13
Damage to stems, branches and twigs of coniferous woody plants

13.1. Root and stem rot

**Description:** External, above-ground symptoms on individual trees are variable and include suppressed growth, reduced vigour, discoloured or small-sized needles, premature needle drop, branch dieback, crown thinning, basal resinosis (resin flow), wilt and death of trees. It is not uncommon for root and butt rots to be very advanced, but showing no obvious symptoms.

**Possible damaging agents:** Fungi: Basidiomycota (Figs. 13.1.1 – 13.1.4), Chromista: Oomycota (water moulds:Figs. 13.1.5 – 13.1.6).

![Fig. 13.1.1. Fruiting bodies of a root rot fungus (*Armillaria* sp.) at the collar of Norway spruce (*Picea abies*). Skole, Ukraine, VK.](image1)

![Fig. 13.1.2. Mycelial fans of the root rot fungus *Armillaria ostoyae* at the collar of Scots pine (*Pinus sylvestris*). Sinop province, Black Sea region, AL.](image2)
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Additional information: Root and butt rot fungi are particularly difficult to detect and manage. Most of them occur as pathogens on living trees and as saprophytes on dead organic matter. They infect the host tree through wounds in the lower part of the trunk or in the roots or penetrate healthy roots directly. In some cases, they kill the cambium at the root collar, whereas in other cases they decay the heartwood of the roots (root rot) or at the stem base (butt rot). Eventually, the rot may expand to the stem of the tree. Symptoms may not become visible until a late stage of the infection (i.e. most of the root system affected). Frequently, trees infected by root and butt rot pathogens are uprooted or broken by, e.g., wind or snow. For pathogen collection and preservation, see Chapter 4.
13.2. Vascular diseases

**Description:** Pathogens (i.e. fungi, bacteria, nematodes) causing vascular diseases invade the active xylem, causing a failure of the transport of water to the foliage. Consequently, wilting symptoms develop on the leaves. Typically, vascular diseases are characterized by tangential bands or arcs of stain in the sapwood. These are often widest at the root collar and taper away up into the stem and down into the roots. The staining is due to the presence of fungal mycelium in the tracheids and to a discoloration of the tracheid walls. In some cases, the fungus may grow radially through the medullary rays resulting in a pattern of stain that is wedge-shaped in cross section. The needles of affected trees are often smaller than normal. They may turn yellow or brown and either fall prematurely or be retained for a few months. Needle wilting may first appear on one or a few branches but often develops quickly throughout the crown. Resin exudation may occur in the lower part of the trunk.

**Possible damaging agents:** Fungi: Ascomycota (Figs. 13.2.1 – 13.2.4), Roundworms: Nematoda (Fig. 13.2.5 – 13.2.6).

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**Fig. 13.2.1.** Symptoms of wilting caused by a blackstain root fungus (*Ophiostoma wageneri*) on Scots pine (*Pinus sylvestris*). Rava-Ruska, Ukraine, IM.

**Fig. 13.2.2.** Wood discoloration caused by bluestain fungus *Ophiostoma sp.* on Scots pine (*Pinus sylvestris*). Rava-Ruska, Ukraine, IM.

**Fig. 13.2.3.** Ponderosa pine (*Pinus ponderosa*) with tangential surface of stained sapwood in lower bole, infected by a black stain root fungus (*Ophiostoma wageneri*). DO.

**Fig. 13.2.4.** Loblolly pine (*Pinus taeda*) stump with blue stain caused by a bluestain fungus (*Ophiostoma ips*). USA, RFB.
Fig. 13.2.5. Forest of Masson pine (*Pinus massonianna*) with reddening pines due to infestation by the pinewood nematode (*Bursaphelenchus xylophilus*). Zhejiang, China, AR.

**Additional information:** Vascular diseases may occur in patches of dead and/or diseased trees. As vectors (e.g., root-feeding weevils) may be attracted by fresh wounds and stumps, thinning may contribute to initiate disease. For detecting staining, the bark has to be removed and the sapwood inspected. For pathogen collection and preservation, see Chapter 4.
13.3. Feeding and boring signs on bark or into wood

**Description:** Frass/dust at the base of the tree (Fig. 13.3.1) and/or presence of resin pitches/resin flows on the stem (Fig. 13.3.4). This material comes from holes (both entrance and exit holes of galleries) made by insects living under the bark or in the wood.

**Possible damaging agents:** Insects: Adults or larvae of different families of Coleoptera beetles: bark and ambrosia beetles (Scolytinae: Figs. 13.3.2 – 13.3.3), weevils (Curculionidae), longhorn beetles (Cerambycidae: Fig. 13.3.1), larvae of horntail sorwood wasps (Hymenoptera: Siricidae), and moths (Lepidoptera, Cossidae, Pyralidae: Fig. 13.3.4, Sesiidae).

**Fig. 13.3.1.** Stem of Siberian fir (*Abies sibirica*) with dust from galleries of larvae of longhorn beetles (Coleoptera, Cerambycidae: *Monochamus urussovi*). Siberia, Russia, YNB.

**Fig. 13.3.2.** Stem of Siberian larch (*Larix sibirica*) with dust from an entrance hole of bark beetles (Coleoptera, Curculionidae, Scolytinae: *Ips subelongatus*). Ulanbataar, Mongolia, YNB.

**Fig. 13.3.3.** Bark of Siberian fir (*Abies sibirica*) with saw dust from the exit holes of bark beetles (Coleoptera, Curculionidae, Scolytinae: *Polygraphus proximus*). Siberia, Russia, YNB.

**Fig. 13.3.4.** Stem of North-American pine (*Pinus* sp.) with pitch accumulation on the bark resulting from the feeding of pine moths (Lepidoptera, Pyralidae: *Dioryctria zimmermanni*). USA, WC.
**Additional information:** Try to find the hole from which frass/dust came – it can be at any height but likely not far from the base of the stem. If possible, try to find and sample adult or larvae in the gallery behind the hole; otherwise it will be almost impossible to identify the species. For insect collection and preservation, see Chapter 3.
13.4. Abiotic damage

**Description:** Large variations in stem, branch and twig damage may occur because of abiotic factors. The most frequent are detailed below.

**Possible damaging agents:**

**Frost** (Fig. 13.4.1.): Internal radial shake, frost cracks, growth loss and a general weakening.

- Frost lesions are created by frost-killed cambium. They are rough, callused patches on the main stem. Necrotic bark over time sloughs off to expose the sapwood. Raised lateral woody folds are called frost ribs and they surround older cankers. This type of injury generally occurs on young trees. Subsequent freezing of these lesions generally can cause internal radial shake seen as brownish, resin-soaked rings of disrupted wood.
- Frost cracks are generally seen in older trees. This type of damage is characterized by long, dark vertical cracks in the main stem.
- Late spring frosts are usually more injurious than early fall frosts. Reduced lateral and leader growth or tip dieback are common. Internal radial shake can adversely affect growth rates and wood quality. Frosts lesions or frost cracks act as entry points for decay fungi or can lead to stem breakage.

**Snow** (Fig. 13.4.2.): damage symptoms include temporarily or permanently bent main stems, depending on duration and movement of the snow pack and branch stripping or breakage, stem breakage, or uprooting. Symptoms are seen in small groups or on scattered individual trees in affected stands. Older trees can suffer from top breakage.

**Ice** (Fig. 13.4.3.): Abrasion of the main stem.

- Windblown ice crystals corrode portions of the main stem above the snowline. Affected areas of stem have a smooth appearance.

**Hail** (Fig. 13.4.4.): damage symptoms can be seen over a broader area and consist of stripped branches, stem lesions, scars and bruises on the upper surface of branches or tattered, ragged crowns with missing foliage and buds. Damage symptoms are aligned in one direction. Buds, foliage, and branches litter the ground.

**Wind** (Fig. 13.4.5.):

- Strong winds can cause branches to break off or uproot the entire tree. Uprooted trees lie parallel, often with a large mass of roots and soil attached. Damage can be in small areas or extended to larger areas. Susceptible trees are often diseased and located along the margin of an area, have shallow roots because of a high water table or shallow soils, or are stressed by other factors, such as poor drainage.

**Wounds:** Bark removal, gouges, cracks, cankers in the bark, blackened carbon.

**Fire** (Fig. 13.4.6.): Fire wounds are identified by charred and blackened bark. Fire injury to foliage can be from direct burning or from radiant heat. Mortality is common, especially if stems are affected.

**Mechanical damage:** Mechanical wounds, typically caused by logging activities, are commonly found as gouges on the lower trunk.
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Fig. 13.4.1. Loblolly pine (*Pinus taeda*) stems breakage as a result of frost and winter injury. USA, TT.

Fig. 13.4.2. Top breakage of old Scots pines (*Pinus sylvestris*) due to the snow load on the crown. Olesno, Poland, MN.

Fig. 13.4.3. Scots pine (*Pinus sylvestris*) stems breakage as a result of icing and accumulation of wet snow masses. Katowice, Poland, MN.

Fig. 13.4.4. Scars, bruises and tattered lesions on the upper surface of Norway spruce (*Picea abies*) twigs caused by hail. Slavske, Ukraine, VK.

Fig. 13.4.5. Windthrown Norway spruce (*Picea abies*) trees after the storm Cyryl. Jeleśnia, Poland, MKA.

Fig. 13.4.6. Fire damage in Scots pine forest (*Pinus sylvestris*). Brody, Ukraine, VK.

**Additional information:** Lateral shoots often take over when terminal shoots are frost-damaged. Older seedlings or saplings that have repeatedly experienced frost develop a bushy growth form. Healthy, vigorous seedlings and succulent new needles appear to be more sensitive to summer frost damage. Frost cracks sometimes can be mixed with lightning hits. However, lightning injury leaves a
more jagged furrow in the bark and may have an accompanying broken top. A
variety of biotic and abiotic agents can cause damage resembling frost damage.
For example, repeated frost injury resembles damage caused by animal browsing.
Consider climatic conditions and look for signs of animal activities to distinguish
between these agents. Heavy snowfall or hail can cause significant mortality in
young plantations. Losses occur in patches or as scattered individual trees.
Growth is reduced when foliage and buds are removed. In younger trees,
deformity results from permanently bent main stems or broken tops due to snow
press. Deformity of older trees is caused by top breakage. Hail-related branch or
stem scars and top breakage act as entry points for disease. Tree mortality occurs
when a tree is toppled. Trees exposed to continuous wind exposure, especially in
higher elevations, are vulnerable to winter desiccation damage. Trees that fall
because of root rot, break at the root collar and lie in a crisscross pattern in root-
disease centres.
13.5. Cankers

**Description:** Cankers on trees consist of localized dead (necrotic) sections of bark on stems, branches or twigs. Cankers may appear swollen or sunken, and vary in shape and size. The bark appears discoloured compared to healthy bark, and is often cracked at the margin. Resin flow usually occurs on the canker surface and can be particularly pronounced at its margins. Once a canker has girdled the affected tree part, the stem/branch/twig distal to the canker dies. If the trunk is affected, the entire tree eventually dies. The ability of the tree to heal around wounded tissue depends to some extent on the vigour of the tree. Most plant pathogens are unable to penetrate healthy bark directly but can successfully invade wounded bark tissue. Cankers caused by fungi on stems, branches and twigs may be annual (lasting for one year), perennial (lasting for multiple years usually evident by concentric rings of callus), or diffuse (where necrosis spread is so rapid that the host does not have the opportunity to build barriers, e.g., wound periderm and callus, to stop it). Multiple cankers can be present on a single tree.

**Possible damaging agents:** **Fungi:** Ascomycota, Basidiomycota, mitosporic fungi (Figs. 13.5.1 - 13.5.5).

**Fig. 13.5.1.** Swollen, resinous cankers caused by the necrotrophic pathogen (*Lachnellula willkommii*) on twigs of larch (*Larix* spp.). Austria, TC.

**Fig. 13.5.2.** Canker on the stem of pine (*Pinus* spp.) caused by a pine dieback fungus (*Crumenulopsis sororia*). Austria, TC.
Fig. 13.5.3. Resin flow caused by a canker pathogen (*Seiridium cardinale*) on a branch of a cypress tree (*Cupressus sempervirens*). Italy, WSL.

Fig. 13.5.4. Swollen tissue surrounding a canker caused by *Neonectria fuckeliana* on Norway spruce (*Picea abies*). Akershus county, Norway, VT.

Fig. 13.5.5. Resin flow caused by *Neonectria fuckeliana* and signs of the pathogen (red fruiting bodies) on bark of Norway spruce (*Picea abies*). Akershus county, Norway, VT.

**Additional information:** For fungal collection and preservation, see Chapter 4.
13.6. Emergence or exit holes and galleries under bark

**Description:** Emergence or exit holes are usually visible on the bark. Galleries go under the bark, sometimes into the wood. Often they have hardened resin walls around a hole through the bark into the wood (more often on the bark of stems, less often on twigs or branches). Exit holes may also correspond to insect parasitoids.

**Possible damaging agents:** Insects: Adults of several families of Coleoptera (Anobiidae, Buprestidae: Fig. 13.6.3, Cerambycidae: Figs. 13.6.3, 13.6.5, Curculionidae: Fig. 13.6.1, Scolytinae: Figs. 13.6.2, 13.6.4, 13.6.5, Lyctidae, etc.), adults of Hymenopteran horntails or wood wasps (Siricidae and Sesiidae).

**Fig. 13.6.1.** Twig of Yunnan pine (*Pinus yunnanensis*) with emergence holes of adult weevils (Coleoptera, Curculionidae: *Pissodes yunnanensis*). Dali, China, AR.

**Fig. 13.6.2.** Stem of Norway spruce (*Picea abies*) with entrance holes of a bark beetle (Curculionidae, Scolytinae: *Dendroctonus micans*). Trabzon, Turkey, NK.

**Fig. 13.6.3.** Stem of cypress (*Cupressus sempervirens*) with adult emergence holes of different species of beetles (Coleoptera, Cerambycidae - circular holes; Buprestidae - D-shaped holes). Epidaurus, Greece, AR.

**Fig. 13.6.4.** Branch of a Norway spruce (*Picea abies*); bark partly removed to expose galleries of a bark beetle (Curculionidae, Scolytinae: *Pityogenes chalcographus*). Korbielów, Poland, MKA.
Fig. 13.6.5. Stem of Siberian fir (*Abies sibirica*) with exit hole of a longhorn beetle (Coleoptera: Cerambycidae: *Monochamus urussovi*). Siberia, Russia, YNB.

Fig. 13.6.6. Galleries of a bark beetle (Coleoptera, Curculionidae, Scolytinae: *Polygraphus proximus*) under the bark of Siberian fir (*Abies sibirica*). Siberia, Russia, YNB.

**Additional information:** Try to carefully open the hole and collect adults or larvae in the gallery behind it. Otherwise, it will be almost impossible to identify the species. Note with precision the shape of the hole (e.g., perfectly circular, ovoid, etc.) which can be helpful for identification of the family of the damaging agent. For insect collection and preservation, see Chapter 3.
13.7. Twig boring

**Description:** Larvae of insects from different orders construct tunnels inside twigs of conifers. Twigs then bend and might dry. Bark of twigs may be eaten by larvae.

**Possible damaging agents:** Insects: Larvae of moths (Pyralidae, Tortricidae: Figs. 13.7.1, 13.7.2, 13.7.4) and beetles (Curculionidae [weevils: Fig. 13.7.3], Scolytinae [bark beetles]).

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**Fig. 13.7.1.** Twig of ponderosa pine (*Pinus ponderosa*) with an opening of a tunnel and a larva of the ponderosa pine tip moth (Lepidoptera: Tortricidae: *Rhyacionia zozana*). California, USA, DO.

**Fig. 13.7.2.** Twig of a pine (*Pinus* sp.) with an open tunnel of a larva of the European pine shoot moth (Lepidoptera: Tortricidae: *Rhyacionia buoliana*). Poland, MS.

**Fig. 13.7.3.** Twig of Yunnan pine (*Pinus yunnanensis*) opened to show internal gallery causes by weevils (Coleoptera: Curculionidae: *Pissodes yunannensis*). Note the weevil pupa. Dali, China, AR.

**Fig. 13.7.4.** Twig of a pine (*Pinus* sp.) with an open tunnel of a larva of the European pine shoot moth (Lepidoptera: Tortricidae: *Rhyacionia buoliana*). Ásotthalom, Hungary, GC.

**Additional information:** Twigs should be photographed and then carefully opened to allow collection and preservation of the damaging larvae. If you find a viable larva or pupa inside the tunnel, try to rear it to the adult stage and save a moth for proper identification. For insect collection and preservation, see Chapter 3.
13.8. Maturation feeding

**Description:** Scars on the bark or pieces of bark removed/damaged by gnawing. Might be with or without resin around.

**Possible damaging agents: Insects:** Adults of Coleoptera (Cerambycidae (longhorn beetles): Fig. 13.8.1) and weevils (Curculionidae: Figs 13.8.2 – 13.8.4).

Fig. 13.8.1. Female of a longhorn beetle (Coleoptera, Cerambycidae: *Monochamus urussovi*) at the moment of maturation feeding on a twig of Siberian fir (*Abies sibirica*). Siberia, Russia, YNB.

Fig. 13.8.2. Seedlings of an unknown conifer species damaged by maturation feeding of a bark beetle (Coleoptera, Cerambycidae: *Hylastes ater*). Chile, WMC.

Fig. 13.8.3. Stem of a young pine (*Pinus* sp.) with signs of maturation feeding of a weevil (Coleoptera: Curculionidae: *Hylobius abietis*). Slovakia, MZ.

Fig. 13.8.4. Twig of Norway spruce (*Picea abies*) with large brown trunk beetle (Coleoptera: Curculionidae: *Hylobius abietis*) and its maturation feeding. Uppsala, Sweden, CH.

**Additional information:** It is usually impossible to identify an actual damaging agent if it is not collected during the process of maturation feeding. As this kind of feeding usually takes place in spring or early summer, try to start observation early in the season. For insect collection and preservation, see Chapter 3.
13.9. Rust canker

**Description:** The affected stems, branches or twigs may become swollen and deformed. Resin flow is frequently visible on the canker surface. Abundant production of blister-like fruiting bodies may emerge from cankers and represent the most obvious diagnostic trait. However, these fruiting bodies are produced only at a certain time of the season and may last only for a short period, depending on the weather conditions.

**Possible damaging agents:** *Fungi:* Basidiomycota (Pucciniales: Fig. 13.9.1 – 13.9.4).

**Fig. 13.9.1.** Orange-yellow blisters of a rust fungus (*Cronartium ribicola*) on a branch of Weymouth pine (*Pinus strobus*). Lviv, Ukraine, VK.

**Fig. 13.9.2.** White pine blister rust fungus (*Cronartium ribicola*) on Weymouth pine (*Pinus strobus*) (aecial stage). Lviv, Ukraine, VK.

**Fig. 13.9.3.** Singleleaf pinyon (*Pinus monophylla*) with a sporulating stem canker caused by the blister rust pathogen *Cronartium occidentale*. Douglas County, Nevada, USA, BS.

**Fig. 13.9.4.** Close-up view of fruiting bodies (pycnia) of the fusiform rust fungus (*Cronartium quercuum* f.sp. *fusiforme*) with resin flow. USA, RLA.
**Fig. 13.9.5.** Necrotic blighted shrivel needles and twisted top of Scots pine (*Pinus sylvestris*) caused by a rust fungus (*Melampsora pinitorqua*). Note: A similar symptom can be caused by shoot moths (see section 13.7). Stradch, Ukraine, VK.

**Fig. 13.9.6.** Dieback of Eastern white pine (*Pinus strobus*) twigs and deformation due to a rust fungus (*Cronartium ribicola*). Banská Štiavnica, Slovakia, AK.

**Additional information:** All rust fungi are obligate parasites and most of them are characterized by complex life cycles, generally involving two unrelated host plant species (primary host and alternate host). For pathogen collection and preservation, see Chapter 4.
13.10. Feeding signs or attached scales

**Description:** More or less visible punctures on the bark left by sucking insects, or sucking insects themselves in cracks of bark or sometimes on the bark and then firmly attached to the bark.

**Possible damaging agents: Insects:** Hemiptera adults and nymphs (Aphididae: aphids: Figs. 13.10.5 – 13.10.6, Coccidae: scales: Figs. 13.10.1 – 13.10.2 and other families, true bugs (Aradidae: Figs. 13.10.3 – 13.10.4, Coreidae, and other families).

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**Fig. 13.10.1.** Twig of bishop pine (*Pinus muricata*) with adult of the Monterey pine scale attached (Hemiptera, Homoptera, Coccidae: *Physokermes insignicola*). USA, USNCSIP.

**Fig. 13.10.2.** Twig of fir (*Abies* sp.) with attached adult of a soft scale (Hemiptera, Homoptera, Coccidae: *Physokermes concolor*). USA, USNCSIP.

**Fig. 13.10.3.** Long-winged female of a flat bug (Hemiptera, Heteroptera: *Aradus cinnamomeus*) in a crack of pine (*Pinus* sp.) bark. Kharkiv, Ukraine, BML.

**Fig. 13.10.4.** Short-winged female of a flat bug (Hemiptera, Heteroptera: *Aradus cinnamomeus*) in a crack of pine (*Pinus* sp.) bark. Kharkiv, Ukraine, BML.
Fig. 13.10.5. Pine twig (*Pinus* sp.) colonized by aphids (Homoptera, Aphididae: *Cinara strobi*). USA, JB.

Fig. 13.10.6. Stem of a fir (*Abies* sp.) colonized by aphids (Homoptera, Aphididae: *Cinara* sp.). USA, OG.

**Additional information:** It is usually impossible to identify an actual damaging agent if it is not collected during the process of feeding. Flat bugs usually spend a long time (months or years) at the same regions of the stem (sometimes in the same cracks of bark). Adults of scale insects are firmly attached to the bark. For insect collection and preservation, see Chapter 3.
13.11. Galls

**Description:** Twigs or branches have swelling or abnormal rounded outgrowth of woody tissues, often with a lot of hardened resin (resin galls). A moth’s larva lives inside the gall.

**Possible damaging agents:** Larvae of Lepidoptera (e.g., Tortricidae: Figs. 13.11.1 – 13.11.3) and Diptera (Cecidomyiidae midges: Fig. 13.11.4).

**Fig. 13.11.1.** Resin gall of a tortricid moth (Lepidoptera, Tortricidae: *Retinia resinella*) on a branch of pine (*Pinus* sp.). Ásotthalom, Hungary, GC.

**Fig. 13.11.2.** A tortricid moth (Lepidoptera, Tortricidae: *Retinia resinella*) in the resin gall on pine (*Pinus* sp.). Ásotthalom, Hungary, GC.

**Fig. 13.11.3.** Branch of larch (*Larix* sp.) with a gall caused by a tortricid (Lepidoptera, Tortricidae: *Cydia*). Sopron, Hungary, GC.

**Fig. 13.11.4.** Stem of white spruce (*Picea glauca*) with galls of the spruce gall midge (Diptera, Cecidomyiidae: *Dasineura piceae*). Minnesota, USA, SK.

**Additional information:** Galls should be photographed and might then be carefully opened to allow collection and preservation of the damaging larvae. If you find a viable larva or pupa inside the tunnel, try to rear it to the adult stage and save a moth for proper identification. For insect collection and preservation, see Chapter 3.
13.12. Witches’ brooms

**Description:** Witches' broom is a dense cluster of shoots growing from a single point (resembling a broom). These shoots are frequently thicker and shorter than normal ones. Similarly, needles on these shoots may be short and thickened. Consequently, the natural structure of the tree may be changed. The broom may grow for the entire life of the host tree and can reach a considerable size. Cones are usually not formed on witches’ brooms.

**Possible damaging agents:** Fungi: Basidiomycota (Pucciniales), Hemiparasitic plants (mistletoe and dwarf mistletoe), Insects, Phytoplasmas, Viruses (Figs. 13.12.1 – 13.12.7).

![Fig. 13.12.1. Witches’ broom on Scots pine (Pinus sylvestris). Rogaland county, Norway, VT.](image1)

![Fig. 13.12.2. Witches’ broom caused by the fir broom rust pathogen Melampsorella caryophyllacearum on a branch of Silver fir (Abies alba). Skole, Ukraine, VK.](image2)

![Fig. 13.12.3. Blue spruce (Picea pungens) with witches’ broom caused by the rust fungus Chrysomyxa arctostaphyli on the twigs. WMC.](image3)

![Fig. 13.12.4. Close-up view of telial cushions on foliage of incense cedar (Calocedrus decurrens), caused by incense cedar broom rust (Gymnosporangium libocedri). USA, DO.](image4)
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Fig. 13.12.5. Douglas-fir (*Pseudotsuga menziesii*) with witches' brooms caused by Douglas-fir dwarf mistletoe (*Arceuthobium douglasii*). USA, JT.

Fig. 13.12.6. Close-up view of Juniper dwarf mistletoe plant (*Arceuthobium oxycedri*) on Indian juniper (*Juniperus polycarpos*). USA, WMC.

Fig. 13.12.7. Dwarf mistletoe (*Viscum album* subsp. *austriacum*) on a twig of Scots pine (*Pinus sylvestris*). Radechiv, Ukraine, VK.

**Additional information:** For fungal collection and preservation, see Chapter 4.
13.13. Mammal and bird damage

Description: In forests trees sometimes have stems, branches or twigs with large signs of mechanical damage (holes, wounds, browsed tips of the branches, etc.) caused by vertebrate animals during their feeding, especially in winter or spring. Possible damaging agents: Birds (Fig. 13.13.1) and, more often, mammals (Figs.13.13.2 – 13.13.6).

Fig. 13.13.1. Stem of Siberian larch (Larix sibirica) with holes made by a woodpecker (Aves: Picidae) while it procured resin in spring. Southern Siberia, Russia, YNB.

Fig. 13.13.2. A forest road covered with snow and tips of twigs of Norway spruce (Picea abies) cut by squirrel (Mammalia: Sciuridae). St. Petersburg, Russia, AVS.

Fig. 13.13.3. Stem of Norway spruce (Picea abies) damaged by wild boar (Mammalia: Suidae: Sus scrofa). St. Petersburg, Russia, NVS.

Fig. 13.13.4. A young Scots pine (Pinus sylvestris) tree damaged by elk (Mammalia: Cervidae: Alces alces). St. Petersburg, Russia, NVS.
Fig. 13.13.5. Stem of Norway spruce (*Picea abies*) damaged by wild boar (Mammalia: Suidae: *Sus scrofa*). St. Petersburg, Russia, NVS.

Fig. 13.13.6. A stem of Norway spruce (*Picea abies*) damaged by elk (Mammalia: Cervidae: *Alces alces*). St. Petersburg, Russia, NVS.

**Additional information:** Damage signs should be photographed. For species identification, direct observation or consultation with local zoologists or game managers are needed.