Insect Damage to Wooden Architecture (insect ecology, damage, and control)

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1. Current state of cultural properties in Japan

- Many of Japanese cultural properties (buildings, Buddhist statues, folk furnishings, folding screens, etc.) are made of wood
- The Japanese climate is mild with high humidity, with an insect population that is active for much of the year, constantly exposing cultural properties to insect damage
- Harmful insects are numerous both in terms of species and population, resulting in tremendous damage

2. Pest control measures for Japanese cultural properties

- Fumigation with methyl bromide was carried out regularly, without regard to the presence or absence of insect damage
- Following the 1992 Montreal Protocol on Substances that Deplete the Ozone Layer, methyl bromide fumigation was to be phased out completely by 2004
- The need arose or a change in the focus in pest control from extermination to prevention

3. Pest control for cultural properties

- Pest control comprises “prevention” and “extermination.” Out of these, prevention includes inhibiting the proliferation of harmful insects and preventing their entrance and/or damage in advance, while extermination means to kill off insects which have already proliferated
- In order to perform effective pest control, there is a need for everyday storage control and regular inspections for early detection and identification of insect damage
- When harmful insects or insect damage is detected, the insect is identified from collected specimens, exuvia, excrement, or state of damage. It is critical that pest control measures be based on the physiology and ecology of the target insect.

4. Difference between insects and other organisms

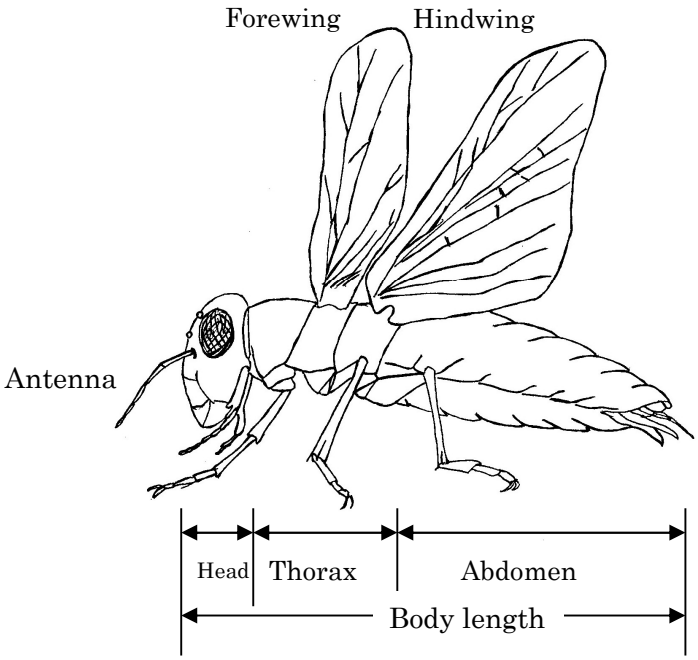

Fig. 1 Typical insect morphology (adult)

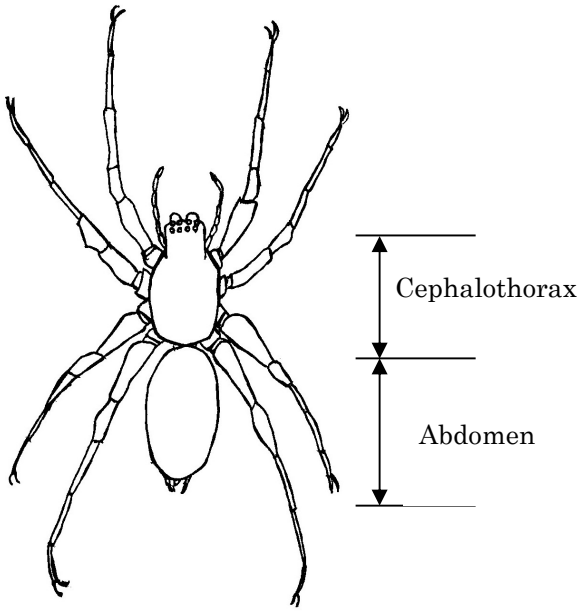

Fig. 2 Typical spider morphology

5. Major insect pests for wooden architecture, and their characteristics

◎Major insect pests

Termites, Drugstore beetle, Powderpost beetle, Long-horned beetle

Snout beetle; auger beetle; metallic wood borer, bees, ants

(1) Termites

There are presently 22 species of termites inhabiting Japan. Out of these, *Yamato-shiroari* (*Reticulitermes speratus*) and *ie-shiroari* (*Coptotermes formosanus*) inflict damage on cultural properties. In Okinawa, there is some damage caused by *daikoku-shiroari* (*Kalotermes kotoensis*). In recent years, the western drywood termite (*Incisitermes minor*) has made entry into Japan and damage is spreading, although there have been no cases of damage to cultural properties to date.

* Four species of termites inhabiting Japan

1) *Yamato-shiroari* (*Reticulitermes speratus*): Japan, China, Korean peninsula

2) *Ie-shiroari* (*Coptotermes formosanus*): Japan, Taiwan, China, USA, Brazil, Pakistan, South Africa, etc.

3) *Daikoku-shiroari* (*Kalotermes kotoensis*): Japan (Amami Islands and southward; Ogasawara Islands), USA, across Asia

4) Western drywood termite (*Incisitermes minor*): Japan (localized), USA, Mexico, etc.

Comparison of major termite species in Japan

Table: Comparison of major termite species in Japan

		Yamato-shiroari (*Reticulitermes speratus*)	*Ie-shiroari* (*Coptotermes formosanus*)	*Daikoku-shiroari* (*Kalotermes kotoensis*)	Western drywood termite (*Incisitermes minor*)
		Subterranean termite		Drywood termite	
Damage to cultural properties		Most numerous cases	Heavy damage	Slightly in Okinawa	None (high likelihood of infiltration)
Alate	Swarming	April – May Daytime	June – July Evening – night	March – November Evening – night	June – September Daytime
	Phototaxis	None	Attracted to lights	Attracted to lights	None
Nest		Damaged location serves as a nest. No specially processed nest is made	A specially processed carton nest is made. Ancillary nests are also made	No special nest is made. The insects merely bore holes in the wood and live in a group	
Colony		20,000 – 30,000 insects maximum	500,000 – 600,000 insects More than 1 million insects	Several thousand insects maximum	
Termite trail		Yes	Yes	No	
Damaging behavior		Prefer moist, rotted wood and primarily infest the lower components of buildings. Infestation speed is slow and damage is slight compared to *Ie-shiroari* (*Coptotermes formosanus*)	Also infest dry wood, with damage extending to the entire building. Infestation speed is high, with intense damage. Prefer new wood to old wood.	Only infest dry wood. Sandy fecal matter is excreted from damaged wood.	

(2) Drugstore beetle

Infestation by drugstore beetles is not as fast as termites. This insect causes damage to wood quietly and inconspicuously.

Nicobium hirtum (known in Japan as the "*kebuka shibanmushi* (hairy drugstore beetle)") particularly prefers old wood, and infests conifer and broadleaf alike. Adults are about 3 – 6 mm in body length with dense, short hair on their back. Most of the damage is caused by the larvae. Round holes of 3 mm or so in diameter, bored into the surface of old components in wooden buildings, are usually indications of infestation by this species. Distribution is throughout Japan and much of the world.

In addition to *Nicobium hirtum*, *Pseudomesothes pulverulentus* (known in Japan as "*kuronokohige shibanmushi* (black saw-horned drugstore beetle)") has long been known to be a wood-damaging pest. In recent surveys, infestation by *Priobium cylindricum* ("*ohnaga shibanmushi* (large long drugstore beetle)"), *Trichodesma japonicum* ("*kurotosaka shibanmushi* (black combed drugstore beetle)"), *Hadrobregmus pertinax* ("*ezomatsu shibanmushi* (Japanese spruce drugstore beetle)"), and *Sculptotheca hilleri* (*chibikinoko shibanmushi* (pygmy mushroom drugstore beetle)" have been identified.

(3) Powderpost beetles

This insect infests wood such as lauan and Japanese oak as well as bamboo. Primary damage is to the sapwood portion of broadleaf wood with a high starch content. The powderpost beetle is a representative example.

The powderpost beetle (*Lyctus brunneus*) was known in Japan as a "pest of bamboo," but with the massive imports of foreign timber from southern countries, the insect is now a "pest of rauan." The adult is about 2 – 7 mm in body length, which differs according to its nutritional status at the larval stage. Most of damage is caused by the larva, mainly to broadleaf materials with high starch content. Distribution is throughout Japan and much of the world.

(4) Longhorn beetles

Longhorn beetles bore holes in raw logs and dry wood. There are few reported cases of longhorn beetle damage in Japan. A representative example is the *Konoa granulata.*

Konoa granulata ("ohhana kamikiri (large flower longhorn beetle)") is native to Japan. The adult is large, with a body length of 15 – 23 mm. Adult insects converge on flowers, but the larvae live in dead broadleaf materials.

(5) Snout beetles; auger beetles; metallic wood borers

Snout beetles and metallic wood borers infiltrate deep within dry wooden materials. Auger beetles are omnivores, feeding on wood and bamboo.

The adult of *Sipalinus gigas* ("oh-zomushi (large snout beetle)") is 12 – 30 mm long, the largest snout beetle in Japan. Because the larvae infiltrate particularly deeply in pine, cedar, cypress, oak, and beech, the species is known as a major wood-damaging pest. Distribution is across Japan, the Korean peninsula, and Southeast Asia.

Dinoderus minutus ("*chibi take nagashinkui* (pygmy bamboo auger beetle)") and *Dinoderus japonicus* ("*nihon take nagashinkui* (Japanese bamboo auger beetle)") are both 2 – 4 mm long and notorious as bamboo destroyers. These insects also damage many wooden products.

Buprestis haemorrhoidalis ("*kuro tamamushi* (black metallic wood borer)") larvae cause damage to dead pines and firs.

(6) Bees and wasps; ants

Japanese carpenter bees (*Xylocopa appendiculata circumvolans*) bore holes about 10 mm in diameter under the eaves of wooden buildings to raise their young. Thread-waisted wasps contaminate buildings by making mud nests under the eaves of buildings. Ants cause deterioration to wood materials as they use old wood for their nests.

6. Pest control measures

As wood-damaging insects avoid bright areas and carry out their activities in inconspicuous places, they have usually caused significant damage by the time they are discovered. Therefore, in order to protect wooden buildings from insect damage, the key is to practice constant vigilance to detect and stop the damage and infestation as early as possible. It is also important to implement appropriate preventative measures before damage occurs.

6.1 Prevention

- Visual inspection
- Trapping
- Vacuum cleaner to collect specimens and droppings
- Prevention using chemical agents

In wooden buildings, it is preferable to exercise initiative by having visual inspections performed by a pest control expert with knowledge and experience on insect damage.

Visual inspection

- Naked eye inspection focusing on areas prone to insect infestation
- Live insects, carcasses, exuvia, frass (feces and chewed wood), chewing marks
- Press wood gently and check for denting or breakage. Tap lightly with a hammer to check for a hollow sound
- Interview neighbors

◎ **How to detect termites**

Early detection is crucial for protecting cultural properties from termites. The following clues make it easy for the lay person to check for termite infestation.

(1) Termite trail

Yamato-shiroari (*Reticulitermes speratus*) and *ie-shiroari* (*Coptotermes formosanus*) usually infiltrate buildings via underground termite trails. Conduct periodical checks under the floors and around the building to see whether termite trails can be found on the foundation, stone struts, and footplates.

(2) Frass

Termites dislike wind and light. In order to maintain the right amount of moisture, they create frass, or wood-colored mounds, made of a kneaded mixture of fecal matter, sand, chewed wood, and saliva, to plug cracks or joints in the wood or to block the entrance to tunnels.

(3) Evidence of chewing

In addition to the distinct pattern of concentric circles of wood cross sections, advanced termite infestation can be detected by a hollow sound upon tapping, or by denting or breakage when pressure is applied.

(4) Deformation of the building

Advanced termite damage may result in subsistence of pillars or buckling of ridges or eaves. Sliding partition doors and shutters may become difficult to open and close, and there is often a slight give in tatami mats and floor panels.

(5) Alates

In the warm season, winged termites (alates) swarm from damaged wood. In general, swarming occurs in the daytime in April and May for *Reticulitermes speratus*, nighttime in June and July for *Coptotermes formosanus*, nighttime in June to September for *Kalotermes kotoensis*, and daytime March to November for the western drywood termite.

(6) Fecal matter of drywood termites

Kalotermes kotoensis and the western drywood termite feed only on dry wood and push dry, sandy fecal matter outside the wood they are damaging.

<u>Prevention with chemical agents</u>

(1) Treating wood components

- Chemical treatment of wooden building materials
- Spraying or applying chemicals with residual effectiveness and which do not cause chemical damage to the cultural property (building)

(2) Treating the soil

- Chemical treatment of the soil to prevent harmful insects from gaining access from the soil.

6.2 Extermination

- Low oxygen treatment (oxygen concentration less than 0.3% by volume, 10 weeks)
- Carbon dioxide treatment (60 – 80% by volume, 3 weeks)
- Low temperature treatment (-20°C – -40°C, 3 – 7 days)
- High temperature treatment (55°C – 60°C, 1 day)

Fumigation

Requirements for fumigating agents

1. Must be as harmless as possible to the object being fumigated
2. Must be minimally adsorbed by the object being fumigated
3. Must diffuse and penetrate well
4. Must be minimally flammable or explosive
5. Must be insecticidal and/or germicidal
6. Must be as harmless as possible to human health and the environment

Main ingredients of fumigating agents

- Methyl bromide (phased out completely by the end of 2004 in Japan)
- * Sulfuryl fluoride (insecticide)
- * Propylene oxide (insecticide, germicide)
- * Ethylene oxide (insecticide, germicide)

Asterisks (*) indicate “certified chemicals,” chemicals certified by the Japan Institute of Insect Damage to Cultural Properties as causing relatively little harm to the materials used in cultural properties.