quarantine, physical removal of infested trees, and outreach to increase public awareness.[9] Since CLB larvae develop deep within wood, sustained monitoring and inter-agency coordination are necessary to prevent long-term establishment.[9]

Monitoring and Early Detection Methods

Public support plays a crucial role in the early detection of the citrus longhorned beetle (CLB), with all initial detections reported by the public prior to 2008.[5] One effective method for identifying CLB infestations is the observation of characteristic exit holes on host trees, which indicate adult emergence. Additionally, innovative detection techniques have been explored, such as training dogs to recognize beetle pheromones, enabling them to locate CLB at various life stages through scent detection.[1] Continuous and systematic monitoring remains essential to promptly identify new infestations, allowing timely implementation of management actions to prevent further spread.

Chemical Control Approaches

In the past, trunk or soil injections with imidacloprid, a neo nicotinoid systemic insecticide, were applied in the U.S. and Japan to each potential host tree growing within an 800 m radius from infested trees to reduce Asian longhorned beetle (ALB) population density and prevent infestation spread.[17] Given the biological similarities between ALB and CLB, similar chemical approaches may be considered for CLB management, but targeted studies are needed to confirm efficacy and environmental impact.

In Europe, chemical treatments have been rarely used due to their significant environmental and health risks, including biodiversity loss, water contamination, harm to non-target organisms, and the development of resistance.[17] The severity of these impacts depends on the specificity and toxicity of the substances applied.[17] Therefore, if eradication efforts fail, alternative management strategies such as biological control become necessary.

Physical Control Methods

Physical methods offer effective, chemical-free options for managing CLB. Wrapping trunks with fine mesh netting, sticky cardboard, or fishing nets can block oviposition and capture adult beetles. Wire netting combined with piling soil around the trunk base has also reduced egg-laying in citrus orchards.[18] These approaches provide practical alternatives within integrated pest management frameworks.[18]

Biological Control

Biological control efforts for CLB have focused on a variety of natural enemies, including entomopathogenic fungi, nematodes, predators, and parasitoids.[17] Commercially available fungal agents such as *Beauveria brongniartii* and *Metarhizium brunneum* have shown high mortality rates in infected CLB individuals, and their effectiveness can increase when combined with neonicotinoid insecticides.[17] Entomopathogenic nematodes from the genera *Steinernema* and *Heterorhabditis* have also proven effective, especially when applied into larval tunnels[17]. Among parasitoids, *Aprostocetus fukutai* stands out as the most promising agent for CLB control, demonstrating high parasitism rates, host specificity, and suitability for mass rearing.[17] These natural enemies offer a viable alternative to chemical control, particularly in integrated pest management strategies targeting long-term suppression of CLB populations.[17]

Genetic and Cultural Control Practices

In the past decade, efforts to identify tree species or clones resistant to CLB have not yielded effective results. However, planting non-host tree species is considered a practical strategy to reduce new infestations.[17]

Host Removal

All other control measures involve significant trade-offs such as high cost, environmental risks, or limited efficacy. Removing infested host trees and adjacent high-risk trees eliminates beetle breeding sites and directly reduces CLB populations. This method remains the most straightforward and effective strategy within an integrated management framework.[17]

V. Available Datasets and Resources

Comprehensive datasets are essential for understanding the biology, distribution, and management of the citrus longhorned beetle (CLB). These data support scientific research, guide regulatory decisions, and facilitate the development of effective detection and control strategies.

Image Datasets for CLB Detection

Image datasets play a key role in developing machine learning and deep learning models aimed at automating the detection and identification of citrus longhorned beetle infestations, enhancing early warning and management efforts.

As of June 2025, there is not a publicly available, standardized, and large-scale image dataset specifically dedicated to the citrus longhorned beetle (CLB). Existing visual resources are limited to individual images or small curated collections primarily used for identification and educational purposes. While these resources support visual reference and inspection activities, the absence of a unified dataset limits their use for systematic detection and large-scale monitoring applications.

In addition, *invasive.org*[19] maintains curated image collections that include high-risk wood-boring beetles not currently established in the United States, as well as species intercepted through regulatory inspections. These collections include images of Asian longhorned beetle and related cerambycids, providing reference material for early detection and visual comparison during inspection and surveillance activities.

Genetic and Genomic Datasets

Genetic and genomic resources for *Anoplophora chinensis* are essential for understanding its identification, evolutionary origin, invasion potential, and potential management strategies, especially given its status as a regulated quarantine pest.

- **Mitochondrial COI Gene Sequencing and Identification**: The mitochondrial cytochrome oxidase subunit I (mtCOI) gene sequence of *Anoplophora chinensis*, approximately 729 base pairs in length, is publicly available in the NCBI GenBank under accession number KX530204. BLAST analysis of this sequence shows 98-99% similarity with other *A. chinensis* sequences, 96-97% similarity with *Anoplophora macularia*, and 93% similarity with *A. glabripennis*. Phylogenetic relationships were inferred using the neighbor-joining method and the Kimura two-parameter model with 1000 bootstrap replicates, supporting the differentiation of A. chinensis from closely related species. Multiple sequence alignments were generated using M-Coffee. This dataset provides a reliable molecular marker for species identification and monitoring, and it serves as a valuable resource for future genomic and population studies on A. chinensis invasion patterns.[12]
- **Population-Level COI Sequence Analysis**: A large-scale population genetic study by Qin et al. (2023) analyzed COI sequences from *A. chinensis* specimens collected in China to investigate population structure and evolutionary history. The study included maximum likelihood phylogenetic analyses, revealing significant divergence within the clades and potential pathways of geographic dispersal. These findings suggest *A. chinensis* has undergone multiple introductory events and regional differentiation, which is critical for assessing biological invasiveness and designing control strategies.[13]

Table 2: Key Genetic and Genomic Datasets for Citrus Longhorned Beetle

Dataset Name	Type of Data	Key Contents / Purpose	Access Information
Anoplophora chinensis Mitochondrial COI Gene	Mitochondrial cytochrome oxidase subunit I (mtCOI) gene sequence	Approximately 729 bp partial mitochondrial cytochrome oxidase subunit I (COI) gene sequence for species identification and population monitoring	NCBI GenBank, Accession Number: KX530204[12]
Anoplophora chinensis Population Genetics Study	Population Genetic (COI gene)	Large-scale analysis of COI sequences revealing population structure, phylogenetic relationships, and introduction history across China	Qin et al., 2023 (doi: 10.33471/2023.9979)[13]

Population Monitoring Data

Beyond genetic and image data, systematic records of *Anoplophora chinensis* (CLB) populations and infestation incidences are essential for monitoring spread, evaluating risk, and guiding control measures.

- **CLB Detection Data (U.S.):**

- The U.S. Department of Agriculture (USDA) and state-level plant health agencies have documented several CLB detections in the United States, most notably in Tukwila, Washington in 2001, where an infestation was traced back to imported bonsai trees from Asia. This triggered an intensive response involving tree removals, delimitation surveys, chemical treatments, and multi-year monitoring.[5]
- Despite these responses, the United States currently lacks a centralized, long-term trapping dataset for CLB. Surveillance activities are conducted reactively, not as part of a national-scale monitoring program. Data are generally limited to state reports and USDA eradication documentation.[8]
- As of July 2025, no verified CLB populations are known to be established in the United States. All historical infestations have been declared eradicated after extensive follow-up and delimitation surveys.[14]

- **General Data Repositories and Resources:** The U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS)[8], the National Agricultural Pest Information System (NAPIS)[15], and the U.S. National Invasive Species Information Center (NISIC)[14] maintain key resources related to citrus longhorned beetle (CLB) detection, quarantine, and eradication efforts in the United States. These platforms provide regulatory updates, presence data, and surveillance summaries critical for monitoring and managing CLB infestations.

VI. Ongoing Research and Future Prospects

The ongoing threat posed by the citrus longhorned beetle (*Anoplophora chinensis*) to the U.S. citrus industry drives continuous research efforts focused on improved detection, eradication, and management strategies. Unlike well-established pests, CLB populations in U.S. have been contained through targeted eradication; however, the potential for new introductions and the complexity of effective control demand sustained scientific and regulatory attention.[8]

Novel Detection and Monitoring Approaches

Efforts to enhance early detection have centered on improving trap designs and lure efficacy. Research has identified male-produced pheromone components such as 4-(n-heptyloxy)butan-1-ol, which show promise in attracting CLB and increasing trap sensitivity[16]. Despite these advances, wide-scale pheromone-based monitoring programs remain underdeveloped in the U.S., partly due to the absence of established populations.

Sustainable Management Strategies and Regulatory Framework

The current management paradigm emphasizes early detection combined with rapid quarantine and eradication efforts. The U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) enforces import restrictions and deploys targeted surveys in high-risk areas to prevent CLB establishment.[8] Continued collaborations between federal, state, and local agencies is essential for maintaining pest-free status. Future management will likely incorporate advances in pheromone trapping, biological control agents, and public outreach to enhance surveillance efficiency and reduce reliance on chemical interventions.

Understanding Host – Pest Interactions

The citrus longhorned beetle damages over 100 different tree species, including citrus as well as various hardwoods.[11] This broad host range complicates detection and control efforts in diverse environments.

Understanding how this beetle affects host trees is critical for assessing its establishment potential and designing effective monitoring and management strategies. The larvae of CLB tunnel deeply into the xylem and phloem tissues of host trees, where they feed and develop, disrupting water and nutrient transport. Over time, this vascular damage compromises the tree's structural integrity, leading to branch dieback, canopy thinning, reduced growth, and, in severe infestations, tree mortality.[5,17]

Long Term Vision

Currently, no established populations of citrus longhorned beetle (CLB) exist in the United States. Therefore, the primary long-term goal is to prevent reintroduction and establishment. Because most introductions occur via international trade pathways, stringent regulatory controls on imports are critical. Early detection and continuous monitoring play a vital role in rapid response efforts to contain potential outbreaks. Consequently, public awareness and stakeholder education are essential components of an effective surveillance and management strategy.

VII. Conclusions

The citrus longhorned beetle (*Anoplophora chinensis*) poses a continuing risk to both agricultural and natural ecosystems due to its wide host range, capacity to infest healthy trees, and ability to remain undetected during the early stages of infestation. Although no established populations are currently reported in the United States, previous interceptions demonstrate the ongoing threat posed by global trade, particularly in live plants and wood-based materials.

Effective management of CLB requires an integrated strategy that combines early detection, regulatory enforcement, public awareness, and multi-method control approaches. While chemical treatments may assist in containment efforts, their limited impact on internal larval stages and potential environmental consequences restrict their long-term utility. Physical barriers, biological agents, and targeted host removal offer promising alternatives within an IPM framework.

Further research is needed to strengthen diagnostic tools, improve pheromone-based monitoring systems, and expand the availability of high-quality datasets for both visual and genetic identification. Understanding the beetle's population dynamics, invasion pathways, and host interactions will be essential for designing sustainable and science-based management strategies.

Maintaining a CLB-free status will depend on continued collaboration between regulatory bodies, researchers, and industry stakeholders. Preventing future introductions must remain a priority, supported by ongoing surveillance and strict controls on the movement of high-risk plant materials.

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