= Tylopilus felleus =

Tylopilus felleus , commonly known as the bitter bolete or the bitter tylopilus , is a fungus of the bolete family . Its distribution includes east Asia , Europe , and eastern North America , extending south into Mexico and Central America . A mycorrhizal species , it grows in deciduous and coniferous woodland , often fruiting under beech and oak . Its fruit bodies have convex to flat caps that are some shade of brown , buff , or tan , and typically measure up to 15 cm (6 in) in diameter . The pore surface is initially white before turning pinkish with age . Like most boletes it lacks a ring , and it may be distinguished from Boletus edulis and other similar species by its unusual pink pores and the prominent dark brown netlike pattern on its stalk .

French mycologist Pierre Bulliard described this species as Boletus felleus in 1788 before it was transferred into the new genus Tylopilus . It is the type species of Tylopilus , and the only member of the genus found in Europe . Tylopilus felleus has been the subject of research into bioactive compounds that have been tested for antitumour and antibiotic properties . Although not poisonous , it is generally considered inedible , due to its overwhelming bitterness .

= = Taxonomy = =

The species was first described in the scientific literature as le bolet chicotin (Boletus felleus) by French mycologist Pierre Bulliard in 1788 . As the large genus Boletus was carved up into smaller genera , Petter Karsten transferred it in 1881 to Tylopilus , a genus diagnosed by its pink spores and adnate tubes . T. felleus is the type species of Tylopilus , and the only member of the genus found in Europe . Synonyms include Boletus alutarius , described by Elias Magnus Fries in 1815 and later by Friedrich Wilhelm Gottlieb Rostkovius in 1844 , and Paul Christoph Hennings 's subsequent transfer of Fries 's taxon into Tylopilus , T. alutarius . Lucien Quélet placed the taxon in Dictyopus in 1886 and then Rhodoporus in 1888 , but neither of these genera are recognised today , the former having been merged into Boletus and the latter into Tylopilus . Genetic analysis published in 2013 shows that T. felleus and many (but not all) other members of Tylopilus form a Tylopilus clade within a larger group informally called anaxoboletus in the Boletineae . Other clades in the group include the porcini and Strobilomyces clades , as well as three other groups composed of members of various genera including Xerocomus , Xerocomellus and Boletus badius and relatives .

A variety described from the Great Lakes region , var. uliginosus , was recognised by Alexander H. Smith and Harry D. Thiers in 1971 on the basis of its microscopic features , a distinction supported by Professor C.B. Wolfe of Pennsylvania State University . However , Index Fungorum does not consider this an independent taxon . Similarly , Boletus felleus var. minor , published originally by William Chambers Coker and A.H. Beers in 1943 (later transferred to Tylopilus by Albert Pilát and Aurel Dermek in 1974) , has been folded into synonymy with T. felleus . Charles Horton Peck described Boletus felleus var. obesus in 1889 , but no record of a type specimen exists . Although some records exist of T. felleus in Australia , their spores are of consistently smaller dimensions and this taxon has been classified as a separate species , T. brevisporus .

Tylopilus felleus derives its genus name from the Greek tylos " bump " and pilos " hat " , and its specific name from the Latin fel meaning " bile " referring to its bitter taste , similar to bile . The mushroom is commonly known as the " bitter bolete " or the " bitter tylopilus " .

= = Description = =

The cap of this species grows up to 15 cm (6 in) in diameter , though some North American specimens reach 30 cm (12 in) across . Grey @-@ yellow to pale- or walnut @-@ brown , it is slightly downy at first and later becomes smooth with a matte lustre . It is initially convex before flattening out with maturity . The cap skin does not peel away from the flesh . The pores underneath are white at first and become pinkish with maturity . They are adnate to the stalk and bulge downwards as the mushroom ages . The pores bruise carmine or brownish , often developing rusty @-@ brown spots with age , and number about one or two per millimetre . The tubes are long

relative to the size of the cap , measuring 2 ? 3 cm (0 @.@ 8 ? 1 @.@ 2 in) deep in the middle part of the cap . The stalk is initially bulbous before stretching and thinning in the upper part ; the lower part of the stalk remains swollen , sometimes shrinking at the base where it attaches to the substrate . It measures 7 ? 10 cm (2 @.@ 8 ? 3 @.@ 9 in) ? rarely to 20 cm (7 @.@ 9 in) ? tall , and 2 ? 3 cm (0 @.@ 8 ? 1 @.@ 2 in) wide , and can bulge out to 6 cm (2 @.@ 4 in) across at the base . It is lighter in colour than the cap , and covered with a coarse brown network of markings , which have been likened to fishnet stockings in appearance . Described as " very appetising " in appearance , the flesh is white or creamy , and pink beneath the cap cuticle ; the flesh can also develop pinkish tones where it has been cut . It has a slight smell , which has been described as pleasant , as well as faintly unpleasant . The flesh is softer than that of other boletes , and tends to become more spongy as the mushroom matures . Insects rarely infest this species .

The colour of the spore print is brownish , with pink , reddish , or rosy tints . Spores are somewhat fuse @-@ shaped , smooth , and measure 11 ? 17 by 3 ? 5 µm . The basidia (spore @-@ bearing cells) are club @-@ shaped , four @-@ spored , and measure 18 ? 25 @.@ 6 by 7 @.@ 0 ? 10 @.@ 2 µm . Cystidia on the walls of the tubes (pleurocystidia) are fuse @-@ shaped with a central swelling , thin @-@ walled , and have granular contents . They possess sharp to tapered tips , and have overall dimensions of 36 ? 44 by 8 @.@ 0 ? 11 @.@ 0 µm . On the pore edges , the cheilocystidia are similar in shape to the pleurocystidia , measuring 24 @.@ 8 ? 44 @.@ 0 by 7 @.@ 3 ? 11 @.@ 0 µm . The hymenium of Smith and Thiers 's variety uliginosus , when mounted in Melzer 's reagent , shows reddish globules of pigment measuring 2 ? 8 µm that appear in the hyphae and throughout the hymenium , and a large (8 ? 12 µm) globule in the pleurocystidia .

Several chemical tests have been documented that can help confirm the identify of this species . On the cap flesh , application of formaldehyde turns the tissue pinkish , iron salts result in a colour change to greyish @-@ green , aniline causes a lavender to reddish @-@ brown colour , and phenol a purplish pink to reddish brown . On the cap cuticle , nitric acid causes an orange @-@ salmon colour , sulphuric acid creates orange @-@ red , ammonia usually makes brown , and a potassium hydroxide solution usually makes orange .

= = Similar species = =

Italian cook and author Antonio Carluccio reports this is one of the most common fungi brought to him to identify , having been mistaken for an edible species . Young specimens can be confused with many edible boletes , though as the pores become more pink the species becomes easier to identify . Some guidebooks advocate tasting the flesh , the smallest piece of which will be very bitter . The dark @-@ on @-@ light reticulation in the stalk is distinctive , and is the opposite colouration of that on the stalk of the prized Boletus edulis . T. felleus is found in the same habitat as B. badius , though the latter 's yellow tubes and blue @-@ bruising flesh easily distinguish it . B. subtomentosus can have a similar @-@ coloured cap , but its yellow pores and slender stalk aid identification .

Tylopilus rubrobrunneus , found in hardwood forests of eastern North America , is similar in appearance to T. felleus , but has a purplish to purple @-@ brown cap . It is also inedible due to its bitter taste . Another North American species , T. variobrunneus , has a cap that is reddish @-@ brown to chestnut @-@ brown , with olive tones in youth . It has shorter spores than T. felleus , typically measuring 9 ? 13 by 3 ? 4 @.@ 5 ?m . In the field , it can be distinguished from the latter species by its mild to slightly bitter taste . T. rhoadsiae , found in the southeastern United States , has a lighter @-@ coloured cap that is smaller , up to 9 cm (3 @.@ 5 in) in diameter . The edible T. indecisus and T. ferrugineus can be confused with T. felleus , but have less reticulated stalks . The dimensions of the spores of the Australian species T. brevisporus range from 9 @.@ 2 to 10 @.@ 5 by 3 @.@ 5 to 3 @.@ 9 ?m . T. neofelleus , limited in distribution to deciduous forests of China , New Guinea , Japan , and Taiwan , can be distinguished from T. felleus macroscopically by its vinaceous @-@ brown cap and pinkish @-@ brown to vinaceous stalk , and microscopically by its smaller spores (measuring 11 ? 14 by 4 ? 5 ?m) and longer pleurocystidia (49 ? 107 by 14 ? 24 ?m) .

= = Ecology , distribution and habitat = =

Like all Tylopilus species , T. felleus is mycorrhizal . It is found in deciduous and coniferous woodland , often under beech and oak in well @-@ drained acid soils , which can be sandy , gravelly or peaty . If encountered on calcareous (chalky) soil , it will be in moist areas that have become waterlogged and have ample leaf litter . Fruit bodies grow singly or in small groups , and occasionally in small clusters with two or three joined at the base of the stem . Fruit bodies have also been growing in the cavities of old trees , on old conifer stumps , or on buried rotten wood . The fungus obtains most of its nitrogen requirements from amino acids derived from the breakdown of proteins , although a lesser amount is obtained from the amino sugar glucosamine (a breakdown product of chitin , a major component of fungal cell walls) . The mycorrhizal plant partner benefits from the fungus 's ability to use these forms of nitrogen , which are often abundant in the forest floor . Fruit bodies appear over summer and autumn , anytime from June to October or even November , in many of the northern temperate zones . Large numbers may appear in some years , and none in others , generally proportional to the amount of rainfall . Variety uliginosus , known from Michigan , grows among lichens and mosses under pines .

In North America , it is known from eastern Canada , south to Florida and west to Minnesota in the United States , and into Mexico and Central America . Its European distribution is widespread ; it is relatively common in many regions , but rare or almost absent in others . In Asia , it has been recorded from the vicinity of Dashkin in the Astore District of northern Pakistan , and as far east as China , where it has been recorded from Hebei , Jiangsu , Fujian , Guangdong and Sichuan provinces , and Korea .

The strong taste of the fruit body may have some role in insects avoiding it . The small fly species Megaselia pygmaeoides feeds on and infests the fruit bodies of T. felleus in North America , though it seems to prefer other boletes in Europe . Fruit bodies can be parasitized by the mould Sepedonium ampullosporum . Infection results in necrosis of the mushroom tissue , and a yellow colour caused by the formation of large amounts of pigmented aleurioconidia (single @-@ celled conidia produced by extrusion from the conidiophores) .

The bacterium Paenibacillus tylopili has been isolated from the mycorrhizosphere of T. felleus ; this is the region around its subterranean hyphae where nutrients released from the fungus affect the activity of the microbial population in the soil . The bacterium excretes enzymes that allow it to break down the biomolecule chitin .

Fruit bodies of T. felleus have a high capacity to accumulate radioactive caesium (137Cs) from contaminated soil , a characteristic attributed to the deep soil penetration achieved by the mycelium . In contrast , the species has a limited capacity to accumulate the radioactive isotope 210Po .

= = Edibility = =

As its common name suggests , it is extremely bitter , though not toxic as such . This bitterness is worsened by cooking . One specimen can foul the taste of a whole meal prepared with mushrooms . Despite this , it is sold in local markets (tianguis) in Mexico . A local recipe from France , Romania and East Germany calls for stewing it in skimmed milk after which it can be eaten , or powdered and used for flavouring . The mushroom is not bitter for those who lack genetic sensitivity to bitter taste , a trait endowed by the gene TAS2R38 (taste receptor 2 member 38) . The compound responsible for the bitter taste has not been identified .

= = Research = =

The mycelium of Tylopilus felleus can be grown in axenic culture , on agar containing growth medium . The fungus can form fruit bodies if the temperature is suitable , and the light conditions simulate a 12 @-@ hour day . The mushrooms are usually deformed , often lacking stalks so that the cap grows directly on the surface , and the caps are usually 0 @.@ 5 ? 1 @.@ 0 cm (0 @.@ 2 ? 0 @.@ 4 in) in diameter . There are few Boletaceae species known to fruit in culture , as

ectomycorrhizal fungi tend to not fruit when separated from their host plant .

Compounds from T. felleus have been extracted and researched for potential medical uses . Tylopilan is a beta @-@ glucan that was isolated from the fruit bodies in 1988 and shown in laboratory tests to have cytotoxic properties and to stimulate non @-@ specific immunological response . In particular , it enhances phagocytosis , the process by which macrophages and granulocytes engulf and digest foreign bacteria . In experiments on mice with tumour cells , it appeared to have antitumour effects when administered in combination with a preparation of Propionibacterium acnes in a 1994 Polish study . Researchers in 2004 reported that extracts of the fruit body inhibit the enzyme pancreatic lipase ; it was the second most inhibitory of 100 mushrooms they tested . A compound present in the mushroom , N @-@ ? @-@ glutamyl boletine , has mild antibacterial activity .