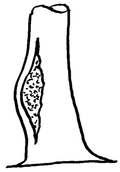
3.3 Fungus-Host Combinations

3.3.1 Fomes fomentarius (L.:Fr.) Fr.



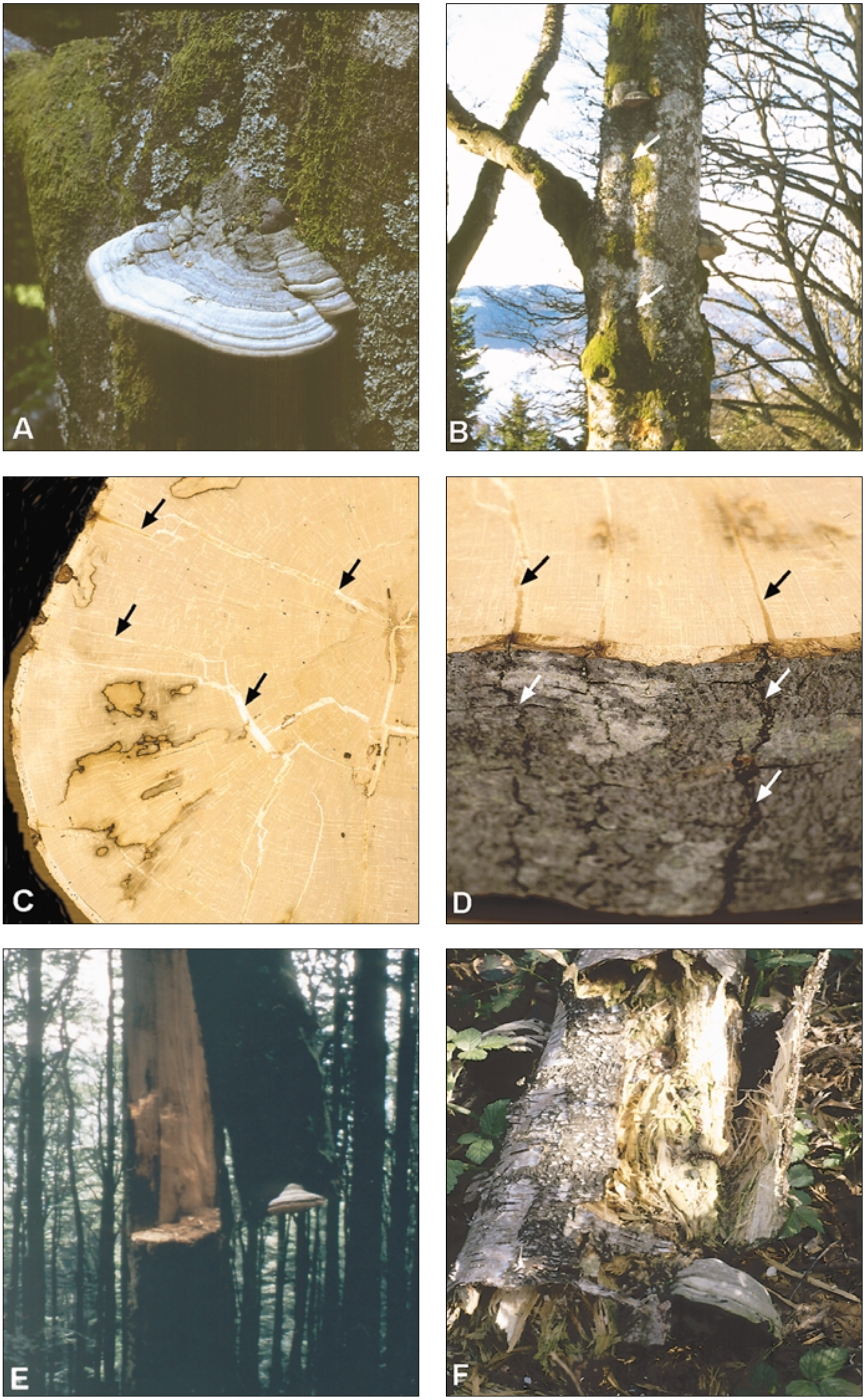
3.3.1.1 *Distribution and Hosts*

Fomes fomentarius is distributed within the northern hemisphere in Europe, North America, China and Japan. In Europe it is found on many different hosts: beech, birch, oak, lime, poplar, willow, maple and more rarely on alder and hornbeam (Kreisel 1961; Breitenbach and Kränzlin 1986; Schwarze 1992b). It is also found on conifers, but very rarely (Jahn 1990). *Fomes fomentarius* prefers different main hosts, depending on the region. In extensive parts of mainland Europe beech is the preferred host, but in England *Fomes fomentarius* occurs only very rarely on beech (Pegler 1973; Schwarze 1992b). North of the limit of beech, e.g. in Scotland, it is found mostly on birch, and in the Mediterranean region on various species of oak (MacDonald 1938; Schwarze 1992b). Within its geographical area of distribution in Europe, the shape and color of the perennial fruit bodies can vary considerably (Schwarze 1992b).

3.3.1.2 *Fruit Bodies*

The perennial bracket- to hoof-shaped fruit bodies (Fig. 24A) are 10–30 cm across and firmly attached to the substrate (Breitenbach and Kränzlin 1986; Schwarze 1994). The upper side is zoned concentrically with wavy furrows. Color ranges from silvery white, grayish, gray-brown to nearly black (Schwarze 1994). These color differences have caused some systematists to propose a separation within the species (Kreisel 1961). Thus, the black fruit bodies of *Fomes fomentarius* were sometimes classified as *Fomes nigricans*. Schwarze (1994) observed considerable intraspecific variability within Europe, this also manifesting itself in the color of the fruit body. The color is lighter at lower latitudes, at low elevations and on the south side of stems. A regional study covering different places of origin in Great Britain and in mainland Europe revealed no constant features which would be suitable for reliable separation of different varieties of *Fomes fomentarius* (Schwarze 1994). The existing phenotype differences can be attributed either to different ecotypes or to interactions between the genotype and its environment.

The fruit bodies of *Fomes fomentarius* form their spores in the spring and autumn. Enormous numbers of spores are produced, especially in the spring (May to June), but spore formation is relatively small in autumn (Nuss 1986). To put this in figures: some fruit bodies of *Fomes fomentarius* can form 887 million basidiospores every hour, which works out at 239 million cm^{-2} of spore-forming layer (Buchwald 1938).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3.3.1.3
Possibilities of Misidentification

The fruit bodies of *Fomes fomentarius* are often confused with those of *Phellinus igniarius* (L.:Fr.) Quél., *Ganoderma* spp. and certain forms of *Fomitopsis pinicola* (Breitenbach and Kränzlin 1986; Schmidt 1994). In doubtful cases, the caustic potash reaction will help. For this a small piece of the crust from the upper side of the cap is placed in a drop of caustic potash solution. If the solution turns dark blood-red, attributable to the substance fomentariol, it is *Fomes fomentarius* (Arpin et al. 1974).

3.3.1.4
Useful Information

Fomes fomentarius belongs to a series of wood-decay fungi which beside the ability to destroy wood are also capable of colonizing pollen grains and then breaking them down (Hutchison and Barron 1997). This allows the fungus to use an additional source of nutrients which is very rich in nitrogen (Hutchison and Barron 1997). In earlier days the trama of the fruit body had a practical use: it was used to make tinder, caps, gloves and breeches (Herrmann 1962; Scholian 1996).

Fomes fomentarius also has the ability to form chlamydospores of very different shapes and forms. These are found in the xylem rays of beech wood, and more rarely in the vessels of beech and oak (Schwarze 1995).

3.3.1.5
Appearance of the Decay

As a stem decay pathogen, *Fomes fomentarius* penetrates into the wood of weakened and healthy trees via bark wounds or broken branches, and causes a simultaneous rot in the infected host (Campbell 1932; MacDonald 1938; Schwarze 1994). Typical for the appearance of the decayed wood are the black lines appearing in the yellowish-white rotted wood, which are known as pseudosclerotic layers (demarcation lines) and demarcate individual fungus colonies against other mycelia or against the wood still not infected. They are produced by the intensified activity of phenoloxidases, converting substances of the fungus or the host into melanin (Butin 1996). However, these demarcation lines are not an absolute identification feature for *Fomes fomentarius*, as other species such as *Armillaria* and *Ustulina deusta* can also cause them.

Fig. 24A–F. **A** Perennial bracket-shaped fruit body of *Fomes fomentarius*. The upper side is zoned concentrically with wavy grooves. The fruit bodies range in color from silvery white, grayish, gray-brown to nearly black. **B** Fluting of beech (*arrows*) caused by *Fomes fomentarius*. **C** White mycelial skins (*arrows*) of *F. fomentarius* are formed in cracks in the wood of the stem (shrinkage cracks), and extend to the bark. Demarcation lines occur in the wood, appearing as *dark lines*. **D** Mycelial skins (*black arrows*) formed in the stem wood are connected with fine bark cracks (*white arrows*). **E** Fracture of a beech stem infected with *Fomes fomentarius*. The fracture runs at a shallow angle to the stem and gives the impression of a cut produced by a guillotine. **F** A fibrous decay is frequently observed on birch stems lying on the ground

Another typical feature is that cracks in the wood are filled with tough leathery yellowish-white mycelial skins (Fig. 24C). As Lohwag (1931) showed in comprehensive studies, they advance towards the bark (Fig. 24D). According to Lohwag (1931), cracks arise in the infected tree as a result of wind action, and *Fomes fomentarius* can spread through them particularly well and without interruption (Sect. 3.3.1.6.1). This happens by means of its mycelial skins which run both radially and tangentially in the wood, and on reaching the cambium they destroy it locally. Fluting occurs on the tree surface as a result of the undisturbed or even increased growth of the adjacent cambium regions (Fig. 24B). Lohwag (1931) calls these striking longitudinal furrows 'fungal fluting' of beech. However, not every longitudinal furrow can be attributed to *Fomes fomentarius*, for fluting can also be formed by included bark. Fluting furrows are not always necessarily formed during wood decay, even though extensive areas of the stem crosssection are colonized and decayed by *F. fomentarius*. Fluting furrows always occur in association with local damage to the cambium.

Typically, *Fomes fomentarius* also persists for years on dead standing or fallen stems, until the substrate is completely destroyed. In birch trees lying on the ground the wood has a fibrous consistency (Fig. 24F).

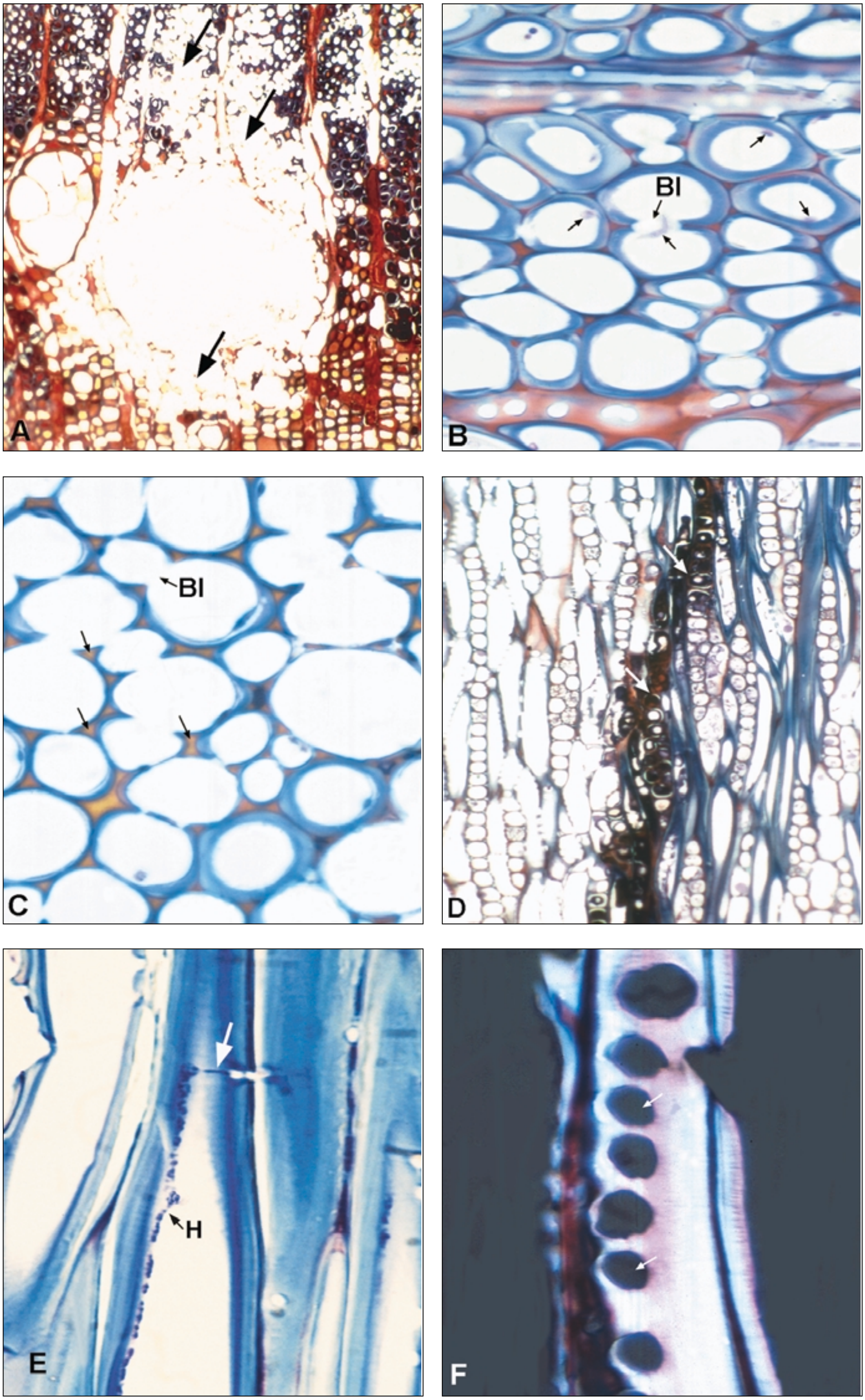
The fracture behavior of fungus-infected stems is extremely brittle, and the fracture itself is smooth and blunt (Fig. 24E). Therefore, attention should be paid above all to warning signals such as perennial old fruit bodies or ribs of woundwood and flutings. Below we shall describe in detail the changes caused by *Fomes fomentarius* at the cell level on beech and oak, and deduce from this why the brittle fracture occurs.

3.3.1.6
Pattern of Wood Decay by Fomes fomentarius

3.3.1.6.1
Fomes fomentarius on Beech

In beech wood infected by *Fomes fomentarius* the hyphae grow mainly in the vessels and along the xylem rays. The decay begins first in the earlywood, which exhibits a uniform decrease in birefringence over all the cells. The hyphae lie mainly in the lumen of the S_3 layer of the fiber tracheids (Fig. 25B)

Fig. 25A–F. A A transverse section of naturally infected oak wood shows the preferential degradation of the earlywood. In many regions the cell walls of the fiber tracheids are intact, but in other regions they are already completely destroyed. Clear degradation of the vessel/fiber tracheid region can be recognized here (*arrow*), while the libriform fiber region is nearly intact (x250). **B** Transverse section of naturally infected beech wood. The cell walls of the fiber tracheids are progressively broken down from the lumen (inside) outwards. Individual hyphae (*arrows*) and bore holes (*Bl*) are recognizable in the lumen of the fiber tracheids (x1000). **C** At the late stage of wood decay, only fragments of the secondary wall are still preserved as well as the intact compound middle lamella (*arrows*) in the transverse section of naturally infected beech wood. The many bore holes (*Bl*) of larger diameter are clearly recognizable (x1000). **D** Tangential section of naturally infected oak wood. A black demarcation line (*arrows*) separates intact wood (*right*) from the decayed wood (x150). **E** Individual bore holes are recognizable in the tangential section of naturally infected oak wood. They are caused by the enzymatic activity of a microhypha (*arrow*) which branches off at right angles from the hypha (*H*) and locally destroys the adjacent cell wall by releasing ectoenzymes (x1000). **F** Under polarized light, bore holes (*arrows*) are recognizable in the cell walls of the fiber tracheids in the tangential section of oak wood; they gradually enlarge and finally fuse together (x1000)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