Asia Pacific Cultural Heritage Conservation Training Program 2007 – Conservation and Restoration of Wooden Buildings

Insect Damage in Wooden Buildings (Ecology, Damage, and Control)

KOMINE Yukio, *Researcher*
Japan Institute of Insect Damage to Cultural Properties

1. The current reality of cultural properties in Japan

- Many of the cultural properties in Japan (e.g. buildings, Buddhist statues, articles of folk craft, and folding screens) are primarily made of wood.
- The climate in Japan is mild and humid, allowing insects to remain active for much of the year. Therefore, there is a constant threat of insect damage.
- Damage is tremendous, as there are many kinds of harmful insects and large populations of these insects.

2. Measures to control insect damage to cultural properties

- Conventionally, cultural properties were subjected to regular fumigation with methyl bromide regardless of whether they had insect damage or not.
- Following the 1992 Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, methyl bromide were phased out of Japan by the end of 2004.
- There is now a need to shift from extermination to control, with emphasis on prevention.

3. Insect control measures for cultural properties

- “Control” includes “prevention” and “extermination,” out of which “prevention” may include suppressing insect breeding or preventing insect pests from gaining entry and causing damage, while “extermination” involves the killing of insect pests which have already been spawned.
- An effective program of insect control requires, in addition to everyday conservation management, regular insect damage inspections for early detection and identification of damage.
- When harmful insects or damage is detected, it is critical to identify the insect through the

inspection of harvested carcasses, exuvia, excrement, and/or the state of damage, and to take insect control measures which are based on the physiology and ecology of that insect.

4. The difference between insects and other creatures

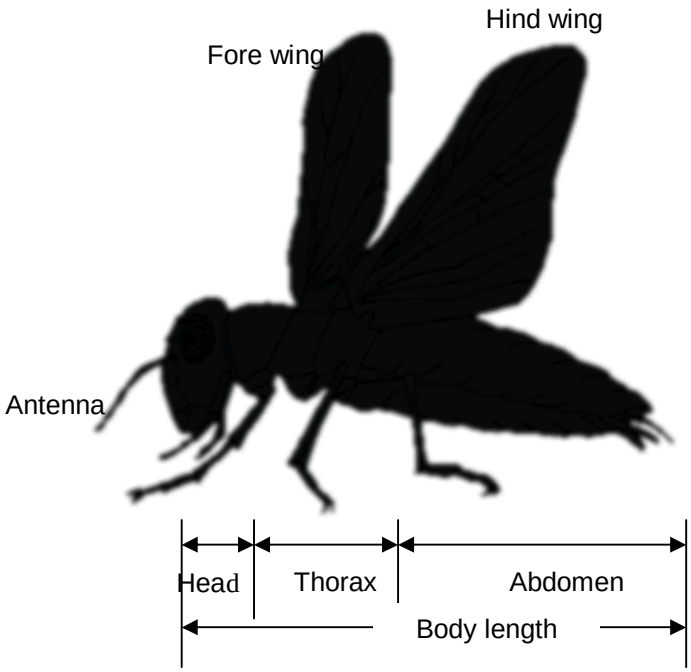

Fig. 1: General insect morphology

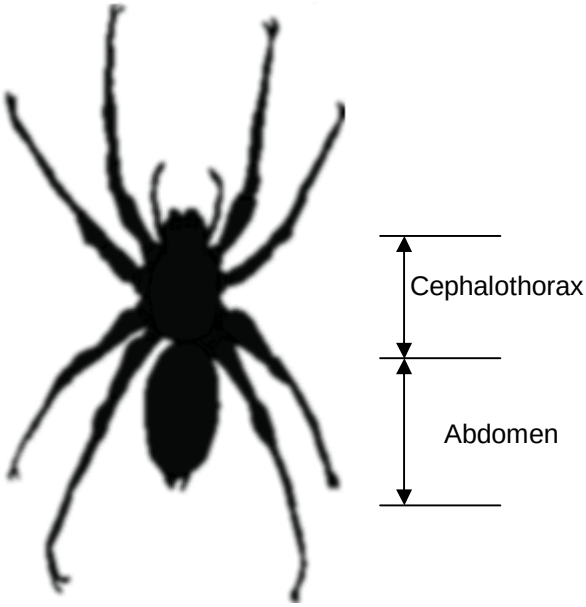

Fig. 2: General spider morphology

5. Primary insect pests of wood buildings, and their characteristics

◎ Primary insect pests

Termites, deathwatch beetles, powder post beetles, longhorned beetles, weevils, horned powder post beetles, metallic wood borers, bees, and ants

(1) Termites

There are more than 22 kinds of termites living in Japan today. Out of these, the Japanese subterranean termite (*Reticulitermes speratus*) and the Formosan subterranean termite (*Coptotermes formosanus*) inflict damage on cultural properties.

In Okinawa, there is a certain amount of damage by drywood termites (*Cryptotermes domesticus*). The western drywood termite (*Incisitermes minor*), a recent arrival in Japan, is increasingly inflicting damage on houses in general, although there has been no incidence of damage to cultural properties.

*Four species of termites in Japan

Japanese subterranean termite: Japan, China, Korean Peninsula.

Formosan subterranean termite: Japan, Taiwan, China, USA, Brazil, Pakistan, South Africa, etc.

Drywood termite: Japan (south of Amami and Ogasawara Islands), USA, whole of Asia

Western drywood termite: Japan (localized), USA, Mexico, etc.

Comparison of main termites in Japan

Table: Comparison of main termites in Japan

		Japanese subterranean termite	Formosan subterranean termite	Drywood termite	Western drywood termite
		Subterranean termites		Drywood termites	
Damage to cultural properties		Most numerous incidences of damage	Tremendous damage	A certain amount of damage in Okinawa	None (high likelihood of invasion)
Alate	Swarming	April – May, daytime	June – July, evening - night	March – November, evening - night	June – September, daytime
	Phototaxis	None	Attracted to electric lights	Attracted to electric lights	None
Nest		The damaged area doubles as a nest. No special structure (termitary) is constructed.	These insects build special, massive structures as nests. They also build sub nests.	There is no particular nest. The insects merely bore holes in the wood and live in a group.	
Colony		Maximum 20,000 – 30,000 insects	From 500,000 or 600,000 to more than 1 million insects	Maximum several thousand insects	
Shelter tubes		This insect builds tubes	This insect builds tubes	These insects do not build tubes	
Damaging behavior		Preferring damp, rotting wood, this termite feeds mostly on the substructure of buildings. The speed of damage is slow and slight compared to the Formosan subterranean termite.	Preferring both damp and dry wood, this insect feeds on the entire building. The speed of damage is fast and severe. This insect prefers newer wood over old wood.	These insects only feed on dry wood. They expel sawdust-like droppings from the holes they make in the wood.	

(2) Deathwatch beetles

The damage inflicted by the deathwatch beetle does not progress as rapidly as termite damage. Deathwatch beetles do their work unobtrusively and away from the spotlight. A representative beetle of this genre is the pubescent anobiid.

The pubescent anobiid (*Nicobium hirtum*) particularly prefers old wood, and feeds on indiscriminately both conifers and broadleaf wood. The adult insect is approximately 3 – 6 millimeters in length, with a dense growth of short hairs on its back. The wood damage is inflicted mostly by the larvae. When there is a round hole, about 3 millimeters in diameter, on the surface of old wood in a wooden building, the pest is usually this insect. The pubescent anobiid ranges throughout Japan and the world.

(3) Powderpost beetles

This insect causes damage to wood such as lauan and *nara* (Japanese oak), and to bamboo. In wood, it feeds mainly on the sapwood portion of broadleaf lumber, with its high starch content. A representative of this group is the *Lyctus brunneus Stephens*.

Lyctus brunneus Stephens, formerly notorious as a bamboo pest in Japan, is now known as a lauan pest, since southern timber has been imported in massive amounts. The adult insect varies in length from about 2 to 7 millimeters depending on its nutritional status during the larval stage. Damage is mostly inflicted by the larvae, which prefer broadleaf timber with rich starch content. The insect is found throughout Japan and the world.

(4) Longhorn beetles

Longhorn beetles cause damage mostly to raw logs and dry timber. Not much has been reported in Japan by way of damage by this insect. A representative of this category is the *Konoa granulata.*

The *Konoa granulata* is endemic to Japan. It is a large insect, with adults between 15 and 23 millimeters in length. The adult insects gather around flowers. The larvae dwell in dead broadleaf timber.

(5) Weevils, bamboo borers, and metallic woodboring beetles

Weevils and metallic woodboring beetles burrow deep within the interior of dry timber. Bamboo borers are indiscriminate, feeding on both wood and bamboo.

The Japanese giant weevil (*Sipalinus gigas*) grows to 12 – 30 millimeters as an adult and is the largest weevil in Japan. The larvae burrow particularly deeply into pine, cedar, cypress, oak, and beech. It is therefore known as the “giant pest of timber.” The insect ranges throughout Japan and from the Korean Peninsula to Southeast Asia.

The bamboo borers *Dinoderus minutus* and *Dinoderus japonicus* are both 2 to 4 millimeters in length. Although they are notorious for being bamboo pests, they will feed on most anything made of wood.

Larvae of the *Buprestis haemorrhoidalis*, a variety of metallic woodboring beetle, cause damage to dead pine and fir wood.

(6) Bees and ants

Japanese carpenter bees drill nest holes, about 10 millimeters in diameter, under the eaves of wooden buildings, where they raise their young. Digger wasps build nests of mud under the eaves of buildings, soiling the building.

Ants use old wood to build their nests, causing the wood to deteriorate.

6. Pest control measures

Wood damaging insects avoid brightly lit areas, carrying out their activities where they do not attract much attention. Therefore, in many cases the damage is already quite extensive by the time it is noticed. It follows, then, that the way to protect wooden buildings from insect damage is to pay attention at all times, detect insect damage promptly, and stop any further damage. It is also important to take preventative measures before damage is inflicted.

(1) Prevention

- Visual inspection
- Trap survey
- Collection survey using a vacuum cleaner for insect collection
- Prevention with chemicals

With wooden buildings, it is preferable to take the initiative in having a technician who has knowledge and experience with insect damage conduct a visual inspection.

Visual inspection

- Inspection with the naked eye. Place emphasis on places where insect damage is likely to occur.
- Inspect for live insects, carcasses, exuvia, frass (insect excrement and wood dust), and/or characteristic patterns of damage.
- Check to see whether light pressure on the wood will make it cave in or break. Tap with a hammer to check for a hollow sound.
- Conduct a survey of the neighbors' experiences.

◎ How to detect termites

Early detection is of paramount importance in protecting cultural properties from termites. Using the following clues, even a lay person can determine whether a building is infested with termites.

1) Shelter tubes

Japanese and Formosan subterranean termites usually invade a structure through shelter tubes spanning the ground and the building. The crawl space under a building, and the surrounding areas, should be inspected periodically for any shelter tubes on the surface of the foundation,

stone struts, or footplate.

2) Termite mud

Termites dislike the wind and light. To maintain an appropriate level of humidity, these insects may plug cracks or joints in the wood, or build mounds, with termite mud, made of their droppings, sand, dirt, and chewed-up timber, mixed together with their own saliva.

3) Traces of damage

Telltale signs include the characteristic concentric patterns on the cut end of timber, indicating where the insect has eaten the wood. More extensive termite damage can result in a hollow sound when the wood surface is tapped, or caving in or breaking when strong pressure is applied to the wood.

4) Abnormal changes in the building

Buildings with extensive termite damage may have sunken pillars or undulating roof ridge and/or eaves. In many cases, the sliding doors or shutters will cease to open and shut smoothly, or the tatami or floor will give a vague impression of sinking.

5) Swarming

During the warmer months, winged termites will swarm from damaged wood seeking a new home. Generally, the Japanese subterranean termite swarms in the daytime during April and May, the Formosa subterranean termite in the nighttime during June and July, the drywood termite at night between June and September, and the western drywood termite in the daytime from March to November.

6) Droppings of drywood termites

Drywood termites and western drywood termites feed only on drywood. They expel dry, sawdust-like droppings outside the damaged wood.

Prevention with chemicals

—Wood treatment—

Chemical treatment of the timber used in the building

Spraying or applying a chemical agent that does not cause chemical damage to the cultural property (building) and has residual activity.

—Soil treatment—

Treating the soil with chemicals to prevent pests from gaining entry from the soil.

(2) Extermination

- With chemicals (fumigation)
- Without chemicals

Extermination with chemicals (fumigation)

―Conditions for fumigation―

1) As much as possible, avoid chemical damage to the article to be fumigated
2) Minimal amount of chemical adsorbed on the article to be fumigated
3) Good diffusion and good penetration
4) Minimal flammability or explosiveness
5) Insecticidal and bactericidal properties
6) Impact on human health and the environment as low as possible

Primary ingredient of fumigants

- Methyl bromide (phased out by the end of 2004 in Japan)
- Sulfuryl fluoride (insecticide)
- Propylene oxide (insecticide and bactericide)
- Ethylene oxide (insecticide and bactericide)
- Methyl iodide (insecticide and bactericide)

Extermination without chemicals

Low oxygen concentration (Oxygen concentration less than 0.3% by volume, 10 weeks)

Carbon dioxide (60 – 80% by volume, 3 weeks)

Low temperature (minus 20 – minus 40ºC, 3 – 7 days)

High temperature (55 – 60ºC, 1 day)

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