= Auriscalpium vulgare =

Auriscalpium vulgare , commonly known as the pinecone mushroom , the cone tooth , or the ear @-@ pick fungus , is a species of fungus in the family Auriscalpiaceae of the order Russulales . It was first described in 1753 by Carl Linnaeus , who included it as a member of the tooth fungi genus Hydnum , but British mycologist Samuel Frederick Gray recognized its uniqueness and in 1821 transferred it to the genus Auriscalpium that he created to contain it . The fungus is widely distributed in Europe , Central America , North America , and temperate Asia . Although common , its small size and nondescript colors lead it to be easily overlooked in the pine woods where it grows . A. vulgare is not generally considered edible because of its tough texture , but some historical literature says it used to be consumed in France and Italy .

The fruit bodies (mushrooms) grow on conifer litter or on conifer cones that may be partially or completely buried in soil . The dark brown cap of the small , spoon @-@ shaped mushroom is covered with fine brown hairs , and reaches a diameter of up to 2 cm (0 @.@ 8 in) . On the underside of the cap are a crowded array of tiny tooth @-@ shaped protrusions (" teeth ") up to 3 mm long ; they are initially whitish to purplish @-@ pink before turning brown in age . The dark brown and hairy stem , up to 55 mm (2 @.@ 2 in) long and 2 mm thick , attaches to one edge of the cap . The mushroom produces a white spore print out of roughly spherical spores .

High levels of humidity are essential for optimum fruit body development , and growth is inhibited by excesses of either light or darkness . Fruit bodies change their geotropic response three times during their development , which helps ensure that the teeth ultimately point downward for optimum spore release . The pure culture , cell division and the ultrastructure of A. vulgare 's hyphae and mycelia have been studied and described in search of potentially useful characters for phylogenetic analysis . When grown in culture , the fungus can be induced to produce fruit bodies under suitable conditions .

= = History , taxonomy and phylogeny = =

The species was first described in the scientific literature by Carl Linnaeus under the name Hydnum auriscalpium in his 1753 Species Plantarum . Linnaeus placed three other tooth fungi in the genus Hydnum : H. imbricatum , H. repandum , and H. tomentosum . In 1821 Samuel Frederick Gray considered H. auriscalpium to be sufficiently distinct from the other Hydnum species to warrant the creation of a new genus , Auriscalpium , to contain it . In the process , its name was changed to Auriscalpium vulgare .

Otto Kuntze and Howard James Banker later independently sought to restore Linnaeus ' species name , but the resulting combination (Auriscalpium auriscalpium) is a tautonym and disallowed under the rules for botanical nomenclature (ICBN 2005 rule 23 @.@ 4) , and these combinations are therefore no longer validly published . Other names given to the fungus and now considered synonyms include Hydnum fechtneri , named by Josef Velenovský in 1922 , and later combinations based on this name . A. vulgare is the type species of the widely distributed genus of eight species that it belongs to .

Despite vast differences in appearance and morphology , A. vulgare is related to such varied taxa as the gilled fungi of Lentinus , the poroid genus Albatrellus , the coral @-@ like Clavicorona , and fellow tooth fungus Hericium . The relationship of all of these taxa ? members of the Auriscalpiaceae family of the order Russulales ? has been demonstrated through molecular phylogenetics .

Auriscalpium vulgare is commonly known as the " pinecone mushroom " , the " cone tooth " , " pine cone tooth " , or the " ear @-@ pick fungus " . Gray called it the " common earpick @-@ stool " ; it was also referred to as the " fir @-@ cone Hydnum " , when it was still considered to be a member of that genus . The specific epithet vulgare means " common " . The generic name Auriscalpium is Latin for " ear pick " and refers to a small , scoop @-@ shaped instrument used to remove foreign matter from the ear .

= = Description = =

The fruit body of A. vulgare is fibrous when fresh and becomes stiff when dry . It is small species rarely exceeding 55 mm (2 @.@ 2 in) in height , with a cap usually smaller than an adult 's fingernails : 0 @.@ 5 to 2 cm (0 @.@ 2 to 0 @.@ 8 in) ? although it has been known to reach up to 4 cm (1 @.@ 6 in) .

Auriscalpium vulgare usually has a single stem , but occasionally several stems arise from a thick common base . It attaches to the side of the cap and is cylindrical or slightly flattened with a bulbous base . Its surface is covered with hairy fibers (especially near the base) , and its mature color is a dark chestnut brown . The cap is semicircular or kidney @-@ shaped , flat on the lower surface and rounded on the top . The surface is at first much like the stem : covered with bristles and dark chestnut brown . However , it becomes smooth with maturity and can darken to the point of being almost black . The cap margin is usually buff to light brown ? roughly the same color as the spines and lighter in color than the center . It becomes rolled inward (revolute) and often wavy in maturity . The spines on the underside of the cap are a few millimeters long and cylindrical down to their sharp tips . White to light brown when young , they later become covered with a white spore mass and then turn an ashy gray . Occasionally , fruit bodies are produced that lack a cap entirely .

The cap flesh is composed of two distinct layers : a thin , compact , black @-@ brown and hairy upper layer , and a thick , soft , white to light brown lower layer that is made of thin , thread @-@ like filaments arranged in a roughly parallel fashion . The stem is similarly divided , with a thin , dark and hairy cortical layer covered by hairs , which encircles inner ochre @-@ colored flesh . A drop of potassium hydroxide applied to the surface of the mushroom will cause it to instantly stain black .

The mushroom , which has no distinct taste or odor , is generally considered inedible because of its toughness and diminutive size . An 1887 textbook noted , however , that it was " commonly eaten in France and Italy " .

= = = Microscopic characteristics = = =

Spore deposits are white . Viewed under a light microscope , the spores appear hyaline (translucent) , covered with minute wart @-@ like bumps , and are spherical or nearly so , with dimensions of 4 @.@ 6 ? 5 @.@ 5 by 4 ? 5 µm . They are amyloid (reacting to Melzer 's reagent) and cyanophilous (staining in methyl blue) . The basidia (spore @-@ bearing cells of the hymenium) are four @-@ spored with basal clamps , and measure 15 ? 24 by 3 ? 4 µm , and sterigmata (extensions of the basidia that bear the spores) are swollen at the base and roughly 3 µm long . The hyphal system is dimitic , comprising both generative (undifferentiated) and skeletal (structural) hyphae . The thin @-@ walled generative hyphae are hyaline , and have clamp connections ; the thick @-@ walled skeletal hyphae are thicker overall and lack such connections . The cortex (the tougher outer layer of flesh) is made of parallel unbranched generative hyphae that are brown , thick @-@ walled , clumped together , and frequently clamped . The internal flesh is made of interwoven generative and skeletal hyphae . Gloeoplerous hyphae (containing oily or granular contents) are also present , protruding into the hymenium as club @-@ like or sharp @-@ pointed gloeocystidia .

The hyphae of basidiomycetous fungi are partitioned by cross @-@ walls called septa , and these septa have pores that permit the passage of cytoplasm or protoplasm between adjacent hyphal compartments . In an effort to determine ultrastructural characters useful for systematic and phylogenetic analyses of the Agaricomycotina , Gail Celio and colleagues used electron microscopy to examine both the structure of the septal pore , and nuclear division in A. vulgare . They determined that septa found in hyphae of the hymenium have bell @-@ shaped pore " caps " with multiple perforations . Each cap extends along the length of the septum , along with a zone surrounding the pore that is free of organelles . Due to the scarcity of similar data from other Agaricomycotina species , it is unknown whether the extended septal pore cap margins of A. vulgare are phylogenetically informative . Regarding nuclear division , the process of metaphase I of meiosis is similar to the metaphase of mitosis . Spherical spindle pole bodies containing electron @-@ opaque inclusions are set within gaps on opposite ends of the nuclear membrane . This membrane

has occasional gaps but is largely continuous . Fragments of endoplasmic reticulum occur near the spindle pole bodies , but do not form a cap .

= = Growth in culture = =

Auriscalpium vulgare can be grown in pure culture on agar @-@ containing plates supplemented with nutrients . The colonies that grow are white to pale cream , and cover the agar surface within six weeks from the initial inoculation . The mycelium is made of bent @-@ over hyphae , without any aerial hyphae (hyphae that extend above the surface of the agar) . Typically , two indistinct zones develop at about 6 mm and 15 mm from the initial inoculum spot , with each zone roughly 4 mm wide . The zones appear somewhat lighter in color because the hyphae are more closely packed and form crystalline substances that deposit into the agar .

The mature mycelium consists of thin @-@ walled , densely packed hyphae that are 1 @.@ 5 ? 3 @.@ 2 µm in diameter . They are often gnarled or somewhat spiral (subhelicoid) , and frequently branched at an angle of about 45 ° , with a clamp at the base of the branch . They contain amorphous granules that appear refractive when viewed under phase contrast microscopy , and their walls are often encrusted with tiny granules . Gloeocystidia (thin @-@ walled cystidia with refractive , frequently granular contents) are common ; they measure 50 ? 85 by 6 @.@ 5 ? 8 @.@ 5 µm , and are club @-@ shaped (sometimes elongated) , thin @-@ walled , and often have one or two lobes with rounded tips . Containing foamy and pale yellow contents , they are a refractive yellow color under phase contrast . Initially they are erect but they soon fall under their own weight to lie on the agar surface . Crystalline deposits are abundant as small , randomly scattered plate @-@ like or star @-@ like crystals .

Fruiting begins about six weeks after the initial inoculation on the agar plate , but only when portions of fruit bodies (spines or stem sections) are used as the inoculum to initiate growth ; the use of mycelium as the inoculum precludes subsequent fruiting . Mature fruit bodies grow very close to the initial site of inoculation ? within 3 mm ? and take about 60 days to mature after they first start to form .

= = Fruit body development = =

Fruit body primordia first appear between the scales of the cones , and require 9 to 35 days to reach their final height . They consist of an inner core of thin @-@ walled generative hyphae enclosed by an outer coat of skeletal hyphae . Immature fruit bodies are white and delicate , but gradually become brown as they mature . Because the cap is grown from the stem tip after it bends , cap development interrupts stem growth , and this shift to centrifugal growth (that is , growth outward from the stem) results in the typical kidney @-@ shaped or semicircular cap . Although the fruit body takes at least 9 days to mature , spores production begins within 48 ? 72 hours of the start of cap growth . Spines start out as minute protuberances on the part of the stem adjoining the undersurface of the cap . As the cap enlarges , these spines are spread horizontally , and more protuberances are formed , which elongate vertically downwards .

When grown in favorable conditions of high water availability and humidity , the fruit body can proliferate by growing additional (secondary) fruit bodies on all parts of its upper and lower surfaces . These secondary growths typically number between four and seven ; some may be aborted as the nutrients from the pine cone substrate are depleted , resulting in stems lacking caps . In one instance , a complete secondary proliferation was noted (i.e. , growing from a primary proliferation) that developed completely so as to produce viable spores . Humidity is a limiting factor for optimum fruit body development . Removal of incompletely mature laboratory @-@ grown specimens from a relative humidity (R.H.) of over 98 % to one of 65 ? 75 % causes the fruit bodies to brown and stop growing . When transferred to an even lower R.H. of about 50 % , the stems quickly begin to collapse . Light also affects fruit body development : both continuous illumination and complete darkness inhibit growth .

When a stem is developing , the fungus is negatively geotropic , so that if the axis of the stem is

tilted by 90 degrees , it will return to a vertical position within 24 hours . The extending hyphae that form the cap are themselves diageotropic ? they will grow at right angles to the direction of gravity . Finally , the spines are positively geotropic , and will re @-@ orient themselves to point downward if the mushroom orientation changes . Because the second (cap formation) and third (spine formation) geotropic responses overlap , there is a brief period where two different geotropic responses are operating simultaneously . These geotropic transitions help ensure that the final alignment results in optimum spore dispersal .

= = Habitat and distribution = =

Auriscalpium vulgare is a saprobic species . Its mushrooms grow solitary or clustered on fallen pine cones , especially those that are fully or partially buried . It typically favors Scots Pine (Pinus sylvestris) , but has also been reported on spruce cones , and in California grows primarily on Douglas @-@ fir cones . One author noted finding the mushroom on spruce needles on top of squirrel dens where cone bracts were present in the forest floor . In a study conducted in the Laojun Mountain region of Yunnan Province , China , A. vulgare was found to be one of the most dominant species collected from mixed forest at an altitude of 2 @,@ 600 ? 3 @,@ 000 m (8 @,@ 500 ? 9 @,@ 800 ft) . A study on the effect of slash and burn practices in northeast India showed that the fungus prefers to fruit on burned cones of the Khasi Pine , and that the number of fruit bodies on unburned cones increases with cone girth .

The fungus is widely distributed in Europe , Central and North America , temperate Asia , and Turkey . In North America , its range extends from Canada to the Trans @-@ Mexican Volcanic Belt south of Mexico City . The mushroom is common , appearing in the summer and autumn , although it is easily overlooked because of its small size and nondescript coloration . A. vulgare is the only representative of its genus in temperate areas of the Northern Hemisphere .