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FOREST Pest LEAFLET

Pacific Forestry Centre

Some important woodborers related to export restrictions

J. Vallentgoed

Introduction

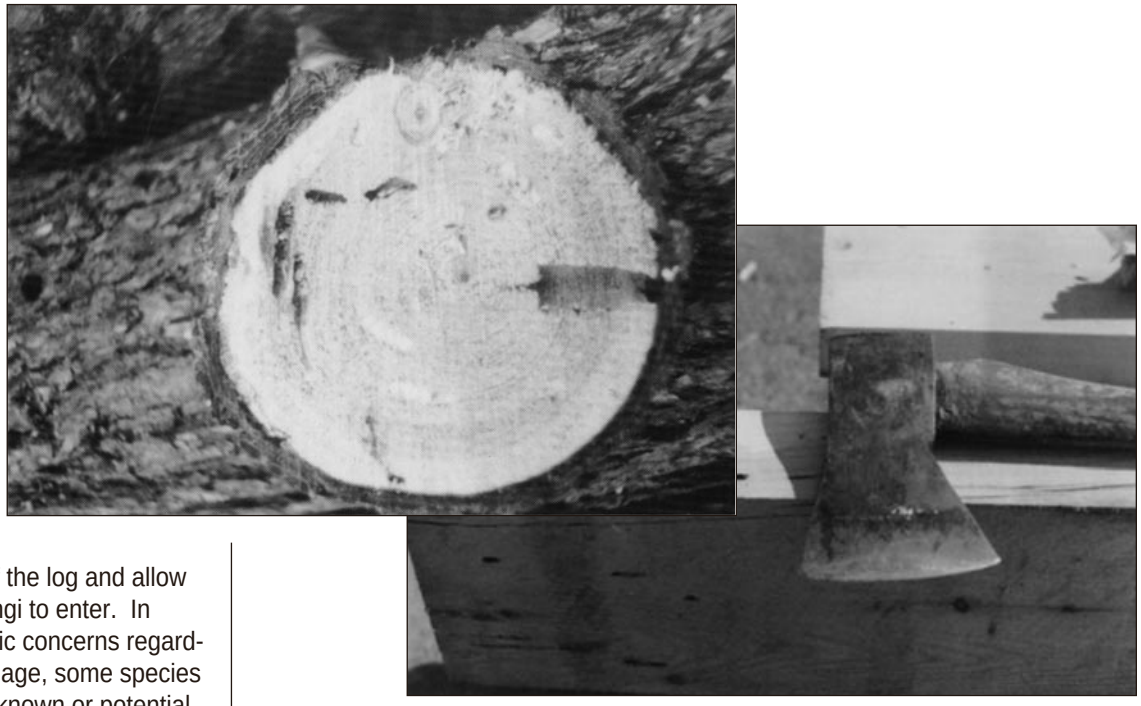

Figure 1. Typical longhorned beetle woodborer damage in log and lumber.

Several species of woodboring insects commonly attack softwood logs in British Columbia. The larvae (grubs) can riddle logs allowed to remain unprocessed after cutting, causing wormholes (grub holes) which may seriously reduce the value of the log and allow stain and decay fungi to enter. In addition to economic concerns regarding woodborer damage, some species of woodborers are known or potential carriers (vectors) of the pine wilt pathogen, the pinewood nematode, *Bursaphelenchus xylophilus*, which causes mortality of pines in Japan. Pinewood nematode occurs rarely in Canada. Nonetheless, during the past 10 years it has become a factor in the export of lumber to a number of European countries. Increasingly, the European Economic Community has demanded that all imported lumber be free from the type of damage (grub holes) which may be caused by potential vectors of the pinewood nematode (Figure 1).

This leaflet describes several common woodborers found in British Columbia. The various species or groups of woodborers are described and their life histories, habits and hosts are discussed. This information will aid the user in detection and identification of damage caused by woodborers, and will also be useful in prevention and control. Longhorned beetles, metallic woodborers and woodwasps are emphasized but ambrosia beetles, shipworms and other woodborers are also discussed.

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The longhorned beetles, Cerambycidae, the metallic woodborers, Buprestidae, and the horntails or woodwasps, Siricidae, are the principal agents which bore deeply into the wood of felled, decked, fire-damaged, diseased, insect-damaged, or otherwise recently dead or severely stressed trees. Adult longhorned beetles, the only known vector of the pinewood nematode in Canada, are readily recognized by their long antennae (Figure 2); the antennae are often longer than the body, and have been recorded up to 12 cm in length. The larvae (or grubs) are called roundheaded borers because they and their tunnels (or grub holes) tend to be more circular in cross section than those of metallic woodborers. Adult metallic woodborers are often brightly colored and have a metallic sheen. The larvae are referred to as flatheaded borers because their bodies are notably flattened and widened at the thorax (immediately behind the head) followed by a long, slender, segmented abdomen. Adult horntails or woodwasps are large and wasp-like in appearance, have two pairs of clear wings, a cylindrical body, and a horn-like process at the tip of the abdomen. Females have an ovipositor protruding from the tip of the abdomen. The larvae are readily distinguished from the larvae of longhorned beetles by a dark spine at the tail end.

The most commonly encountered longhorned or roundheaded woodborers belong to the genus *Monochamus* (sawyer beetles), especially *M. scutellatus* and *M. clamator*, or the genus *Tetropium*, including primarily *T. cinnamopterum parvulum* and *T. velutinum*. The most common metallic woodborers (family Buprestidae) include *Buprestis aurulenta* and *Trachykele blondeli*. The common species of horntails found in British Columbia belong to the genera *Urocerus* and *Sirex*.

The pinewood nematode factor

On June 22, 1990 the Plant Health Committee of the European Economic Community required kiln drying to below 20% moisture content for coniferous lumber imported into the European Community after Junuary 1, 1991, from countries known to have the pinewood nematode. This regulation was enacted purportedly to protect European forests from pinewood nematode and its insect vector, the sawyer beetle (*Monochamus* spp.). A ban could threaten British Columbia's lumber exports to Europe, which are valued to over $600 million. A temporary derogation (exemption) allows the continued use of the mill certification program (no bark, no grub holes). Compliance with this program is critical: three violations from Canada may result in loss of the derogation, thus making kiln drying mandatory. Field identification of the vector involved,

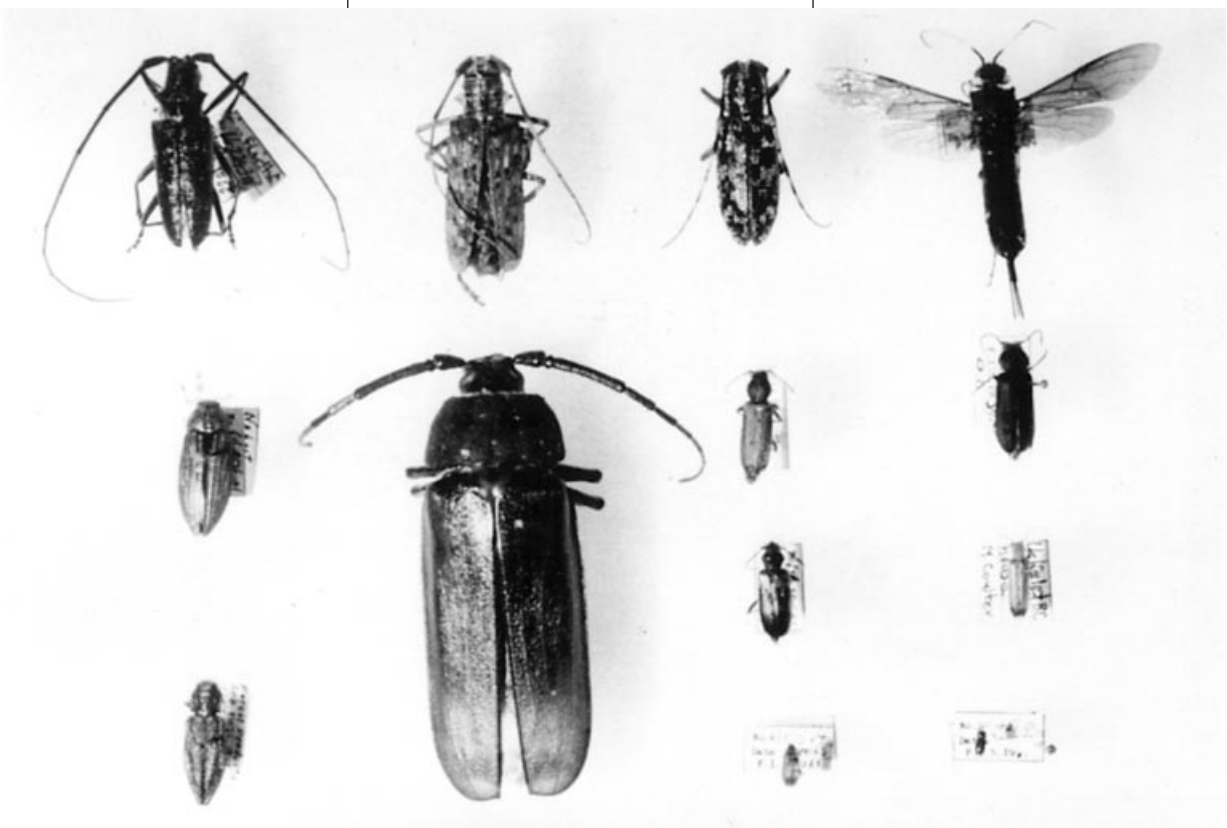

Figure 2. Woodborer adults. From top to bottom, Column 1: *Monochamus scutellatus, Buprestis aurulenta*, *Trachykele blondeli.* Column 2: *Monochamus notatus, Ergates spiculatus.* Column 3: *Monochamus clamator, Tetropium velutinum, Semanotus ligneus ampla, Hemicoelus gibbicollis.* Column 4: *Urocerus albicornis, Asemum striatum, Nacerdes melanura, Trypodendron lineatum.*

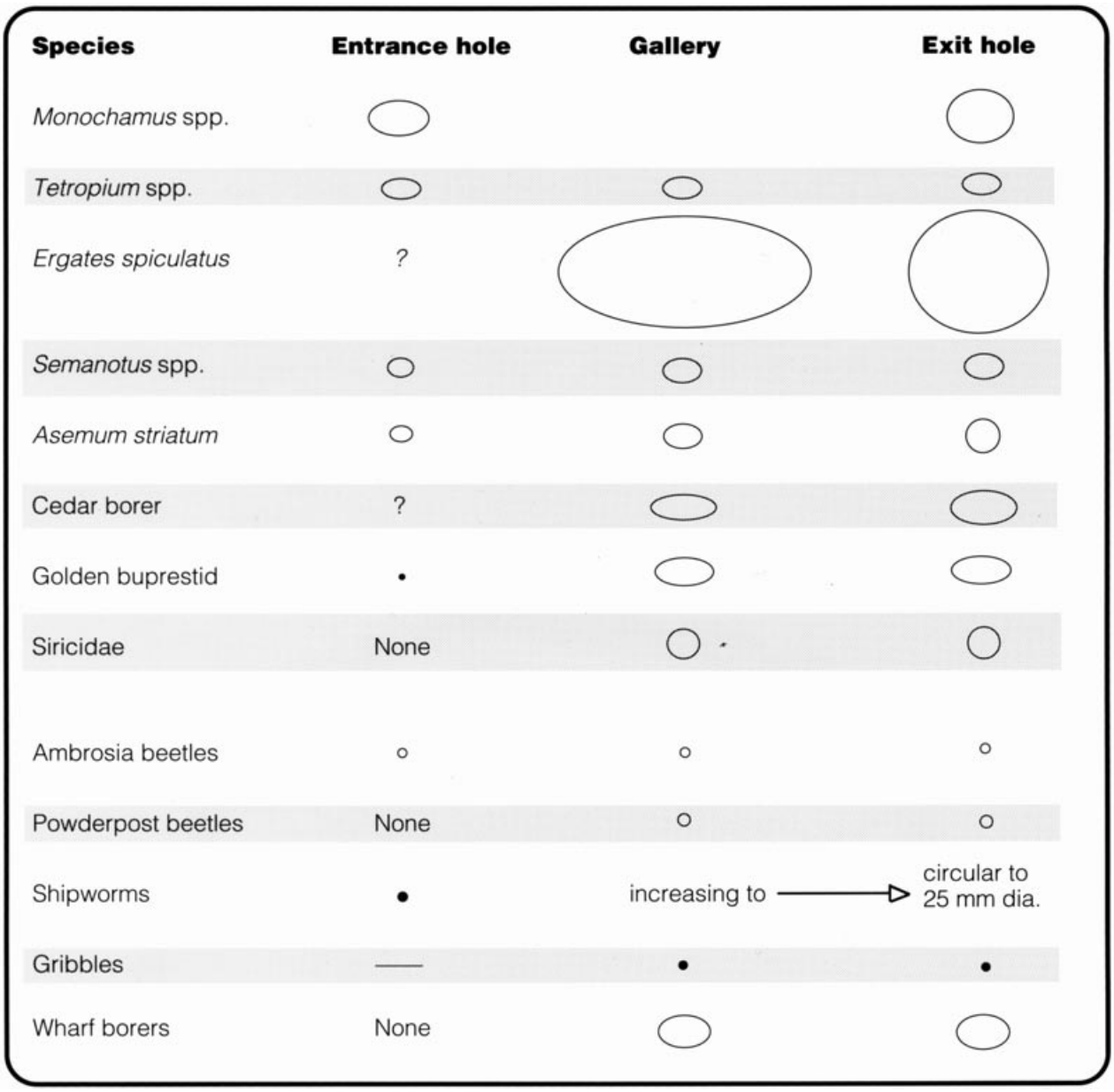

Figure 3. Shapes and sizes of entrance holes, galleries and exit holes of various woodborers in British Columbia (approximate actual size).

the type of damage caused, and the controls available could facilitate further exemptions and improve the product available for export.

The Canadian position remains that the Mill Certification Program is sufficient, considering the minimal threat, and should continue to be so. The push from Canada will be to continue with this program of regulation. Meanwhile, heat treatment (pasteurizing) as a control method is being investigated and exemptions of rarely attacked host species like hemlock and cedar are being requested.

Hosts, life histories and habits

Sawyer beetles, *Monochamus* spp.

The sawyer beetles (Cerambycidae) in British Columbia include the species *Monochamus* scutellatus, *M. clamator* (which now includes M. maculosus), M. notatus, and M. obtusus (Figure 2). The preferred hosts are pines, Douglas-fir, spruces, and true firs. Larvae (or grubs) feed for four to eight weeks on the inner bark and cambium, then penetrate the sapwood, usually moving downward in standing trees. Their presence and numbers may be readily determined by the small piles of excelsior-like borings around each entry hole. Entrance holes into the wood are oval and average 4 × 9 mm (Figure 3). Mines (grub holes or galleries), which increase in size as the larvae mature, are irregular, broad and tightly packed with bark chips, frass, and shreds of wood up to 5 cm long. Mines are generally U-shaped back toward the surface, but may occasionally extend right through the log (Fig. 4). Larvae overwinter; pupation (the inactive

stage during which the transformation from larva to adult takes place) occurs in enlarged cavities at the end of the larval gallery, usually within 8 mm of the wood surface. Adults emerge from May to mid-August; exit holes are circular, and average 8 mm in diameter in cross section (the shape and size of all woodborer exit holes and galleries may be misleading if seen at oblique angles). Adults feed on bark and cambium of twigs or needles on living coniferous hosts, and may live for two and a half months. Eggs are laid in bark niches chewed by adults during early July to mid-August; these hatch in about 10 days. Up to nine eggs may be deposited in a niche and one female may lay up to 70 eggs. The life cycle is normally one to two years although durations of up to five years have been recorded (Figure 5).

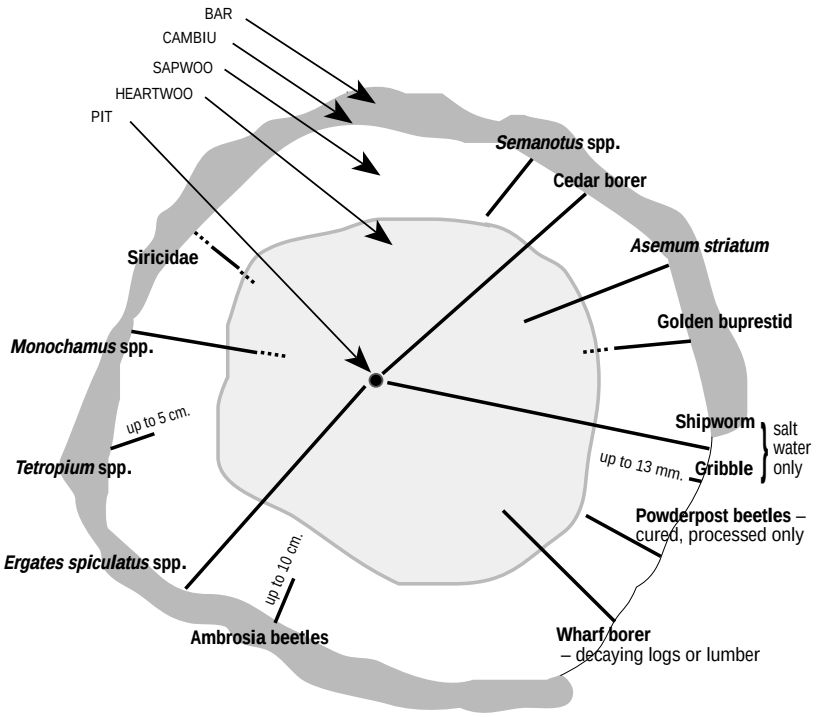

Figure 4. Approximate depths to which woodborers penetrate standing trees, logs and lumber.

Spruce and western larch borers, *Tetropium* spp.

Tetropium velutinum (Figure 2) attacks mainly larch and western hemlock, and while *T. c. parvulum* prefers spruce, it may also attack pines and true firs. The young larva feeds for up to 70 days in the cambium before penetrating the sapwood. The entrance hole into the sapwood is elliptical and about 3 x 7 mm (Figure 3). The larva bores downward and spends the winter in the L-shaped gallery which can extend up to 5 cm into the sapwood and terminates in a plug-sealed pupal chamber (Figure 4). The pupal period lasts from seven to nine days, and the young adult spends a week or more in the gallery before emerging. The adults emerge in early summer (possibly through the entrance hole), and within four to eight weeks the female deposits her eggs between and under bark scales. From T. velutinum, this occurs from early May to August; for T.c. parvulum, this occurs from the end of June to mid-July. The eggs hatch after 10 to 16 days. The life cycle is usually completed in one year (Figure 5).

Other roundheaded borers

Other woodborers of the family Cerambycidae that are less commonly found include the ponderous borer, Ergates spiculatus, (Figure 2) which attacks dead Douglas-fir and ponderosa pine and to a lesser degree, other pines and true firs. Mature larvae are up to 70 mm long and are occasionally found boring deep in the heartwood (Figure 4). Larval galleries contain fibrous boring dust and exit holes are 20 mm or larger in diameter (Figure 3). Adults are dark brown, up to 65 mm long, thick-bodies and emerge from July to September. Sermanotus (Figure 2) are more common, attack western red cedar, yellow cedar, true firs and other conifers to a lesser degree, and they occasionally degrade lumber. The larvae, up to 18 mm in length when mature, feed mainly in the phloem-cambium area but may penetrate into the sapwood through oval entrance holes that measure approximately 5 mm (Figures 3,4) just prior to pupation which usually occurs in June. The adults are two-tone dark and medium reddish brown and are generally up to 17 mm long; exit holes are only slightly larger than entrance holes. The black spruce borer, Asemum striatum, (Figure 2) is abundant in fire-killed Douglas-fir. Larval entrance holes are oval and are about 4 mm across (Figure 3). Mature larvae, up to 25 mm long, mine oval tunnels up to 20 cm in length in both sapwood and heartwood (Figure 4). Emergence holes are round and about 5 mm in diameter. The adult is uniformly brown or black, up to 18 mm long, and often it will reattack dead trees.

Numerous other species of this family occur in British Columbia. Some species bore into wood but occur infrequently, some mine extensively under the bark and have larvae similar in appearance in metallic woodborer larvae, some feed in roots while others prefer long-dead or rotting wood, and still others feed on brush species or hardwoods.

Horntails or woodwasps, Siricidae

Woodwasps (Figure 2) attack weakened, dying, or recently dead trees of almost all conifer species. The larval mines are generally U-shaped and are from 5 to 20 cm in length; they sometimes penetrate into the heartwood, and terminate in a pupal chamber near the surface. Siricids overwinter as larvae and pupation occurs in late spring and early summer. Young adults may spend several weeks in the pupal chamber before emerging through round, exit holes about 5 mm in diameter (Figure 3, 4). Eggs are laid from mid-July until August and some large females may lay up to 500 eggs. Eggs and spores of a symbiotic fungus, Amylostereum, which the larvae are reported to eat, are deposited through a long ovipositor (25 mm in length) directly into the wood. The eggs hatch after 14 to 28 days.

In the two-year cycle (a life cycle may take one to three years), larvae overwinter and go into diapause in the spring after the first winter; the adults emerge at the end of the second year (Figure 5). Adults attack scars on living trees, trees of low vigor, fire-killed trees, and freshly felled trees.

Western cedar borer, *T. blondeli*, and **golden buprestid**, *B. aurulenta*

While the western cedar borer (Figure 2) primarily attacks western red cedar, it has also been recorded in yellow cypress and incense cedar, *Trachykele blondeli* larvae bore from the branches into the bole where they prefer heartwood; larval mines are up to 25 mm wide. Gallery entrance holes in branches are small and generally not noted. Mines are oval or flattened in cross section and are tightly packed with fine, light-colored frass. After two or more years, mature larvae pupate at the end of the larval galleries during late summer. About 20 days later, they transform to adults in the fall and then overwinter in the galleries. The following spring, the adult beetles chew through to the surface, leaving emergence holes that are typically about 8 mm in diameter (Figures 3,4). Adult beetles feed inermittently on cedar foliage for several days before mating. The life cycle is generally two or more years (Figure 5).

The golden buprestid (Figure 2) prefers Douglas-fir but also attacks spruces, true firs, pines and western red cedar. Unlike several other species of buprestids which first mine the inner bark, newly emerged larvae of B. aurulenta bore directly into the sapwood usually penetrating 1 to 2 cm below the surface where they excavate mines which enlarge as the larvae grow in size; occasionally, heartwood is penetrated. Entrance holes are minute and are not easily seen. Galleries are oval in cross section and are tightly packed with fine, light-colored frass (Figure 3,4). Mature larvae pupate during late summer and transform to adults in the fall; the adults overwinter in the galleries. In the spring, newly emerged adults require a period of feeding on Douglas-fir foliage before they mature and mate. In the late spring or summer, the females lay eggs in bark crevices and scars. The eggs, laid singly or in masses, hatch soon afterwards. The larval stage lasts two to four years under normal conditions, however, in seasoned wood under low humidity (wood in structures), larvae may live up to 60 years and adults may emerge at any season in such cases (Figure 5).

Numerous other woodborer species of the family Buprestidae occur in British Columbia, some are woodborers in softwoods but occur infrequently; some limit activity to the inner bark; some feed in cones, others are leafminers, while still others feed exclusively in hardwoods.

Descriptions

Sawyer beetles *Monochamus* spp.

Egg: 1×4 mm, elongate, curved, smooth, white and leathery, one end slightly flattened and the other somewhat pointed.

Larva: at maturity 25 to 50 mm long, whitish grub, legless and markedly segmented.

Pupa: About 20 mm long, creamy white, and resembles the adult.

Adult: 15 to 35 mm long, body black to gray-reddish brown, depending on species, elytra (hardened fore wings) sparsely covered with black and white scales (short pointed hairs) except for scattered velvety patches of dense black (brown) scales. Antennae longer than body, those of male, black to gray-brown and longer than those of female, which are alternately banded black and gray (Fig. 2).

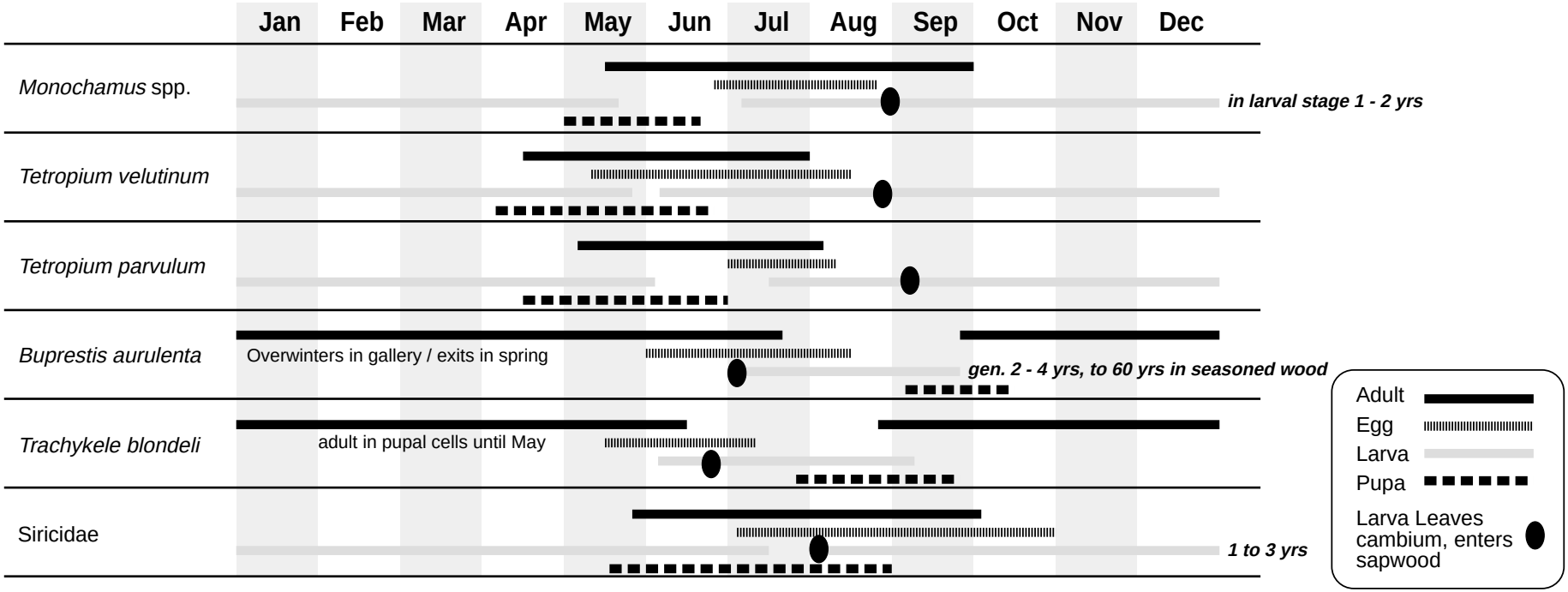

Figure 5. Life cycles of the major British Columbia woodborers.

Spruce and larch borers, *Tetropium* spp.

Egg: 1×0.5 mm, elliptical, white and loosely clustered.

Larva: 10 to 13 mm long, 2.5 to 3.0 mm wide at maturity, yellowish white, cylindrical, slender, three pairs of thoracic legs, mandibles black, brown head recessed in thorax.

Pupa: gray-white, similar to adult in size and form.

Adult: 10 to 15 mm long, 3 to 4 mm wide. Head black, eyes deeply notiched, antennae medium brown to black, twice as long as head and thorax, upper surface of thorax shiny black (T. c. parvulum), velvety black (T. velutinum), elytra variably pale yellow-brown to black, densely clothed with pale gold-colored scales, legs medium to dark brown (Fig. 2).

Horntails or woodwasps, *Urocerus* spp., *Sirex* spp.

Egg: 1-2 mm, elongate-oval, generally white.

Larva: mature larva to approximately 32 mm in length, whitish, cylindrical with three pairs of vestigial thoracic legs, head hemispherical with mandibles strongly pigmented and toothed, pigmented terminal abdominal spine. Appears S-shaped from the side.

Pupa: long, slender, similar to adult in size, gray white, within parchmentlike cocoon, distinct adult shape.

Adult: 12 to 50 mm long, elongate, thick-waisted, abdomen black to metallic blue-black, often yellow-banded, two pairs of membranous wings, ovipositor of female one-half or greater body length. *Urocerus* spp. has yellow patch behind each eye. Size and coloration vary with sex and species (Fig. 2).

Western cedar borer, *Trachykele blondeli*, and **golden buprestid,** *Buprestis aurulenta.*

Egg: 2.5×1.75 mm, oblong, off-white ashy gray (pearly white, oval and flattened for the golden buprestid).

Larva: young larva 2-3 mm $\times$ 0.5-1 mm, mature larva 30 to 40 mm $\times$ 6 to 8 mm, creamy white except for dark brown mouth parts, small head retracted into broad, flat thorax, abdomen is long and much narrower than thorax and consists of 10 subcylindrical segments.

Pupa: 16 to 22 mm $\times$ 6 to 8 mm (slightly smaller for golden buprestid), white except for the brown eye spots.

Adult: 12 to 20 mm $\times$ 4 to 8 mm, elongate-oval, tapered posteriorly, brilliant bronzy green or blue, elytra longitudinally corrugated, antennae short and 11-segmented (borders of grooved wing cases and underside of body coppery gold on golden buprestid) (Figure 2).

Distribution and hosts

In British Columbia, some species of woodborers occur over limited geographic areas or show a preference for a limited number of hosts; many species, however, occur throughout the province (Table 1).

Woodborers have historically not presented major problems as forest pests; consequently, sampling has been limited. Collections and published records of the Forest Insect and Disease Survey since 1949 provide general trends about woodborer distribution. The pinewood nematode vector, *Monochamus* spp., has been recorded throughout the province and could occur in all forests and mill yards where woodborer damage is noted and to varying degrees in most conifer species except cedar, cypress, or juniper.

Table 1. Distribution and hosts of some woodborers in B.C.

Pest	Hosts[1]	Forest regions[2]	Remarks[2]
Monochamus spp.	-P,Df,-F,-S, wL,wH(rare)	All	No samples from QCI or NW corner of BC
Tetropium c.parvulum	wS,eS	Kamloops, PG, Cariboo, PR	
Tetropium velutinum	wL,Df,eS,wS, lP,ww,aF,wH	All	Sparse but occurs throughout BC
Urocerus spp.,	-F,-S,Df,wH,	All	All regions except
Sirex spp.	-P,wL,yC, wrC		NW corner BC
Trachykele blondeli	wrC, yC	Vancouver	Lower coast and S. Vancouver Is. only
Buprestis aurulenta	Df,-P,wrC, wH,sS,aF	Vancouver Nelson, Kamloops	S. half of BC only

Other woodborers of interest

Trypodendron spp.,	-P,-S,-F,wH,	All	Distrib. and nos.
Gnathotrichus spp.	Df,wL,wrC,yC		vary with sp.
Ergates spiculatus	pP,Df,	Vancouver Nelson Kamloops	Southern one-third Of BC
Semanotus spp.	wrC,-F,Df	All	Scattered, more common in south
Asemum striatum	Df,lP,pP,alF, eS,wS	All	Scattered through all other regions
Nacerdes melanura	softwood and hardwood spp.	Vancouver	Coastal only

1 -F=true firs, aF=amabilis fir, alF=alpine fir, Df=Douglas-fir, -P=pines, lP=lodgepole pine, pP=ponderosa pine, wwP=western white pine, -S=spruces, eS=Engelmann spruce, sS=Sitka spruce, wS=white spruce, wH=western hemlock, wL=western larch, wrC=western red cedar, yC=yellow cedar.

2 BC-British Columbia, NW-northwest, S.-south, PG-Prince George, PR-Prince Rupert, QCI- Queen Charlotte Islands.

Damage and detection

Sawyer beetles, *Monochamus* spp.

The most susceptible logs are those cut in May or June and left in the woods. Trees recently killed by fire or weakened by other causes such as root rot or bark beetles are also susceptible. The extent of damage to the log depends on the length of time it is left in the bush or decked. Damage to fire-killed timber depends on the time and severity of the fire. Only recently killed trees which still contain sap in the inner bark are attacked. The most severe attacks occur in areas where cutting or windfall during the previous two years has encouraged the buildup of borer populations in tops, cull logs, and dying trees. External signs of damage are egg slits in the bark, piles of shredded wood on the bark (coarser than boring dust produced by bark beetles), and round exit holes 6 to 10 mm in diameter (Figure 6). Internal damage consists initially of flattened larval tunnels which score the inner surface of the bark and cambium layer and meander randomly. This is followed by galleries 4 to 8 mm wide penetrating 5 to 15 cm into the log, often deep into the heartwood and generally U-shaped back toward the surface.

Much of the lumber sawn from heavily attacked logs is of low grade even though a large proportion of the damaged wood is removed in the initial slab cut. Damage to attacked logs increases continually if processing is delayed. Galleries also provide an entrance to rot and stain fungi, including spores of some fungi carried by the borers. Infested logs are less suitable for pulpwood because of fungal staining.

Spruce and larch borers, *Tetropium* spp.

These borers attack only those weakened, felled or fire-damaged trees which have fresh cambium between the end of May and to August. The galleries have a distinctive L-shape, penetrate up to 5 cm, and are densely packed with shreds of wood and frass which are finer than those made by *Monochamus* spp. (Figure 6).

Horntails and woodwasps, Siricidae

External evidence of attack in the form of emergence holes is found only after damage is completed. Damage holes are round and packed with coarse boring dust as compared to shavings in cerambycid borings. Both sapwood and heartwood are attacked, and tunnels can be up to 30 cm in length. When material is cut obliquely, tunnels take an oval appearance and may be mistaken for longhorn damage. If siricid attack is suspected and the tree is checked immediately, sometimes the ovipositor punctures are visible, usually in groups (Figure 6).

Western cedar borer and the golden buprestid, *T. blondeli, B. aurulenta*

Trachykele blondeli attacks standing, healthy trees leaving no visible external injury and causing no mortality; detection is therefore very difficult. Low-elevation, exposed southerly aspects within the geographic range should be considered suspect. Larval tunnels are visible at knot faces after felling and limbing. Attack is also highly variable in a stand over a broad maturity range. Damage is found primarily in the heartwood of the upper part of the bole but occasionally extends as far as the butt (Figure 6).

Oval emergence holes are the only external evidence of golden buprestid damage. Internally, the oval, flattened larval galleries are tightly packed with fine frass and boring dust. Detection of infested lumber before use in construction may be difficult as tunnels of early-instar larvae are only 0.5 to 1.0 mm wide. Structural damage or noticeable wood destruction are rare.

Prevention and control

Efficient logging and processing management are the best methods of preventing and controlling the attack and development of woodborers. In fire-killed timber, severely burned and material may be too dry to attract large sawyer beetle populations, and trees subjected to only reflected heat or root burn may not become infested till the second year. Trees felled and left in the bush, cold-decked, or damaged by defoliators or bark beetles, or infected by root disease, or severely stressed for other reasons are also susceptible to attack by cerambycids, buprestids and siricids.

Measures available to assist in management include the following:

1. Identify woodborer species known to occur in your area.
2. Harvest after the completion of the adult egg-laying period. In general, this means after mid-September.
3. Do not leave felled timber in the bush for a full summer.
4. Deck logs compactly (which reduces penetration of light) to limit egg deposition to mainly the top two or three log layers. Use logs cut in the fall or early winter as the outside layers of decks, as these are least attractive to sawyer beetles.
5. Pile logs in shaded areas or cover them with slash to reduce woodborer attack (caution-some bark beetles prefer shaded host).
6. Pond logs to restrict beetle attack to the exposed dry tops of logs; increased moisture content of the wood also reduces larval survival.
7. Overhead sprinkler watering of log

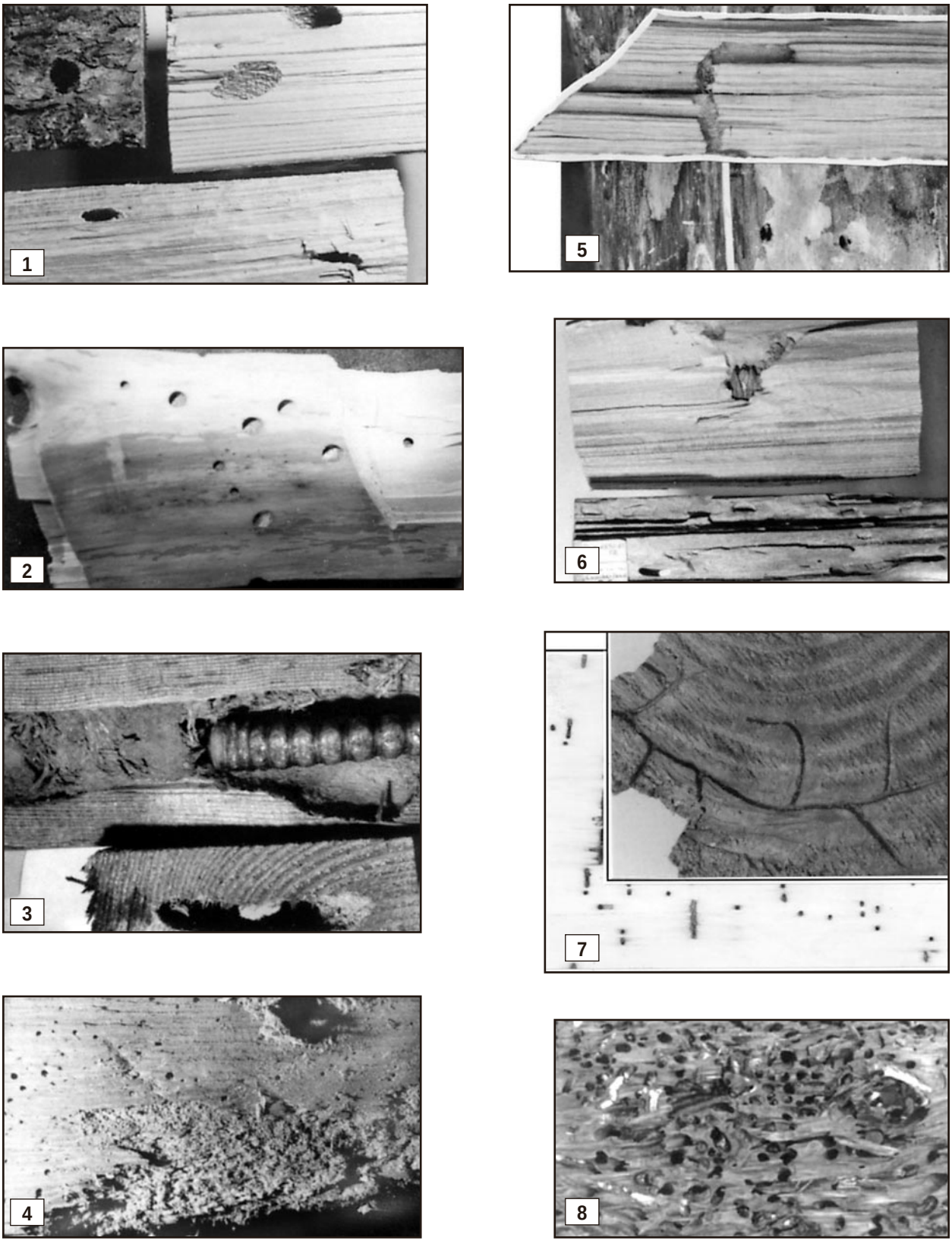

Figure 6. Typical damage caused by various woodborers in B.C. including: 1. sawyer beetles, 2. larch and spruce borers, 3. horntails, 4. metallic woodborers, 5. ponderous borer, 6. ambrosia beetles, 7. powderpost beetles, 8. shipworms.

decks (full coverage) to reduce or prevent attack by woodborers.

8. Apply a registered chemical agent to protect logs. Spray the logs liberally to cover the tops, sides and ends of the logs before egg laying. Sanex (Lindane 10% E.C.) is registered for log decks although use permits may be restrictive.

9. Promptly debark recently felled trees exposed to woodborer attack to prevent further attacks.

10. Use good hygiene in log yards and at mill sites to discourage buildup of populations. Rapidly move all inventories from the felling site through the mill yard and the sawmill.

11. Process uninfested logs before eggs are laid, or before larvae complete their cambial feeding period. In general, logs that have been cut after mid-September should be processed by early May.

12. Process infested material as soon as possible to reduce the depth of penetration by larvae and the size of galleries. This will reduce the extent and severity of damage.

13. Identify the woodborer species to determine the depth to which logs have been penetrated. Maximize lumber recovery by cut control designed around penetration depth.

14. Remove bark from all green lumber; sawyer beetles cannot establish in bark-free material, although adults can emerge from such material if already present.

Other woodborers of interest

In addition to the woodborers already mentioned, there are several other species of interest, such as ship worms, ambrosia beetles or powderpost beetles. All are relatively common but are not considered vectors of the pinewood nematode; nor is the damage they cause likely to be confused with typical sawyer beetle damage.

Ambrosia beetles

Ambrosia beetles, pinhole borers, or pinworms seriously affect the value of commercial timber, both from a damage and a quarantine perspective. In British Columbia, species of the genus Trypodendron are more common in the interior and species of the genus Gnathotrichus are more common on the coast. Most commercial tree species are susceptible to attack although damage usually occurs in Douglas-fir, western hemlock, true firs, and spruces. The pinholes or galleries, in combination with an associated fungus, greatly reduce the value of timber and veneer. In the past, losses have been estimated as high as $64 million per year.

Adults are stubby (Gnathotrichus spp. are more cylindrical), generally shiny, dark brown to black, 3 to 4.5 mm long with a head and a thorax rounded in front (Figure 2). The development from egg to adult requires only 6 to 8 weeks. Attacks begin in March on the coast, peak in May, and continue to August (and to November for Gnathotrichus spp.). Gallery entrances are marked by fine, granular, white boring dust and adults penetrate to 10 cm. The holes are perfectly round and are 1.3 to 1.5 cm in diameter, and they are stained by fungi a few days after attack (Figures 3,4,6). Adults emerge from July to September and hibernate in duff and litter (Trypodendron spp.) or overwinter in the gallery (Gnathotrichus spp.). There is one generation per year.

Logs cut in autumn and early winter appear to be most susceptible although *Gnathotrichus* spp. will also attack logs as soon as two weeks after felling. As with other woodborers, processing prior to attack (in this case, May) is the key to preventing damage; rapid processing even after attack will help reduce losses.

False powderpost beetles

False powderpost beetles (Anobiidae) attack sawn timber or wood in service if high humidity conditions prevail. Fresh logs or recently dead or dying trees are not attacked. They are, however, fairly common woodborers and are occasionally found associated with areas of decay in some logs.

The Pacific powderpost beetle, *Hemicoelus gibbicollis*, (Figure 2) is the most damaging in British Columbia, infesting well-seasoned healthy sapwood of Douglas-fir, true fir, western hemlock, and spruce. Underportions of older buildings without basements are most frequently infested and structural timbers may be repeatedly attacked until they are eventually pulverized.

Adults are generally 2 to 7 mm in length, dark brown to black, elongated and cylindrical with a hoodlike thorax over a retractile head. Mature larvae are white, somewhat curved, and approximately 5 mm long.

Eggs are laid in cracks and crevices. Larval galleries less than 2 mm in diameter are bored primarily into sapwood (Figures 3,4). Larvae can be active for three or more years, often reducing wood to flour-like powder (Figure 6). When mature larvae pupate near the wood surface, adults emerge cutting circular holes through the surface; this and the boring dust are usually the first signs of attack. The same material is attacked repeatedly and infestations may be 20 or more years old before damage becomes obvious. Sapwood may be completely disintegrated, leaving a thin veneer; where the sapwood to heartwood ratio is high, structural weakness may result.

Wharf borer

The wharf borer, *Nacerdes melanura*, a beetle of the family Oedemeridae, is of interest only because typical damage can be confused with cerambycid damage in certain situations, It attacks both sapwood and heartwood of partly decayed material, although damage can occasionally penetrate from decayed wood into adjacent sound wood.

Eggs are laid in cracks and crevices in summer and larvae are grayish white, 12 to 30 mm long and have three pairs of well developed legs. Adults are 6 to 12 mm, reddish brown, bright or metallic, have the apex of elytra black, and have relatively long antennae (Figure 2).

The wharf borer is found along the coast where it develops in moist rotting wood; it prefers wood wetted with salt water. Larval tunnels are intermittently plugged with long torn fibres (Figures 3, 4).

Marine borers

Marine borers damage floated timber in salt water. When the timber is processed, damage may be confused with that caused by woodboring insects. Two families are represented: the mollusks, including the genus Bankia, and members of the genus Teredo, commonly called shipworms or pileworms; in the crustaceans, members of the genus Limnoria, also called gribbles, are common.

The local species, *Bankia setacea*, may reach a size of 60 cm and diameter of 20 mm while *Teredo navalis* only reaches 15 cm in length and a diameter of 10 mm. Both species, as the comon name suggests, have a wormlike appearance. Numerous tunnels can be built in a short time; these start as pin-sized holes on the periphery of logs and can increase rapidly in diameter to 2.5 cm (Figures 3,4). Galleries contain no boring dust but are lined by a calcareous material (Figure 6). All host species may be attacked and due to the minute size of the external hole, serious internal damage may go undetected. Shipworms may survive for several weeks outside salt water and can function effectively in 1% salinity, which is approximately one-third of normal sea water salinity.

The gribble, *Limnoria lignorum*, is 6 mm long and resembles a woodlouse. It attacks in similar fashion to the teredo; however, it is unable to survive in water below 1-1.5% salinity. The tunnels are shorter and smaller, although very numerous. Damage, which penetrates to only 13 mm with tunnels of 1 mm diameter, is severe (Figure 3,4). Activity is easier to detect because the gribble feeds on the outside soft tissue just under the surface and works inward as each layer is eroded by salt water and tidal action.

The pinewood nematode

The pinewood nematode, *Bursaphelenchus xylophilus*, is a microscopic worm, approximately1 mm long and 0.2 mm in circumference. While it is a serious pest causing mortality of pines in Japan, there is no record of tree mortality directly attributable to the nematode in Canada, although it has been found in recently dead or dying trees. It is most common on pines, true firs, and spruces where it can be found active into the heartwood as well as the sapwood. The nematode can increase from one female to many millions in a single year. For optimum development, it requires a temperature of 23-27°C or warmer. Using a retractable stylet, it punctures cells and removes the contents. This feeding activity, and the great numbers that can occur in the resin canals, disrupts the flow of water and eventually causes the death of the tree. After a period of feeding and development, the dispersal (third) stage nematode larvae accumulate within 1 to 2 mm of the vector pupal chamber in the wood; these larvae molt to fourth stage (dauerlarvae) in late spring and are adapted to contaminate the adult beetle just after it emerges from the pupa. In Japan, the vector than carries the nematodes to healthy trees where the nematodes drop into branch wounds created by the beetle during maturation feeding. In contrast, in Canada, transmission occurs during oviposition in recently dead or dying trees (Figure 7).

The nematode in British Columbia

Forestry Canada has been involved with the pinewood nematode for the last 10 years. In that period, in British Columbia, 2000 samples from trees or logs, boards and vectors from diverse locations have been inspected for the nematode. The tree species examined were pine, cedar, western hemlock, true firs, Douglas-fir, and spruce. Nematodes were found in a total of only five trees, mostly pine, from very diverse locations. Out of 645 vector extractions, the pinewood nematode was found in a single adult beetle, *Monochamus* clamator.

Western hemlock and western red cedar were surveyed in 1990 to confirm these hosts are seldom attacked by *Monochamus* beetles. This was done in order to support the request for exemption of these species from the kiln drying requirements. Only one adult of *Monochamus* scutellatus was found in 1000 trees or logs examined. Additionally, in inoculation trials of 22 species of conifer seedlings, western hemlock and western red cedar were not susceptible to pinewood nematode.

Monochamus beetles are the prime vectors of the pinewood nematode and in Canada they are the only known vectors. In British Columbia, 28 woodboring species other than *Monochamus* beetles were reared, primarily from nematode-inoculated bolts, and found to be free of the pinewood nematode.

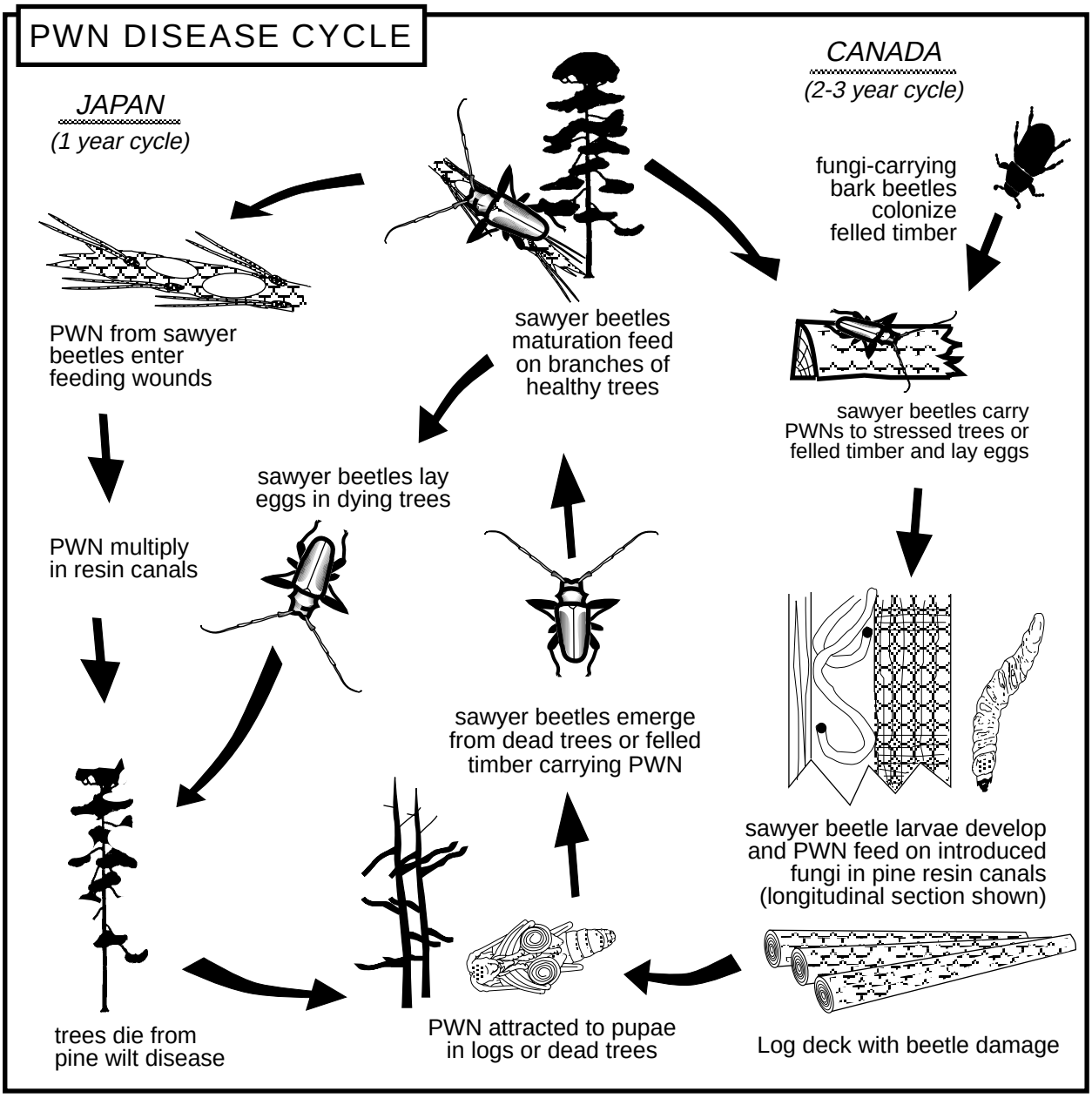

Figure 7. The pinewood nematode – sawyer beetle disease cycle in Japan and Canada.

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