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Recent Detection of an Invasive Termite Species *Coptotermes formosanus*

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ABSTRACT

Field surveys for reports on suspected invasive termite species were received at the National Institute of Ecology's Invasive Species Reporting Center. We collected 10 termites and performed DNA sequence analysis for species identification. Specimens were confirmed as *Coptotermes formosanus*. This is the reconfirmation of *C. formosanus* in South Korea, highlighting the importance of early detection and rapid response and reaffirming the possibility of *C. formosanus* invading South Korea.

Keywords: Invasive species, Formosan subterranean termite, *Coptotermes formosanus*, Interception, Alien Hitchhiker

Introduction

Increased international trade and climate change have led to a continual increase in the risk of entry and settlement of invasive alien species. This is expected to increase ecological, human, and socioeconomic damage. The Ministry of Environment and the National Institute of Ecology run an Invasive Species Reporting Center for rapid detection and response. Reports are obtained through online noticeboard, telephone, cellphone, or email. In 2023, over 600 reports of suspected invasive species were received.

Coptotermes formosanus Shiraki, or the Formosan subterranean termite, is a pest causing the most severe economic damage worldwide (Rust and Su, 2012). It has been mostly detected in urbanized areas. It, is also found in forests when its population is saturated in urban areas (Evans *et al*., 2019). Therefore, it has been included as one of the 100 worst invasive alien species worldwide by the International Union for Conservation of Nature (IUCN) (Lowe *et al*., 2000). As of 2017, damage caused by this species was estimated to be around 20 billion US dollars (Cuthbert *et al*., 2022). These termites cause serious damage to living trees and wooden structures (cultural heritage and houses) in cities. They have never been eradicated after they invade a region (Evans *et al*., 2019).

A soldier of *C. formosanus* has an oval-shape head with two pairs of setae near the fontanelle, which can secrete a defensive chemical substance (Scheffrahn *et al*., 2015). Its adults are yellow-brown, measuring 12-15 mm. They exhibit a lot of hair on the surface of their wings when viewed under a microscope (Su and Scheffrahn, 2000).

Although *C. formosanus* was detected in Busan, Geoje, and Jinju of South Korea in 1998, follow-up surveys failed to detect further individuals. Thus, its invasion and habitation are currently doubtful (Lee *et al*., 2021). Nevertheless, *C. formosanus* is distributed in China, Taiwan, and Japan. It could be introduced into South Korea at any time.

Here, we present a case reported to the Invasive Species Reporting Center managed by the Ministry of Environment and the National Institute of Ecology to prevent the spread of invasive organisms through reporting and early

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response. We confirmed the possibility of *C. formosanus* invading South Korea, aiming to highlight the importance of its early detection and response.

Materials and Methods

Route of termite detection

Termites were detected in a company importing and selling medical products and products for elderly adults in Hwaseong-si (southwest of Gyeonggi-do). This company imported wooden wheelchair tables from Taiwan on March 28th, 2024. On the day the product was received, while inspecting the product, approximately 100 termites were found around wooden pallets and cardboard boxes used to transport the product. The company employees sprayed insecticide to kill termites and burned those boxes. They reported the incident to the National Institute of Ecology's Invasive Species Reporting Center, explaining the situation and providing photographs (Fig. 1A).

The National Institute of Ecology's Invasive Species Reporting Center tried to find more termites by inspecting the importing company in Hwaseong-si, Gyeonggi-do. Those cardboard boxes could not be inspected because they had been incinerated on the day termites were found. However, the products and the pallet that accompanied them were inspected. Mud tubes (or shelter tubes) were found on the wooden pallet (Fig. 1B). All pallets were inspected (Fig. 1C). Although living termites were not found due to the thorough spraying of insecticide by importers, 10 dead termites (killed by insecticide) were found on the floor of the warehouse where the products were stored. These dead termites were brought to the laboratory. These collected termites comprised 7 workers and 3 soldiers.

We explained to the company employees that we had found termites and that there could be more termites. We requested them to also incinerate the pallet. We then completed the first survey, asking the company to report any additional termites they might discover.

DNA sequence analysis

We only used two termite specimens (Fig. 2). Other termites were stored in alcohol. Injury or damage to collected termites made morphological species identification impossible. Thus, we attempted species identification by DNA sequence analysis.

Five termites were used for DNA sequence analysis and stored in 80% ethanol. For sequence analysis, we performed DNA extraction, gene amplification, and sequencing using a Macrogen system (Macrogen, Inc.,

Fig. 1. Photographs of the termite report and the wooden pallet at the time of investigation; (A) Photographs provided by the importing company employee at the time of the report; (B) Mud tubes (or shelter tubes) on the wooden pallet; (C) Inspection of all wooden pallets.

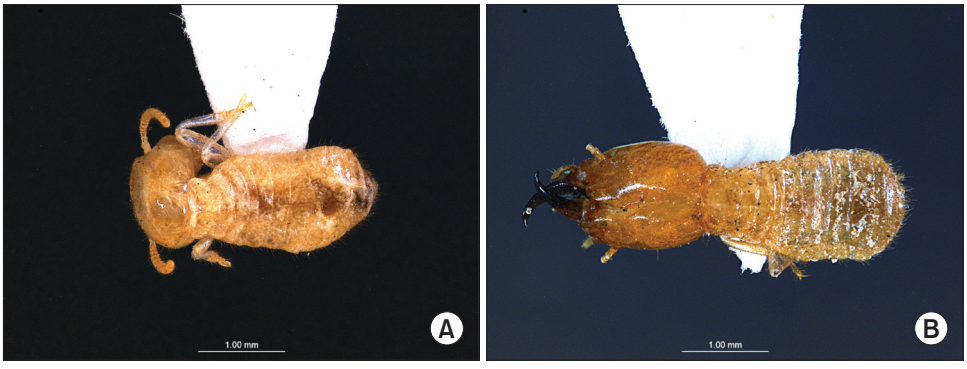

Fig. 2. Photographs of termites collected in the on-site survey: (A) Worker; (B) Soldier.

Korea, Seoul). Primers used for gene amplification were synthesized to target CO I and CO II regions (Thompson *et al.*, 2000) (Table 1). The annealing temperature was set to 45°C. To improve accuracy, gel purification was performed. After gel purification, the product was used for bidirectional sequencing.

Results and Discussion

The species was identified by DNA sequence analysis. Using BioEdit, we obtained a consistent sequence of 494 bp. Searching the sequence using the NCBI's BLAST yielded a 100% match with *C. formosanus* (Table 2). We could not obtain results for the CO I region due to difficulties in gene amplification. For more precise analysis, we constructed a phylogenetic tree using base sequences from assumed *Coptotermes* spp., including three species (*Reticulitermes speratus kyushuensis*, *R. kanmonensis, Glyptotermes nakajimai*) from South Korea and another species (*R. flavipes*) of the same genus. The phylogenetic tree was analyzed using a maximum likelihood model. *C. formosanus* was the best fit for these results (Fig. 3).

Coptotermes formosanus is a serious urban pest that causes significant damage. Thus, the site was revisited for an additional inspection. The second on-site survey was a collaboration between researchers from the Animal and Plant Quarantine Agency, the National Institute of Biological Resources, the National Institute of Forest Science, the National Research Institute of Cultural Heritage, and the National Institute of Ecology. The company's floor was covered in asphalt. The inside of the warehouse was neatly organized with shelves. Wooden pallets were not taken inside the warehouse. They were entrusted to another party for immediate disposal, implying that there was no dry wood inside the warehouse. Co-surveyors conducted a detailed investigation of the interior and exterior of the importing company without finding additional termites. It was determined that the environment was inconducive to termite habitation.

The company employees were asked to make a report if they saw any more termites at the company or if they detected any invasive species, including termites, in other imported products. We sincerely thank the company for participating in initial pest control and making a report to the Invasive Species Reporting Center. Due to their efforts, *C. formosanus* within South Korea has been removed. Since 2010, it has been detected again in South Korea (Kim and Kim, 2024), reaffirming the possibility of invasion.

Coptotermes formosanus is native to south China and Taiwan. Its range is continually expanding northwards, including Hawaii, California, Florida, Georgia, Louisiana, Texas, Mississippi, Alabama, South Carolina, and Virginia in the US. In Japan, *C. formosanus* has been found living as far as northern Tokyo (Messenger and Mullins, 2005; Rust and Su, 2012). *Coptotermes formosanus* inhabits subtropical and temperate climate zones, similar to the climate in South Korea (Rust and Su, 2012). They are mostly found in buildings where humans reside. Their common name in Japan and China means 'house termites'. Given that this species is predominantly distributed across Japan, China, and Taiwan, there is a high risk of entry into South Korea. Indeed, considering temperature and other factors, *C. formosanus* that invaded South Korea is likely to survive and form colonies in southern Korea (Lee *et al.*, 2021). In one study that used a spatial distribution model to predict the future range of *C. formosanus*, the whole Korean peninsula was included in the prediction (Buczkowski and Bertelsmeier, 2017).

Because this species feeds on dead trees and living plants, it can cause damage to forests. Since its introduction to states of Mississippi and Alabama in the US, after sufficient time, *C. formosanus* can damage surrounding forests, killing trees and ultimately changing forest ecosystems (Evans *et al.*, 2019).

Compared to other termite species, the colony size of *C. formosanus* is larger. Therefore, it causes severe damage to wood in a short time. The damage caused by these termites might go unnoticed and only become apparent

Table 1. Oligonucleotide primers used to amplify termite Cytochrome Oxidase I and II sequences

Target gene	Name	Sequence	Product size
COI	LCO1490	GGTCAACAAATCATAAAGATATTGG	650 bp
	HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	
COII	C2-J-3096	AGAGCATCACCAATCATAGAACA	660 bp
	TK-N-3807	GTTTAAGAGACCATTACTTA	

Table 2. Confirmation of genetic identity of *Coptotermes formosanus* through COII gene sequence alignment

Target gene	Species	Common name	Per. identity	Accession no.
COII	*Coptotermes formosanus*	Formosan subterranean termite	100%	KU257993

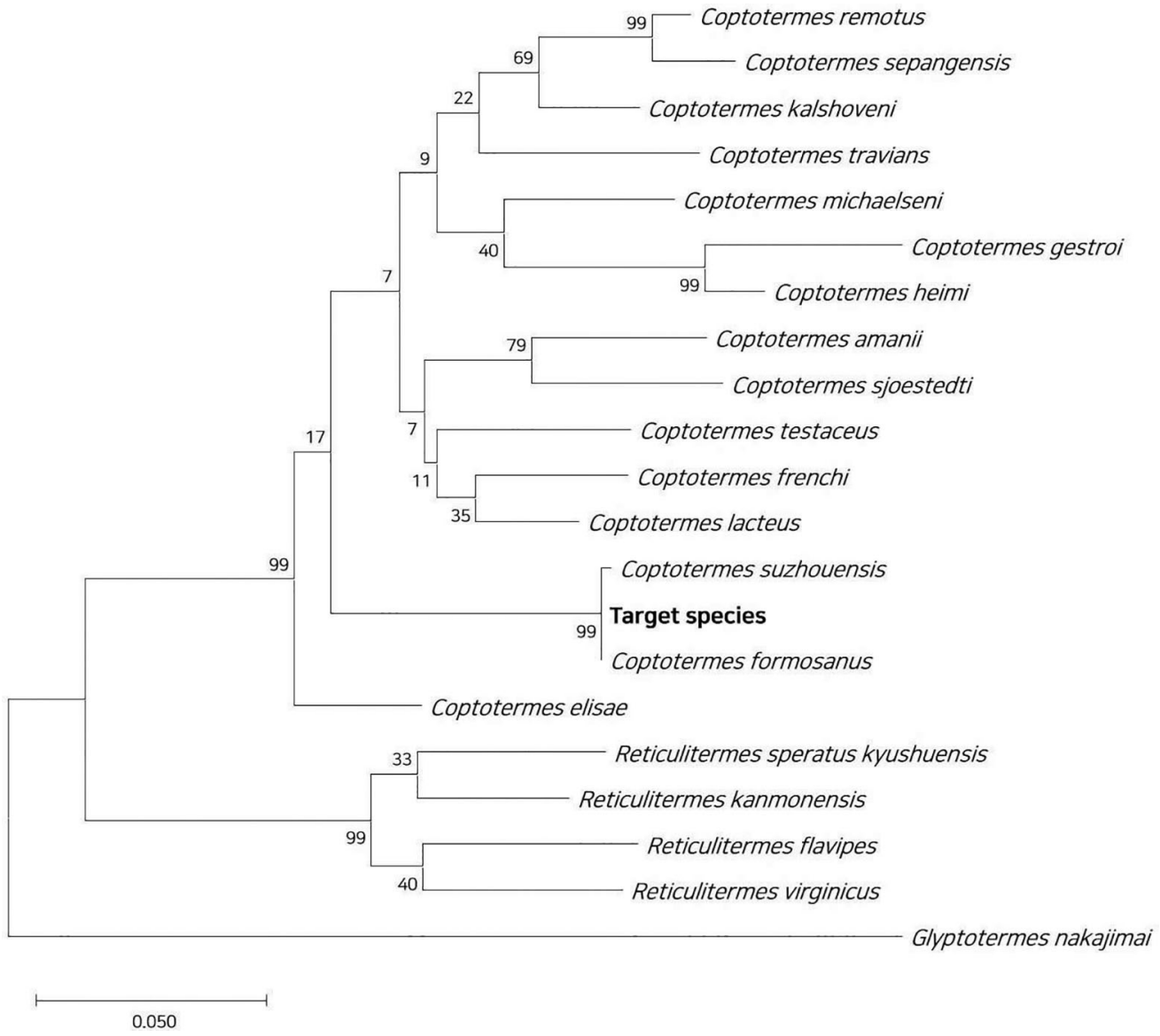

Fig. 3. Phylogenetic tree based on the maximum likelihood method with bootstrap test (4,000 replications).

several years later after causing irreparable damage to the stability of wooden structures (Su and Scheffrahn, 2000). In New Orleans in the US, damage by *C. formosanus* has been found in most of the trees in Armstrong Park. During the nuptial flight season, residents and tourists complained of discomfort due to massive numbers of termites flying toward lights (Osbrink *et al.*, 1999; Messenger and Mullins, 2005).

In the United States, *C. formosanus* was discovered in Hawaii (~1870). Later it invaded the U.S. mainland through supplies used in the Second World War (Blumenfeld *et al.*, 2021). *Coptotermes formosanus* is often found on ships in Florida. It has entered other regions via these ships (Su *et al.*, 2017). This species continued spreading from region to region through timber used in railway construction, discarding furniture, and other routes (Sun *et al.*, 2007; Scheffrahn and Crowe, 2011). If *C. formosanus* were to invade South Korea, it is predicted to cause damage to living trees, including roadside trees, horticultural trees, and fruit-producing trees, significantly damaging wooden cultural heritage and wooden housing.

In this case report, we reconfirmed the invasion of *C. formosanus* in South Korea, highlighting the importance of its early detection and rapid response. This reaffirms that *C. formosanus* could invade South Korea at any time. This case also demonstrates the importance of efforts, both at the national level and at the level of citizens, to prevent invasion by threatening alien species.

Author Contributions

JA: Project manager, project design, manuscript draft and editing; JS: Assistant for project, sample management, data analysis; BJ: Manuscript draft and editing, data analysis; MK: Manuscript draft and editing, data analysis; MC: Manuscript draft and editing, data analysis; SJE: Project design, data analysis (DNA barcoding), manuscript draft and editing.

Conflicts of Interest

The authors have no competing interests relevant to this study to disclose.

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