



Damage to flowers, cones and seeds of coniferous woody plants. Chapter 12

Alain Roques, Venche Talgø, Jian-Ting Fan, Marie-Anne Auger-Rozenberg

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12

Damage to flowers, cones and seeds of coniferous woody plants

A. Roques, V. Talgø, J.-T. Fan and M.-A. Auger-Rozenberg

12.1. Thrips-induced male flower distortion

Description: Flower distorted or shrivelled (Fig. 12.1.1); minute insects present among pollen grains (Fig. 12.1.2).

Possible damaging agents: Insects: Adults of Thysanoptera (Thrips: Fig. 12.1.2)



Fig.12.1.1. Male flowers of Yunnan pine (*Pinus yunnanensis*), deformed by thrips. Lijiang, China, AR.

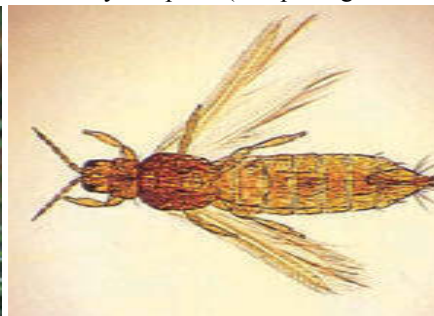


Fig. 12.1.2. A minute thrips (1.5 mm long) that can be found in shrivelled male flowers of *Pseudotsuga macrolepis*. Mexico, DCT.

Additional information: Collect male flowers at time of flowering and dissect pollen bags, look for minute insects (Fig. 12.1.2). For insect collection and preservation, see Chapter 3.

12.2 Damage by external pollen feeders

Description: Flower surface chewed or gnawed, or with some parts removed.

Possible damaging agents: Insects: adults of many families of Coleoptera (Alleculidae: Fig. 12.2.1, Cantharididae, Curculionidae, Elateridae: Fig. 12.2.2, Meloidae, Scarabaeidae, etc.).



Fig. 12.2.1. Male flower of Scots pine (*Pinus sylvestris*) attacked by adult beetles (Coleoptera, Alleculidae). Briançon, France, AR.



Fig. 12.2.2. A click beetle (Coleoptera, Elateridae: *Athous haemorrhoidalis*) on male flower of Scot pine (*Pinus sylvestris*). UK, AP.

Additional information: Observation usually occurs by chance or by beating flowering branch over a Japanese umbrella. For insect collection and preservation, see Chapter 3.

12.3. Damage by internal pollen feeders

Description: Pollen catkins with sunken areas (Fig. 12.3.1), resin pitch (Fig. 12.3.3) or webbing (Fig. 12.3.2); presence of insect larva(e) between pollen grains (Figs. 12.3.1 - 12.3.4) and/or tunnel(s) filled with frass.

Possible damaging agents: Insects: larvae of various Lepidoptera families (Blastobasidae, Pyralidae, etc.) and Hymenoptera (Xyelidae sawflies).



Fig. 12.3.1. Pollen catkin of slash pine (*Pinus elliotti*) tunnelled by a moth larva (Lepidoptera, Blastobasidae: *Holcocera* sp.). USA, AFH.



Fig.12.3.2. Pollen catkins of pine (*Pinus* sp.) with webbing due to early instar larvae of cone moths (Lepidoptera, Pyralidae: *Dioryctria disclusa*). USA, LB.



Fig. 12.3.3. Pollen catkins of slash pine (*Pinus elliotti*) with resin pitches, indicating attack by hymenopteran sawfly larvae (Hymenoptera, Xyleidae: *Xylea* sp.). USA, AFH.



Fig. 12.3.4. *Xylea* larvae emerged from drying slash pine (*Pinus elliotti*) catkins shown in Fig. 12.3.3. USA, AFH.

Additional information: Collect flowers just before pollen shed and dissect them to find larvae. For insect collection and preservation, see Chapter 3.

12.4. Sap-feeder damage on female flowers

Description: Strobilus, flower or conelet drying, without frass expelled. Presence of resin beads (Figs. 12.4.1 - 12.4.2) or not (Figs. 12.4.3 - 12.4.4).

Possible damaging agents: **Insects:** Thysanoptera (e.g., Phlaeothripidae, Thripidae: Figs. 12.4.1 - 12.4.2), Hemipteran seed bug families (e.g., Coreidae, Pentatomidae, Lygaeidae: Fig. 12.4.3), **Mites:** Acari (Eriophyiidae: Fig. 12.4.4).



Fig. 12.4.1. Dried female flower of Mexican Douglas-fir (*Pseudotsuga macrolepis*) following attack by thrips (Thysanoptera). Mexico, DCT.



Fig. 12.4.2. Female conelet of slash pine (*Pinus elliottii*) with resin pitches, damaged by flower thrips (Thysanoptera, Phlaeothripidae: *Gnophothrips fuscus*). USA, BHE.



Fig. 12.4.3. Conelet of shortleaf pine (*Pinus echinata*), aborted following predation by a seed bug (Hemiptera, Coreidae: *Leptoglossus corculus*) (right), besides healthy conelet (left). USA, AFH.



Fig. 12.4.4. Drying female flower (bottom right, healthy ones towards tip) of Chinese cypress (*Cupressus duclouxiana*) following attack by mites (Acari, Eriophyiidae: *Trisetacus* sp.). Lijiang, China, AR.

Additional information: Look for bite marks on the pedicel (mite damage), resin pitches on surface (thrips damage) or for insect feeding damage by sucking insects (bugs). Usually the insects found at openings in dead flowers or conelets are secondary, detritivorous species (e.g., midge larvae). For insect collection and preservation, see Chapter 3. Such damage can also result from physiological disorders (e.g., absence of pollination) or abiotic factors (e.g., frost: see 12.5.).

12.5. Abiotic factors affecting flowers or cones

Description: Flower, conelet or cone dried without any insect, mite or fungal damage visible at opening, and no exit holes visible.

Possible damaging agents: Late frost, drought, pollution.



Fig. 12.5.1. Female flower of Himalayan larch (*Larix potaninii*) killed by late frost. Lijiang, China, AR.



Fig. 12.5.2. Female flower of Douglas fir (*Pseudotsuga menziesii*) killed by late frost during bud break. USA, USDA1.



Fig. 12.5.3. Female flowers of Norway spruce (*Picea abies*; circled in red) killed by late frost. Latronquière, France, CB.



Fig. 12.5.4. Cone of introduced Mexican pine (*Pinus rudis*) with dried base due to summer drought (no insect tunnels or exit holes). Bormes, France, AR.

Additional information: Dissect the cones and flowers to ascertain the absence of pests, as well as of pest damage (tunnels, frass, etc.). Some insects may be found at opening in dead flowers and cones but they are secondary, detritivorous species and do not tunnel the substrate (e.g., midge and other fly larvae).

12.6. External insect damage on female flowers/conelets

Description: External surface gnawed.

Possible damaging agents: Insects: Adults of Coleopteran beetle families (e.g., Rutelidae, Scarabaeidae: Fig. 12.6.1), larvae of Lepidoptera families (e.g., Geometridae, Tortricidae: Fig. 12.6.2) and Hymenoptera (sawflies).



Fig. 12.6.1. An adult scarab beetle (Coleoptera, Scarabaeidae: *Phyllophaga* sp.) feeding on female flowers of loblolly pine (*Pinus taeda*). USA, AFH.



Fig. 12.6.2. Young cone of European larch (*Larix decidua*), gnawed by a larva of larch budmoth (Lepidoptera, Tortricidae: *Zeiraphera griseana*). Briançon, France, AR.

Additional information: Observation by chance (feeding may occur at night) or by beating flowering branches. For insect collection and preservation, see Chapter 3.

12.7. Arthropod-induced flower/conelet distortion

Description: Strobilus/conelet distorted with parts hypertrophied (Figs. 12.7.1 - 12.7.2), usually with resin pitch beads or damaged/dicoloured scales, but without frass or holes visible on the surface. In Cupressaceae, immature seeds can protrude from young berries/cones due to mite infestation (Figs. 12.7.3 - 12.7.4).

Possible damaging agents: **Insects:** larvae of Diptera (Cecidomyiidae, midges: Figs. 12.7.1 - 12.7.2), **Mites:** Acari (Eriophyiidae: Figs. 12.7.3 - 12.7.4).



Fig. 12.7.1. Conelet of slash pine (*Pinus elliotii*) damaged by midge larvae (Diptera, Cecidomyiidae: *Cecidomyia bisetosa*). USA, AFH.



Fig. 12.7.2. Conelet of Korean pine (*Pinus koraiensis*), deformed by midge larvae (Diptera, Cecidomyiidae: *Cecidomyia pini*). Briançon, France, AR.



Fig. 12.7.3. Female flower of incense juniper (*Juniperus thurifera*) with protruding immature seeds due to mites (Acari, Eriophyiidae: *Trisetacus* sp.). Oukaïmden, Morocco, AR.



Fig. 12.7.4. First-year cone of evergreen cypress (*Cupressus sempervirens*) with scale edges deformed by mites (Acari, Eriophyiidae: *Trisetacus* sp.). Toulon, France, AR.

Additional information: Dissect conelet and look for small larvae, whitish to orange. For insect collection and preservation, see Chapter 3.

12.8. Internal insect damage on female flower/conelet

Description: Strobilus/conelet with expelled frass on surface (Figs. 12.8.1, 12.8.3), sometimes mixed with resin pitches (Fig. 12.8.2). Emergence hole(s) may be present (Fig. 12.8.5) or larva(e) or tunnel(s) visible when dissected (Figs. 12.8.4, 12.8.6).

Possible damaging agents: Insects: Larvae and adults of Coleoptera families (e.g., Scolytinae: *Conophthorus* spp., Anobiidae: *Ernobius* spp.: Figs. 12.8.5 – 12.8.6), larvae of Lepidoptera families (e.g., Pyralidae: *Dioryctria* spp.: Figs. 12.8.2 - 12.8.3, Tortricidae: Figs. 12.8.2 – 12.8.3).



Fig. 12.8.1. Female flowers of *Pinus simaoensis* attacked by unidentified larvae of a bud moth (Lepidoptera, Tortricidae). Simao, China, AR.



Fig. 12.8.2. Conelet of Turkish pine (*Pinus brutia*) showing frass mixed with resin expelled by larva of cone pyralid (Lepidoptera, Pyralidae: *Dioryctria mendacella*). Rhodos, Greece, AR.



Fig. 12.8.3. Conelet of Aleppo pine (*Pinus halepensis*) with frass expelled by larva of cone pyralid (Lepidoptera, Pyralidae: *Dioryctria mendacella*). Marrakech, Morocco, AR.



Fig. 12.8.4. Damaged conelet of Scots pine (*Pinus sylvestris*) stuck to the sustaining twig by resin (left) and opened (right) to show the budmoth larva (Lepidoptera, Tortricidae: *Rhyacionia buoliana*). Briançon, France, AR.



Fig. 12.8.5. Conelet of Turkish pine (*Pinus brutia*) with exit holes of adult deathwatch beetles (Coleoptera, Anobiidae: *Ernobius oertzeni*). Pylos, Greece, AR.



Fig. 12.8.6. Conelet of Yunnan pine (*Pinus yunnanensis*), opened to show a deathwatch beetle larva (Coleoptera, Anobiidae: *Ernobius* sp.). Dali, Yunnan, China, AR.

Additional information: Dissect the conelet and extract larva(e) if still present. For insect collection and preservation, see Chapter 3.

12.9. Cone rust

Description: Strobilus/conelet with powdery masses of yellow-orange spores on the surface. Infected cones turn brown prematurely and are easily identified by the presence of orange-coloured aeciospores, which form between the cone scales in late summer.

Possible damaging agents: Fungi: Basidiomycota (Pucciniales: Figs. 12.9.1 – 12.9.4, Uredinales: Figs. 12.9.5 – 12.9.6).



Fig. 12.9.1. Swollen 1st-year conelet of slash pine (*Pinus elliottii*) covered by bright yellow aeciospores of southern cone rust (Basidiomycota, Pucciniales: *Cronartium strobilinum*). USA, USDA1.



Fig. 12.9.2. Comparison of a disease-free 1st-year conelet (right) of slash pine (*Pinus elliottii*) with a conelet of same whorl (left), which has become 3-4 times larger because of infection by southern cone rust (Basidiomycota, Pucciniales: *Cronartium strobilinum*). USA, ELB.



Fig. 12.9.3. Cone of spruce (*Picea mariana*) with aeciospores produced beneath the cone scales by inland spruce cone rust (Basidiomycota, Pucciniales: *Chrysomyxa pirolata*). Entire cone and cross-section. Canada, JRS.



Fig. 12.9.4. Enlarged cone of *Pinus leiophylla* var. *chihuahuana* with scales covered by masses of aeciospores of southwestern pine cone rust. (Basidiomycota, Pucciniales: *Cronartium conigenum*). Southern USA, BHE.

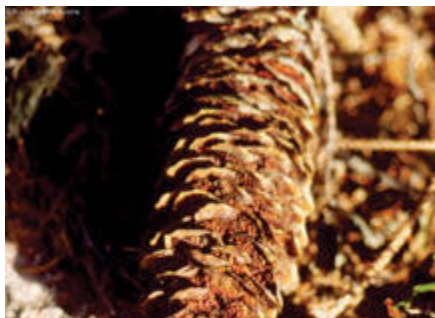


Fig. 12.9.5. Norway spruce (*Picea abies*) cone with sporocarps of a rust (Basidiomycota, Uredinales: *Pucciniastrum areolatum*) that destroys the seed. Austria, TC.



Fig. 12.9.6. Norway spruce (*Picea abies*) cones with fruiting bodies containing aeciospores of a rust (Basidiomycota, Uredinales: *Pucciniastrum areolatum*). Slovakia, AK.

Additional information: A light "dusting" of aeciospores is often observed on vegetation beneath trees with diseased cones. Mycelium of uredinial and telial stages are systematic on the petioles of the alternative broadleaf host species (*Prunus* spp., *Pyrola* spp. and *Moneses* spp.). For fungal preservation and collection, see Chapter 4.

12.10. Sap feeder damage

Description: Presence of whitish/yellowish, non-resin, waxy coverings or woolly organisms on surface; possible presence of honeydew (Fig. 12.10.4).

Possible damaging agents: Insects: Hemiptera, especially scales (Coccoidae, Diaspididae: Figs. 12.10.1 – 12.10.3), Adelgidae (Fig. 12.10.4) and aphids (Aphididae).



Fig. 12.10.1. Cone of Atlas cypress (*Cupressus atlantica*) heavily attacked by scales (Hemiptera, Coccidae). Oukaïmden, Morocco, AR.



Fig. 12.10.2. Cone of incense juniper (*Juniperus thurifera*) with scales on the surface (Hemiptera, Coccidae: *Carulaspis juniperi*). Rié, France, AR.



Fig. 12.10.3. Cone of stone pine (*Pinus pinea*), heavily colonized by scales (Hemiptera, Coccidae). Carrapateira, Portugal, AR.



Fig. 12.10.4. Spruce cone (*Picea* sp.) infested by woolly adelgids (Hemiptera, Adelgidae: *Adelges cooleyi*). USA, AFH.

Additional information:

Note whether the organism present on the surface is protected by a soft or hard covering (scale) or free living (aphid, woolly adelgid). For insect collection and preservation, see Chapter 3.

12.11. External frass protruding due to internal insect feeding

Description: Cone or berry with frass extruding from surface (Figs. 12.11.1 – 12.11.5), sometimes mixed with resin (Figs. 12.11.6 – 12.11.8).

Possible damaging agents: Insects: Larvae of Lepidoptera families (e.g., Gelechiidae, Geometridae, Pyralidae: Figs. 12.11.1, 12.11.2, 12.11.4, Tortricidae: Figs. 12.11.3, 12.11.6, 12.11.7, Yponomeutidae: Fig. 12.11.8), adults and larvae of Coleoptera families (e.g., Anobiidae, Curculionidae Scolytinae; *Conophthorus* spp.: Fig. 12.11.5).



Fig. 12.11.1. Cone of Aleppo pine (*Pinus halepensis*), attacked by larvae of cone pyralids (Lepidoptera, Pyralidae: *Dioryctria* sp.). Pylos, Greece, AR.



Fig. 12.11.2. The cone shown in 12.11.1, bisected to show the damaging larva. Pylos, Greece, AR.



Fig. 12.11.3. Cone of *Keteeleria evelyniana* with frass at basis, expelled by a coneborer larva (Lepidoptera, Tortricidae: *Blastipetrova* sp.). Dali, China, AR.



Fig. 12.11.4. Cone of George's fir (*Abies georgei*) with frass expelled by larvae of cone moths (Lepidoptera, Pyralidae: *Dioryctria* sp.). Dali, China, AR.



Fig. 12.11.5. Cone of eastern white pine (*Pinus strobus*) with frass and resin pitches caused by cone beetles (Coleoptera, Curculionidae Scolytinae: *Conophthorus coniperda*). USA, AFH.



Fig. 12.11.6. Cone of cypress pine (*Callitris* sp.) with frass expelled by a cone moth larva (Lepidoptera, Tortricidae: *Tracholena* sp.). Kamarah, Australia, AR.



Fig. 12.11.7. Cone of Syrian juniper (*Juniperus drupacea*) with frass expelled by larvae of cone tortricid moths (Lepidoptera, Tortricidae: *Pammene mariana*). Parnos mountain, Greece, AR.



Fig. 12.11.8. Berry of incense juniper (*Juniperus thurifera*) with frass expelled by cone moth larvae (Lepidoptera, Yponomeutidae: *Argyresthia reticulata*). Oukaïmden, Morocco, AR.

Additional information: Note whether the expelled frass is coarse or light, and combined with resin or not. Then, open the cone and extract larvae/adults, and note the shape of the tunnel. For insect collection and preservation, see Chapter 3.

12.12. Diptera-induced resin pitch

Description: Cone with a large resin pitch on its surface, but no frass extruding. Cone is at least partly desiccated and discoloured.

Possible damaging agents: Insects: larvae of Diptera (Anthomyiidae: Figs. 12.12.1 – 12.12.4).



Fig. 12.12.1. Cone of *Picea likiangensis* with a resin pitch caused by a cone fly larva (Diptera, Anthomyiidae: *Strobilomyia* sp.). Lijiang, China, AR.



Fig. 12.12.2. European fir (*Abies alba*) cone with desiccated apex and a resin pitch caused by a cone fly larva (Diptera, Anthomyiidae: *Strobilomyia carbonaria*). Briançon, France, AR.



Fig. 12.12.3. Cone of European larch (*Larix decidua*) with typical resinated base due to a cone fly larva (Diptera, Anthomyiidae: *Strobilomyia laricicola*). Briançon, France, AR.



Fig. 12.12.4. Cone of Himalayan larch (*Larix potaninii*) bisected to show the mature cone fly larva in the axis (Diptera, Anthomyiidae: *Strobilomyia lijiangensis*). Lijiang, China, AR.

Additional information: Open the cone and extract the maggot-like larvae present in tunnels. If the resin pitch has fallen from the cone, the discoloration of cones can lead to confusion with symptoms shown in Fig. 12.15.5. For insect collection and preservation, see Chapter 3.

12.13. Fungus-induced resin flow

Description: As a defense, conifers readily produce resin from tissue that is wounded by biotic or abiotic damaging agents, including from cones attacked by fungi. The resin is sticky and nearly colourless when it flows from the wounds, but becomes whitish and solid over time.

Possible damaging agents: Fungi: Ascomycota (Fig. 12.13.1), Basidiomycota (Fig. 12.13.2).



Fig. 12.13.1. Resin flow on Nordmann fir (*Abies nordmanniana*) cones infected by *Neonectria neomacrospora*. Jutland, Denmark, VT.



Fig. 12.13.2. Cones of white spruce (*Picea glauca*) with resin and yellowish aecidia of *Pucciniastrum americanum*. Canada, CFS.

Additional information: Harvesting of cones with heavy resin flow should be avoided to minimize the risk of seed borne diseases. For fungal collection and preservation, see Chapter 4.

12.14. Fungus-induced cone opening

Description: The cones open before maturity due to fungal agents that are dispersed by wind or insects.

Possible damaging agents: Fungi: Ascomycota (Fig. 12.14.1), Basidiomycota (Fig. 12.14.2).



Fig. 12.14.1. Cone of evergreen cypress (*Cupressus sempervirens*), prematurely opened due to cypress canker (*Seiridium cardinale*). Toulon, France, AR.



Fig. 12.14.2. Fruiting bodies (aecidia) of cone rust (*Thekopsora areolata*) between scales of Norway spruce (*Picea abies*). Akershus county, Norway, EF.

Additional information: Fungal attacks on immature cones are problematic in commercial seed production and may also influence natural regeneration. For fungal collection and preservation, see Chapter 4.

12.15. Insect-induced cone discoloration

Description: Cone or berry partly or entirely discoloured, but without frass extruding from surface, or resin pitch.

Possible damaging agents: Insects: Larvae of Coleoptera (Anobiidae: Fig. 12.15.5, Curculionidae: Figs. 12.15.1 – 12.15.4), Diptera (Anthomyiidae, Cecidomyiidae: Fig. 12.15.6) and Lepidoptera (Tortricidae: Figs. 12.15.7 – 12.15.8, Gelechiidae, Yponomeutidae).



Fig. 12.15.1. Cone of Chinese white pine (*Pinus armandii*) with purple discoloured parts due to internal feeding by unidentified weevil larvae (Coleoptera, Curculionidae). Chuxiong, Yunnan, China, AR.



Fig. 12.15.2. Cone of Aleppo pine (*Pinus halepensis*) with blackened parts corresponding to underlying tunnels of cone weevil larvae (Coleoptera, Curculionidae: *Pissodes validirostris*). Marseille, France, AR.



Fig. 12.15.3. Cone of maritime pine (*Pinus pinaster*) entirely discoloured and desiccated (right) following heavy attack by cone weevil larvae (Coleoptera, Curculionidae: *Pissodes validirostris*). Vila Real, Portugal, AR.



Fig. 12.15.4. The damaged cone shown in 12.15.3 bisected to show cone weevil larvae (Coleoptera, Curculionidae: *Pissodes validirostris*). Vila Real, Portugal, AR.



Fig. 12.15.5. Cone of Greek fir (*Abies cephalonica*), with discoloured apex following attack by deathwatch beetles (Coleoptera, Anobiidae: *Ernobius kailidisi*). Taygetos, Greece, AR.



Fig. 12.15.6. Cone of Siberian larch (*Larix gmelini*) with discoloured scales following attack by unidentified seed midges (Diptera, Cecidomyiidae). Jagedaqi, China, AR.



Fig. 12.15.7. Berry of incense juniper (*Juniperus thurifera*) partly discoloured due to cone borer larvae (Lepidoptera, Tortricidae: *Pammene oxycedrana*). Oukaïmden, Morocco, AR.



Fig. 12.15.8. Cone of evergreen cypress (*Cupressus sempervirens*) discoloured following attack by cone borer larvae (Lepidoptera, Tortricidae: *Pseudococcyx tessulatana*). Pylos, Greece, AR.

Additional information: If the cone is only partly discoloured and without exit holes, the damaging larvae are still present. Carefully cut the cone longitudinally (e.g., Fig. 12.15.4) and check the discoloured parts for the presence of larvae. For insect collection and preservation, see Chapter 3.

12.16. Fungi-induced cone discoloration

Description: Dark lesions on immature green cones.

Possible damaging agents: Fungi: Ascomycota (Fig. 12.16.1).



Fig. 12.16.1. Cones of loblolly pine (*Pinus taeda*) with necrosis caused by pitch canker (*Fusarium circinatum*). USA, LDD.

Additional information: No visible fruiting bodies or spores on the surface. For fungal collection and preservation, see Chapter 4.

12.17. Mite-induced cone distortion

Description: Berry distorted, with galled seeds more or less extruding from surface.

Possible damaging agents: Mites: Acari (Eriophyiidae: Figs. 12.17.1 – 12.17.4).



Fig. 12.17.1. Berries of incense juniper (*Juniperus thurifera*) with protruding seeds due to attack by seed mites (Acari, Eriophyiidae: *Trisetacus quadrisetus*). Soria, Spain, AR.



Fig. 12.17.2. A mite-damaged berry shown in Fig. 12.17.1., bisected to show the seeds entirely filled with frass and very tiny mites. AR.



Fig. 12.17.3. Berries of redberry juniper (*Juniperus coahuilensis*) with protruding seeds due to attack by seed mites (Acari, Eriophyiidae: *Trisetacus* sp.). Colorado, USA, AR.



Fig. 12.17.4. Berries of checkerbark juniper (*Juniperus deppeana*) with protruding seeds due to attack by seed mites (Acari, Eriophyiidae: *Trisetacus* sp.). New Mexico, USA, AR.

Additional information: Extract the protruding seed, open it and preserve the content (frass plus tiny mites) as detailed in Chapter 3. Galled seeds may contain mite parasites or predators of larger size.

12.18. Insect-induced cone distortion

Description: Cone noticeably distorted, but without seeds extruding from surface.

Possible damaging agents: Larvae of Diptera (Anthomyiidae: Fig. 12.18.4, Cecidomyiidae midges: Figs. 12.18.1 – 12.18. 2) and Thysanoptera (Thrips: Fig. 12.18.3).



Fig. 12.18.1. Cone of Swiss stone pine (*Pinus cembra*) deformed following attack by midge larvae (Diptera Cecidomyiidae *Cecidomyia pini*). Briançon, France, AR.



Fig. 12.18.2. Deformed cone (left) of Swiss stone pine (*Pinus cembra*) compared to a cone with normal development on the same whorl. Briançon, France, AR.



Fig. 12.18.3. Deformed mature cones of slash pine (*Pinus elliotii*) following an attack at the flowering stage by flower thrips (Thysanoptera, Phlaeothripidae: *Gnophothrips fuscus*). USA, AFH.



Fig. 12.18.4. Cone of European larch, *Larix decidua*, distorted and dessicated at its basis (left), following attack by cone fly larvae (Diptera, Anthomyiidae: *Strobilomya laricicola*). On the right, the same cone sliced to show the damaging larva and its tunnels. Briançon, France, AR.

Additional information: Such deformation is usually a consequence of attack during the early stages of cone development. The insects may no longer be present, but check for whitish or orange maggot-like larvae (Diptera) or minute insects (thrips). For insect collection and conservation, see Chapter 3.

12.19. Fungal damage

Description: Cones may be covered with dark fruiting bodies containing spores.

Possible damaging agents: Fungi: Ascomycota (Figs. 12.19.1 – 12.19.4).



Fig. 12.19.1. *Sirococcus* sp. on cone of noble fir (*Abies procera*). Vest-Agder county, Norway, VT.



Fig. 12.19.2. Fruiting bodies (pycnidia) of *Sirococcus* sp. on cone scales of noble fir (*Abies procera*). Vest-Agder county, Norway, VT.



Fig. 12.19.3 Fruiting bodies (pycnidia) of *Sirococcus* sp. on seed of noble fir (*Abies procera*). Vest-Agder county, Norway, VT.

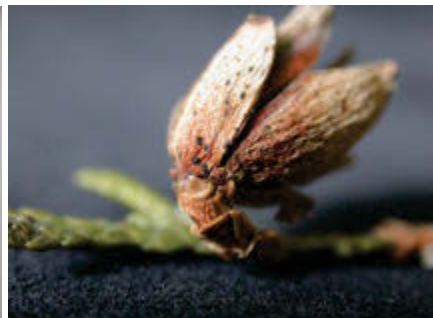


Fig. 12.19.4. *Seiridium cardinale* on a *Thuja* sp. Østfold county, Norway, VT.

Additional information: Fungi may still be the cause of damage if no fruiting bodies are visible. Thus, if seeds are not germinating, isolation on artificial media (agar) is often necessary to determine the cause.

12.20. Internal cone damage by larva, without external symptoms

Description: No frass or exit hole(s) on surface. Colour and development normal, but presence of larvae or tunnels when the cone is cut.

Possible damaging agents: **Insects:** larvae of Coleoptera (Anobiidae: Fig. 12.20.2, Ptinidae, etc.), Diptera (Cecidomyiidae: Fig. 12.20.4) and Lepidoptera (Gelechiidae, Tortricidae: Figs. 12.20.1, 12.20.3, Yponomeutidae).



Fig. 12.20.1. Cone of Lijiang spruce (*Picea likiangensis*) with normal development, bisected to show a larva of cone moth in the axis (Lepidoptera Tortricidae *Cydia* sp.). Lijiang, China, AR.



Fig. 12.20.2. Cone of Norway spruce (*Picea abies*) with normal development, bisected to show larvae of cone beetles along and in the axis (Coleoptera Anobiidae *Ernobius abietis*). Lot, France, AR.



Fig. 12.20.3. Cone of black pine (*Pinus nigra*) with normal development, bisected to show a cut gallery created by a seed moth (left) (Lepidoptera Tortricidae *Cydia conicolana*). Pylos, Greece, AR.



Fig. 12.20.4. Cone of European larch (*Larix decidua*) with apex removed to show midge larvae (Diptera, Cecidomyiidae: *Resseliella skhuravyorum*). Briançon, France, AR.

Additional information: Note the position of the larvae and the larval tunnels. For insect collection and preservation, see Chapter 3.

12.21. Adult emergence hole(s)

Description: Perfectly circular hole(s) in cone or berry external surface.

Possible damaging agents: Insects: Emerging adults of Coleoptera from several families (Anobiidae: Fig. 12.21.3, Cerambycidae: Fig. 12.21.2, Curculionidae: Fig. 12.21.1) and Hymenoptera (Eurytomidae, Torymidae: Figs. 12.21.4 – 12.21.6).



Fig. 12.21.1. Cone of maritime pine (*Pinus pinaster*) with exit holes of adult cone weevils (Coleoptera, Curculionidae: *Pissodes validirostris*). Buçaco, Portugal, AR.



Fig. 12.21.2. Cone of *Pinus simaoensis* with an exit hole of an adult cerambycid (Coleoptera, Cerambycidae: *Xylotrechus* sp.). Xishuanbanna, China, AR.



Fig. 12.21.3. Cone of Aleppo pine (*Pinus halepensis*) with numerous exit holes of adult cone deathwatch beetles (Coleoptera, Anobiidae: *Ernobius oertzenii*). Dubrovnik, Croatia, AR.



Fig. 12.21.4. Berry of incense juniper (*Juniperus thurifera*) with exit holes of adult seed chalcids (Hymenoptera, Torymidae: *Megastigmus thuriferana*). Saint Crépin, France, AR.



Fig. 12.21.5. Cone of Chinese cypress (*Cupressus duclouxiana*) with an exit hole of seed chalcids (Hymenoptera, Torymidae: *Megastigmus duclouxianae*). Lijiang, China, AR.



Fig. 12.21.6. Cone of Mediterranean cypress (*Cupressus sempervirens*) with exit holes of seed chalcids (Hymenoptera, Torymidae: *Megastigmus wachtli*). Samos, Greece, AR.

Additional information: Usually, insects are no longer present by the time damage is observed, but there may still be dead specimens present that did not emerge from the cone. Note the diameter of the exit hole. Emerging parasites of the phytophagous pests may also bear similar circular emergence hole(s). For insect collection and preservation, see Chapter 3.

12.22. Larval emergence hole(s)

Description: Presence of irregularly-shaped hole(s) on cone or berry external surfaces.

Possible damaging agents: Insects: mature larvae of many Lepidoptera (Gelechiidae: Fig. 12.22.3, Geometridae, Pyralidae: Figs. 12.22.1 – 12.22.2, Yponomeutidae), Diptera (Anthomyiidae: Fig.12.22.4, Cecidomyiidae) and Hymenoptera (Diprionidae), falling down to pupate on the ground (Fig. 12.22.4), or immature larvae of Lepidoptera switching from one cone or berry to another.



Fig. 12.22.1. Cone of Yunnan pine (*Pinus yunannensis*) with exit hole of a moth larva (Lepidoptera, Pyralidae: *Dioryctria* sp.). Lijiang, China, AR.



Fig. 12.22.2. Cone of Yunnan pine (*Pinus yunannensis*) with exit hole of a moth larva (Lepidoptera, Pyralidae: *Dioryctria* sp.). Lijiang, China, AR.



Fig. 12.22.3. Berry of prickly juniper (*Juniperus oxycedrus*) with exit hole created by a moth larva (Lepidoptera, Gelechiidae: *Brachyacma oxycedrella*); detail of the internal damage on the right. Corsica, France, AR.



Fig. 12.22.4. Cone of European larch (*Larix decidua*) with a larva emerging to pupate in the soil (Diptera, Anthomyiidae: *Strobilomya laricicola*). Briançon, France, AR.

Additional information: Usually, insects are no longer present by the time damage is observed, but there may still be dead specimens present that did not emerge from the cone. For insect collection and preservation, see Chapter 3.

12.23. Vertebrate damage

Description: Cone partially eaten with minor or major jagged edges; sometimes only the axis remains (Fig. 12.23.1).

Possible damaging agents: **Mammals:** Squirrels (Fig.12.23.1), mice, **Birds** (Fig.12.23.2).



Fig. 12.23.1. Cones of Douglas fir (*Pseudotsuga menziesii*) partially eaten by squirrels. Only the axis remains in some cones. Lot, France, AR.



Fig. 12.23.2. Cones of maritime pine (*Pinus pinaster*) attacked by birds. Lot, France, AR.

Additional information: Symptoms may appear that are characteristic of feeding damage. However, the cones may also be infested by insect larvae which can be used for food by birds. So further investigation is required.

12.24. Insect-induced seed fusion

Description: Seeds fused with scales or galled, cannot disperse out of the cone.

Possible damaging agents: Insects: Larvae of Diptera (Cecidomyiidae gall midges: Figs. 12.24.1 – 12.24.2) and adults and nymphs of Hemipterans: true bugs of several families (e.g., Coreidae: Figs. 12.24.3 – 12.24.4).



Fig. 12.24.1. Cone of Douglas fir (*Pseudotsuga menziesii*) bisected to show galled seeds fused with scales due to gall midge (Diptera, Cecidomyiidae: *Contarinia oregonensis*). USA, AFH.



Fig. 12.24.2. Cone of Norway spruce (*Picea abies*) bisected to show white galls of midges at the junction between axis, scales and seeds (Diptera, Cecidomyiidae: *Kaltenbachiola strobis*). Lot, France, AR.



Fig. 12.24.3. Cone of Scots pine (*Pinus sylvestris*) with a scale dissected to show the seeds fused at its base, following predation by seed bugs (Hemiptera, Coreidae: *Leptoglossus occidentalis*). Rodez, France, AR.



Fig. 12.24.4. Detail of fused seeds that were manually extracted from the cone shown in 12.24.3. AR.

Additional information: When the cone is mature, shake it vigorously to release the seeds; then cut it longitudinally and check those seeds which did not shed/release.

12.25. Seed damage by seed chalcid or seed midge

Description: No visible damage on the seed, but one or several larvae present in the seed (or a circular exit hole where adults have already emerged).

Possible damaging agents: Insects: Larvae of Hymenoptera (Torymidae: Figs. 12.25.1 – 12.25.5, Eurytomidae: Fig. 12.25.6, Cynipidae, etc.) and Diptera (Cecidomyiidae: Figs. 12.25.7, 12.25.8).

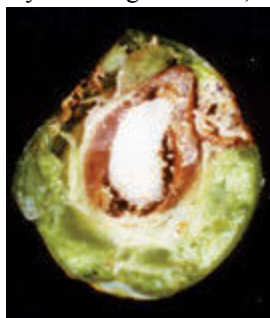


Fig. 12.25.1. Seed of common juniper (*Juniperus communis*) opened to show fully-developed larva of seed chalcid (Hymenoptera, Torymidae: *Megastigmus bipunctatus*). Briançon, France, AR.

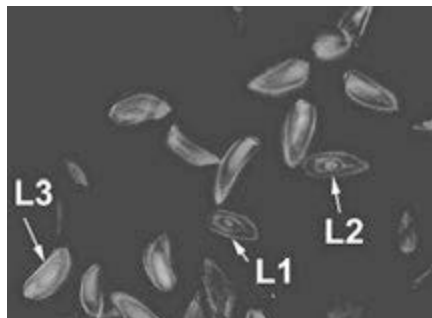


Fig. 12.25.2. Seeds of Chinese cypress (*Cupressus duclouxiana*), X-rayed to show different larval stages of seed chalcids (Hymenoptera, Torymidae: *Megastigmus duclouxianae*). Lijiang, China, AR.



Fig. 12.25.3. Seeds of Douglas fir (*Pseudotsuga menziesii*) with emergence holes of adult seed chalcids (Hymenoptera, Torymidae: *Megastigmus spermotrophus*). Lot, France, AR.

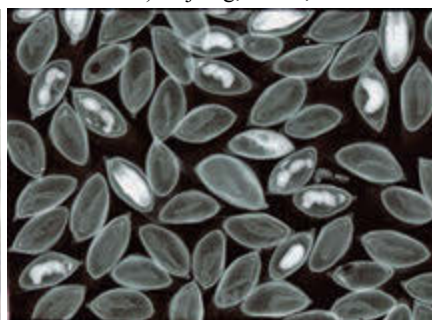


Fig. 12.25.4. X-rayed seeds of Douglas fir (*Pseudotsuga menziesii*) with larvae and pupae of seed chalcids (Hymenoptera, Torymidae: *Megastigmus spermotrophus*). Lot, France, AR.



Fig. 12.25.5. Mature cone of ponderosa pine (*Pinus ponderosa*) with a seed with an exit hole of seed chalcid (Hymenoptera, Torymidae: *Megastigmus albifrons*). Ruidoso, USA, AR.



Fig. 12.25.6. Seed of Siberian larch (*Larix gmelinii*) with an adult seed chalcid about to emerge (Hymenoptera, Eurytomidae: *Eurytoma laricis*). Jagedaqi, China, AR.



Fig. 12.25.7. Seed of balsam fir (*Abies balsamea*) with a midge larva (Diptera, Cecidomyiidae: *Resseliella* sp.). Quebec, AR.

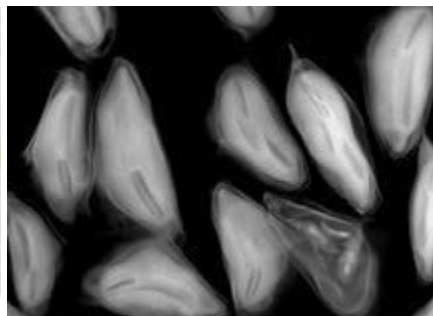


Fig. 12.25.8. X-rayed seeds of European fir (*Abies alba*). One seed is infested by midge larvae (Diptera, Cecidomyiidae: *Resseliella piceae*). Briançon, France, AR.

Additional information: Collect mature seeds. Usually, the infested seed does not differ from the healthy ones in shape, colour or weight, although some exceptions exist. The seed must be opened or, better, X-rayed to ascertain the presence of larvae. Alternatively, to ease identification of the damaging species, infested seeds can be stored until adults emerge. For insect preservation, see Chapter 3.

12.26. Seed damage by true bugs

Description: No visible damage on seed and no larva present when the seed is opened, but seed content more or less consumed. A seed embryo is present, although usually shrivelled.

Possible damaging agents: Insects: Adults and nymphs of Hemiptera: true bugs of several families (Acanthosomatidae, Coreidae: Figs. 12.26.1 – 12.26.2, Lygaeidae: Figs. 12.26.3 – 12.26.4, Pentatomidae, etc.).



Fig. 12.26.1. Conelet of black pine (*Pinus nigra*) predated by a seed bug (Hemiptera, Coreidae: *Leptoglossus occidentalis*). Orléans, France, AR.

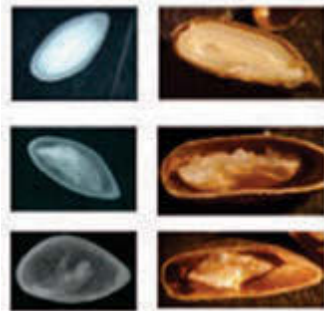


Fig. 12.26.2. Comparison of intact seeds (top) of Aleppo pine (*Pinus halepensis*) with seeds predated to various degrees by seed bugs (Hemiptera, Coreidae: *Leptoglossus occidentalis*) (left: X-ray pictures of the seeds; right: the same seeds sliced). Montpellier, France, AR.



Fig. 12.26.3. Cone of evergreen cypress (*Cupressus sempervirens*) predated by an adult seed bug (Hemiptera, Lygaeidae: *Orsillus maculatus*). Toulon, France, AR.



Fig. 12.26.4. Seeds of evergreen cypress (*Cupressus sempervirens*) predated by seed bugs (Hemiptera, Lygaeidae: *Orsillus maculatus*) (left: X-ray pictures of the seeds; right: the same seeds sliced). Toulon, France, AR.

Additional information: Observation of bugs predating cones will only occur by chance or by beating cones. Traces of feeding (small dots on cone surface) disappear rapidly. Usually, the infested seed does not differ from the healthy ones in shape and colour, but it is of lower weight due to feeding uptake. The seed must be opened or, better, X-rayed to ascertain the damage extent. Most seeds with more than 10% of the endosperm consumed will not germinate.

12.27. Abiotic seed damage

Description: Seeds are either deflated or appear normally developed (e.g., in most Pinaceae) but are entirely empty at opening (or when analysed by X-rays).

Possible damaging agents: Mostly pollination problems (tissue incompatibility, lack of synchrony between pollination and female flower bud burst).



Fig. 12.27.1. Deflated, unpollinated seeds (in the centre) in a cone of Austrian pine (*Pinus nigra*). Orléans, France, AR.

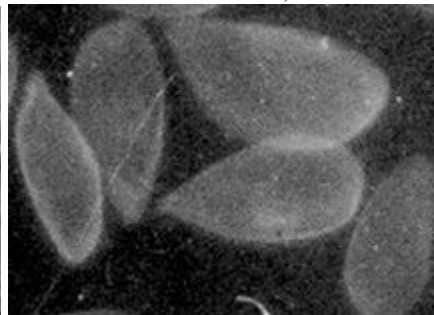


Fig. 12.27.2. Radiograph of seeds of oriental spruce (*Picea orientalis*) showing unpollinated, entirely empty seeds. Les Barres arboretum, France, AR.

Additional information: No embryo remains, often completely shrivelled, which will be visible when the seed is opened, or on X-ray pictures. If remnants of an embryo are observed refer to seed bug damage (section 12.26).

12.28. Seed rot

Description: Even if the seed cover looks intact and healthy, the seed may not germinate. Alternatively, they do germinate, but the seedling dies before or shortly after emerging.

Possible damaging agents: Fungi: Ascomycota (Figs. 12.28.1 – 12.28.3).



Fig. 12.28.1. *Caloscypha fulgens* on subalpine fir seed (*Abies lasiocarpa*) from Canada. VT.



Fig. 12.28.2. *Botrytis cinerea* (sporulation and black sclerotia) on Nordmann fir (*Abies nordmanniana*) seed from Georgia. VT.



Fig. 12.28.3. Radiograph of seeds of slash pine (*Pinus elliottii*) infected by pitch canker (*Fusarium circinatum*), showing deterioration of gametophyte tissues and embryo. USA, TM.

Additional information: For fungal collection and preservation, see Chapter 4.