= Amylostereum =

Amylostereum is the single genus in the fungal family Amylostereaceae . The genus currently comprises four saprotrophic and parasitic species , which live off living or dead wood . The Amylostereaceae cause white rot in the wood by disintegrating the tissue component lignin . They produce crust @-@ like , partially wavy fruit bodies on the surface of infested trees , which are similar to those produced by Stereum species .

There are four described species in the Amylostereaceae : A. chailletii (the type) , A. areolatum , A. ferreum and A. laevigatum . The species were initially considered part of Stereum until mycologist Jacques Boidin found atypical microscopic differences between them . Forty years after his extensive researches from 1958 , Boidin reclassified Amylostereum into its own family .

Three Amylostereum species are symbionts of wood wasps in the genera Sirex , Urocerus , and Xoanon , which infest conifers . The female wood wasps deposit their eggs together with fungal spores and mucus in trees , and the fungus is eaten by the wasp 's larva as food . The fungus propagates vegetatively through the formation of asexual spores in newly emerged females that are stored in special structures adapted for the transport of symbiotic fungi . The A. areolatum ? Sirex woodwasp (S. noctilio) symbiont complex has been studied extensively because of its potential to cause substantial economic losses in the forestry industry , particularly in non @-@ native regions .

= = Taxonomy and history of research = =

Amylostereaceae species were for a long time classified in the genus Stereum , based primary on the layered structure of the fruit body and the similar physiological activity . Mycologist Jacques Boidin separated Amylosterum from Stereum in 1958 , justifying this decision by explaining that microscopic differences such as amyloid spores and encrusted cystidia were sufficiently distinct to warrant recognition as a new genus . Although the type species of the genus (today called A. chailletii) was initially named Trichocarpus ambiguus , the name Trichocarpus had already been used for a genus in the flowering plant family Malvaceae . Boidin thus chose the genus name Amylostereum , referring to the amyloid spores .

Based on DNA analysis , Boidin in 1998 moved Amylostereum into a new , monotypic family , the Amylostereaceae , which he attributed to the Hericiales order . Later studies , however , supported the initial classification in the Russulales .

= = = Classification = = =

The classification of the Amylostereaceae is not completely resolved . The next closest relatives might be ? depending on the research ? either Echinodontium tinctorium and most other species of the genus Echinodontium , or Artomyces pyxidatus . Most of the previous DNA analysis results suggest a narrow relation to Echinodontium , but several results of studies partially contradict this conclusion . Only the classification to the Russulales is regarded as correct . Some authors have suggested that Amylostereum should be placed in the family Echinodontiaceae .

The similarities between A. chailletii and A. areolatum have caused some confusion regarding their placement in the genus . As only the size of their fruit bodies differ from each other in appearance , researcher German Josef Krieglsteiner assumed that both are the same species in different age stages . Experiments with pure cultures of the fungi , however , showed that the mycelia of A. chailletii , A. laevigatum and A. ferreum were partially compatible to each other , but the mycelium of A. areolatum was incompatible to other species . Boidin believes that the common ancestor of all Amylostereum fungi used yellowwoods as a host . This genus of conifers was native in Europe until the Paleogene and Neogene Periods (66 million to 2 @.@ 6 million years ago) , but became extinct there , so the Amylostereum fungi specialized on other conifers and differentiated into several species . Only A. ferreum specialized on yellowwoods in South America .

Compatibility tests as well as molecular analysis indicated that A. areolatum separated very early from other Amylostereum fungi . The other three species separated later from each other and are

thus partially compatible to each other . A. ferreum and A. laevigatum produced in 59 % of all cases a common mycelium , A. ferreum and A. chailletii only in 44 % . There is an undescribed species in Amylostereum ; according to DNA analysis , it stands between A. laevigatum and A. ferreum . This is remarkable , as these fungi originated from Mycetangae (storing organs of Platypodinae) of a North American wood wasp , while A. laevigatum has never been seen as symbiont of wood wasps , neither in North American nor in Europe . The fungus possibly represents a separated species or a subtaxon of A. laevigatum . As A. areolatum and A. chailletii mainly reproduce asexually through the symbiosis of wood wasps , the genetic variability within these species is relatively low .

= = Description = =

= = = Macroscopic = = =

The Amylostereaceae produce crust @-@ like , dry and leathery @-@ corky fruit bodies on the bark of infested trees . The fruit bodies are 0 @.@ 5 ? 1 @.@ 5 mm (0 @.@ 02 ? 0 @.@ 06 in) thick , irregularly shaped and are able to cover a large surface on the bark or otherwise can appear as small spots . They lie directly on the bark . The ochrous , grey or brownish fruit body (hymenium) has a smooth to warty surface texture and is turned outwards . It is bordered by a highly bent and wavy (effuso @-@ reflex) edge on all species except A. laevigatum , which has a churlish surface (a tomentum) and is usually dirty @-@ brown coloured . In some species , the tomentum stands clearly above and forms a kind of roof above the fruit body ; if it completely surrounds this roof , there might appear cuplike shapes .

= = = Microscopic = = =

The Amylostereaceae possess a dimitic trama , meaning that there are in its mycelia two kinds of hyphae . The first type is brownish skeletal hyphae , which provide stability to the fruit body . These hyphae run parallel to the bark and often have hairpin @-@ like turns , so that the loops form thick @-@ walled , cystidium @-@ like structures , the so @-@ called pseudocystidia . The second type is generative hyphae . They are translucent (hyaline) and serve to promote the growth of the fungus . Genuine cystidia arise in the hymenium and the layer directly below , the subhymenium . Both pseudocystidia and cystidia are encrusted , meaning that they feature crystal @-@ like structures on the top .

With the exception of A. laevigatum , all species have a thin separating layer , the cortex , between the hymenium and the tomentum . A cortex is also present on many Stereum fungi (on a broader front) and serves to bend up the fruit body . As this cortex is missing on A. laevigatum , its fruit body lies flat on the bark .

The basidia are 15 ? 25 × 3 @.@ 5 ? 5 @.@ 5 µm and have a slim , club @-@ like shape . Each basidium features four sterigmata , each of which bear one spore . The spores ' shape is slimly ellipsoidal or cylindrical . Their surface is smooth and their walls are thin . Although they are colourless and hyaline , the spores are amyloid , meaning they will turn bluish or purple when stained with Melzer 's reagent . This characteristic differs from other very similar species , and this gave the genus its name .

= = Distribution = =

The range of the Amylostereaceae originally comprised only Holarctic regions , including North America and Eurasia , and the Neotropics , with Central and South America . The introduction of A. areolatum and its symbionts , the Sirex woodwasps , saw the spread of the genus to all continents except Antarctica .

Amylostereum chailletiiz is common in the temperate regions of North America and Eurasia . A. laevigatum can be also found in temperate Eurasia , but it is unclear how broadly this species is

distributed in North America . A. areolatum is originally native in North Africa and Eurasia ; it was however distributed through the 20th century in Australia , New Zealand , Southern Africa as well as in South and North America . Only A. ferreum is originally native in the tropics and is common in Brazil and the Caribbean .

= = Ecology = =

Amylostereaceae usually infest only dead or cut down conifer wood . Three species ? A. areolatum , A. laevigatum and A. chailletii ? may also establish a symbiosis with wood wasps (Siricidae) , which beside freshly logged trees also infest living trees and infect them with fungi . Symbioses have been recorded with several species : Sirex noctilio , S. juvencus , S. nitobei , S. cyaneus , S. edwarsii , S. nitidus , and , in Japan , Urocerus antennatus and Xoanon matsumurae . Wasps of the genera Sirex and Urocerus store oidia (the hypha of fungi split up to spores) in special abdominal organs . The wood wasps infect trees by splashing a phytotoxic secretion below the bark and at the same time injecting fungal spores into the hole . The secretion weakens the tree and temporarily diminishes its immune system , whereby the fungus can spread along the xylem . The infection with Amylostereaceae fulfill two functions for the wasps : it provides the larvae food , because the white rot softens the wood ; at the same time , the mycelia of the fungi serves as food for the larvae . After the larvae pupate , it absorbs the mycelia of the Amylostereaceae into its body to oviposit together with its eggs . The fungus benefits from the symbiosis as it spreads faster and more effectively than through airborne spores and furthermore does not need to develop fruit bodies . A. ferreum is the only Amylosterum species that has not been associated with any woodwasps .

= = = Host spectrum = = =

The host spectrum of the Amylostereaceae comprises several , partially very different genera of Coniferae . A. chailletii usually infests Pinaceae such as firs (Abies) and spruces (Picea) , but also cedars (Cedrus) and Douglas firs (Pseudotsuga) . A. areolatum has a similar host spectrum , which uses mainly firs , Japanese cedars (Cryptomeria) , larches (Larix) , spruces , pines (Pinus) and Douglas firs as hosts . While spruces dominate as hosts in the native habitat , this species is more common in pines on other locations . The host spectrum of A. laevigatum comprises Cupressaceae such as junipers (Juniperus) or cypresses (Cupressus) and the English yew (Taxus baccata) . A. ferreum is , however , only common on neotropic yellowwoods (Podocarpus) .

= = = Symptoms of infestation = = =

The Amylostereaceae are white rot pathogens . They disintegrate the lignin of the host wood , whereby the infested wood parts become less stable and take a fibrous structure . The wood bleaches as fungal enzymes break down and remove the brown @-@ pigmented lignin . The distribution in wood takes place mainly along the transport channels in the xylem . If the wood is crosscut , the red rot is vertically positioned , on which bleached , infested areas contrast with intact wood . Symptoms of infestion by the symbiotic partner ? wood wasps ? include circular exit holes in the crust and acute stress through dryness , common in hanging , falling or tanning needles .

= = Ecological and economical importance = =

In their native habitat , all Amylostereum species have a minor importance as forest pests . The infestation through wood wasps does not assume greater dimensions and is , compared with other pests , almost insignificant . The infection rates are even lower during sexual reproduction via fruit bodies , as the wasps do not play a part in the process . Furthermore , the Amylostereum fungi are alone often incapable of infesting healthy trees . They thus mostly act as saprobiontics . Pine monocultures in Australia , New Zealand , Africa and South America were shown to be susceptible to the Sirex woodwasp (Sirex noctilio) , which was introduced there and which is associated with A.

areolatum . The wasp 's phytotoxic secretion , its larvae and the fungus combine very effectively with each other and contribute to forest decline rates of up to 80 % . This is mainly owing to the poor water and nutrient supply of the trees , which can poorly reconcile the drought stress caused by infestation . S. noctilio was detected in North America in the 2000s (decade) ; in Canada alone , the total economic loss to the forestry industry caused by the Sirex ? Amylostereum symbiosis could be as high as $ 254 million per year for the next 20 years .

As a countermeasure , cultures of the nematode Deladenus siricidicola have been used as biological control to protect trees since the 1980s . This parasite feeds on the mycelia of A. areolatum and is therefore a food competitor of wood wasp larvae . Where S. noctilio larvae are present , the parasite infects and sterilizes the eggs of female wasps , causing them to be infertile . These infertile females lay infected eggs into new trees and thus spread the nematode . This control method has proven to be relatively successful to combat the Sirex ? Amylostereum complex . In the Southern Hemisphere , where the technique has been widely employed , reductions of parasitism levels of 70 % ? 100 % have been achieved .