= Lactifluus volemus =

Lactifluus volemus , formerly known as Lactarius volemus , is a species of fungus in the family Russulaceae . It is widely distributed in the northern hemisphere , in temperate regions of Europe , North America and Asia as well as some subtropical and tropical regions of Central America and Asia . A mycorrhizal fungus , its fruit bodies grow on the ground at the base of various species of trees from summer to autumn , either individually or in groups . It is valued as an edible mushroom , and is sold in markets in Asia . Several other Lactifluus mushrooms resemble L. volemus , such as the closely related edible species L. corrugis , but these can be distinguished by differences in distribution , visible morphology , and microscopic characteristics . L. volemus produces a white spore print and has roughly spherical spores about 7 ? 8 micrometres in diameter .

The colour of the L. volemus mushroom varies from apricot to tawny , and the cap may be up to 11 cm (4 1 ? 2 in) wide . The pale golden yellow gills on the underside of the cap are closely spaced and sometimes forked . One of the mushroom 's most distinctive features is the large amount of latex (" milk ") that it exudes when the gills are damaged , leading to the common names weeping milk cap and voluminous @-@ latex milky . It also has a distinctive fishy smell , which does not affect the taste . The fruit bodies have been chemically analysed and found to contain several sterols related to ergosterol , some of which are unique to this species . The mushroom also contains a natural rubber that has been chemically characterized . Phylogenetic analysis suggests that Lactifluus volemus represents several species or subspecies , rather than a single taxon .

= = Taxonomy and naming = =

The first mention of Lactifluus volemus in the scientific literature was in Carl Linnaeus 's 1753 Species Plantarum , under the name Agaricus lactifluus . In 1821 , Swedish mycologist Elias Magnus Fries called it Agaricus volemus in his Systema Mycologicum . In this work he proposed a grouping of related species (called a tribus , or tribe) within the genus Agaricus , which he named Galorrheus . Fries later recognised Lactarius as a distinct genus in his 1838 Epicrisis Systematis Mycologici , citing Galorrheus as a synonym . Although Linnaeus had published the species before Fries , Fries 's name is sanctioned and thus has nomenclatural priority . In 1871 Paul Kummer raised most of Fries 's tribes to generic rank , and so renamed the species Galorrheus volemus . The variety L. volemus var. subrugosus was identified by Charles Horton Peck in 1879 , but is now classified as a separate species , L. corrugis . In 1891 , Otto Kuntze moved the species into Lactifluus , which was afterwards long considered a synonym of Lactarius but confirmed as a separate genus through molecular phylogenetics in 2008 and subsequent taxonomical rearrangements within the family Russulaceae .

Another historical synonym is Lactarius lactifluus , used by Lucien Quélet in 1886 , a renaming based on Linnaeus 's Agaricus lactifluus . Lactarius wangii , reported by Hua @-@ An Wen and Jian @-@ Zhe Ying to be a new species from China in 2005 , was synonymised two years later with L. volemus .

The specific epithet " volemus " is derived from the Latin vola , meaning " the hollow of the hand " , suggestive of Fries 's reference to the large amount of latex " flowing enough to fill the hand " . Common names for L. volemus include the weeping milk cap , the tawny milkcap , the orange @-@ brown milky , the voluminous @-@ latex milky , the lactarius orange , the fishy milkcap , and the apricot milk cap . In the West Virginian mountains of the United States , the mushroom is called a " leatherback " or a " bradley " . The latter name may originate from its German name Brätling .

= = Phylogeny = =

Lactifluus volemus was the type species of the section Dulces in subgenus Lactarius , and is currently classified in Lactifluus section Lactifluus . The group around this L. volemus includes species with a dry cap , abundant latex , and a white or pale cream spore print . Because the closely related L. corrugis has overlapping morphological characters , including similar colouration in the

cap and stem , it has been difficult to reliably distinguish between the two species . The difficulty in discerning the two is exacerbated by the fact that both species have several colour forms : Japanese specimens of L. volemus may have a red cap , a yellow cap with a long stem , or a velvet @-@ like surface texture ; the caps of L. corrugis may be either red , commonly rust @-@ coloured . In 2005 , Japanese researchers clarified the relationships between these two species and others in section Dulces using molecular phylogenetics , and by comparing differences in fatty acid composition , morphology , and taste . The colour variants group phylogenetically into different subclades , suggesting that they might better be considered as " different species , subspecies , or varieties " . A 2010 molecular study of L. volemus of northern Thailand found that 79 tested specimens could be divided into 18 distinct phylogenetic species ; six of these were described as new species : Lactifluus acicularis , L. crocatus , L. distantifolius , L. longipilus , L. pinguis and L. vitellinus .

= = Description = =

= = = Macromorphology = = =

The fruit body of Lactifluus volemus has a fleshy and firm cap with a velvety or smooth surface and a shape that changes with maturity : it starts off convex , with edges curved inwards , then later grows flat with a depression in the middle . With a typical diameter of 5 to 11 cm (2 ? 4 1 ? 2 in) , its colour ranges from apricot to tawny . The cap colouration , however , is somewhat variable , as has been noted in Asian , European , and North American specimens . The stem , whose height varies between 4 and 12 cm (1 1 ? 2 and 5 in) , and which is typically between 1 and 1 @.@ 5 cm (0 @.@ 4 and 0 @.@ 6 in) thick , has a slightly lighter colouration than the cap . It is firm , with a velvety or smooth surface that sometimes has depressions running longitudinally up and down its length . The gills are adnate to slightly decurrent , brittle , narrow , quite closely spaced and sometimes forked . Normally a pale golden yellow colour , the gills turn brown when bruised . Interspersed between the gills are lamellulae , short gills that do not extend to the stem . The flesh is whitish and firm . The mushroom smells somewhat fishy ; one source suggests the odour is " like a dead shad , which anglers will tell you is probably the most malodorous freshwater fish " . The odour is concentrated when the fruit bodies are dried . One of the mushroom 's most distinctive features is the abundant latex , so plentiful that a small nick on the gills will cause it to " weep " the milky substance . The latex tends to impart brown stains on whatever it contacts .

= = = Micromorphology = = =

The spore print is whitish . The spores are roughly spherical , translucent (hyaline) , and typically measure 7 @.@ 5 ? 10 @.@ 0 by 7 @.@ 5 ? 9 @.@ 0 µm . The spore surface is reticulate ? covered with ridges that form a complete network . The ridges are up to 0 @.@ 8 µm high and have conspicuous projections up to 1 @.@ 2 µm high . The spore @-@ bearing cells of the hymenium , the basidia , are club @-@ shaped , hyaline , four @-@ spored , and have dimensions of 40 ? 62 by 7 @.@ 2 ? 10 @.@ 4 µm . Interspersed among the basidia are sterile cells called cystidia . The pleurocystidia (cystidia on the side of a gill) are roughly spindle- to club @-@ shaped , and measure 48 ? 145 by 5 ? 13 µm . The cheilocystidia (cystidia on the edge of a gill) may be spindle- , club- , or awl @-@ shaped (subulate) , or intermediate in between these forms , and measure 27 ? 60 by 5 ? 7 µm . Additionally , there are cystidia present on both the surface of the cap and the stem . If a drop of ferric sulphate (used as a chemical test in mushroom identification) is applied to the mushroom flesh , it will immediately stain dark bluish @-@ green .

= = = Varieties = = =

The variety Lactifluus volemus var. flavus was described by Alexander H. Smith and Lexemuel Ray

Hesler in their 1979 monograph of North American Lactarius species . This rare variety , found in the southeastern United States (ranging from South Carolina to Florida and extending west to Texas) , has a cap that stays yellow throughout its development . It also has slightly smaller spores than the regular variety : 6 @.@ 5 ? 9 @.@ 0 by 6 ? 8 µm . Some authors have considered the rarely collected L. volemus var. oedematopus , found in central and southern Europe , to be a distinct variety distinguished from the common variety by a darker reddish @-@ brown cap and a swollen stem . This assessment is not universally accepted , possibly because it falls within the range of morphological variation shown by the main variety . L. volemus var. asiaticus was named in 2004 based on Vietnamese specimens ; associating with Khasi pine (Pinus khasya) , it has small , dull brown , velvety fruit bodies . In general , little taxonomical significance has been ascribed to the several varieties of L. volemus that have been proposed .

= = = Similar species = = =

Lactifluus volemus is closely related to L. corrugis , and generally similar in appearance . L. corrugis usually has more surface wrinkles , darker gills , weaker or absent scent , and less orange colouration ; however , intermediate colour forms can be found . The two can be distinguished more definitively by microscopic characteristics : L. corrugis has larger spores ? typically 10 @.@ 4 ? 12 @.@ 8 by 9 @.@ 6 ? 11 @.@ 8 µm ? with a coarser surface reticulum , and larger pleurocystidia . The species Lactifluus austrovolemus is closely related , but has more crowded gills , while L. lamprocystidiatus can only be reliably distinguished from L. volemus by microscopic characteristics : the reticulations on its spores are taller and more acute , and the meshes formed by the intersections of the reticulations are smaller . Both L. austrovolemus and L. lamprocystidiatus are known only from Papua New Guinea . Lactifluus hygrophoroides also resembles L. volemus , but differs in having widely spaced gills , and spores that lack surface reticulations .

Some species of the genus Lactarius are also similar : The tropical African Lactarius chromospermus has a superficial resemblance to L. volemus , but the former species , in addition to its African distribution , can be identified by its cinnamon @-@ brown spore print ? unique in the Russulaceae . Lactarius subvelutinus is also similar to L. volemus , but lacks the fishy odour , has a dull yellow @-@ orange to bright golden orange cap , narrow gills , and a white latex that does not change colour .

= = Edibility and other uses = =

Despite the unappealing fishy scent that develops after the mushroom is picked , Lactifluus volemus is edible and recommended for culinary usage , though , typical of milk caps , it has a slightly granular texture that some may find unappetizing . The odor disappears during cooking . The latex only has a mild taste . The species is considered good for novice mushroom hunters to eat , and is best prepared by slow cooking to prevent it from becoming too hard ; specimens that have been rehydrated after having been dried will require longer cooking times to eliminate the grainy texture . The mushroom has also been suggested for use in casseroles and thick sauces . Pan frying is not a recommended cooking technique , due to the large amounts of latex it exudes . L. volemus is one of several species of milk caps that are sold in rural markets in Yunnan Province , China , and it is among the most popular wild edible mushroom species collected for consumption and sale in Nepal . In their 2009 book on milk caps of North America , Bessette and colleagues consider the mushroom " the best @-@ known and most popular edible milk mushroom " in the eastern United States . A Turkish study of the nutritional composition of the fruit bodies concluded that L. volemus is a good source of protein and carbohydrates .

= = = Bioactive compounds = = =

Fruit bodies contains a unique sterol molecule called volemolide , a derivative of the common fungal sterol ergosterol that may have application in fungal chemotaxonomy . A 2001 study identified a

further nine sterols , three of which were previously unknown to science . According to the authors , these types of highly oxygenated compounds ? similar to sterols found in marine soft coral and sponges ? are rare in fungi . The mushroom also contains volemitol (D @-@ glycero @-@ D @-@ mannoheptitol) , a seven @-@ carbon sugar alcohol first isolated from the species by the French scientist Émile Bourquelot in 1889 . Volemitol occurs as a free sugar in many plant and brown algal species .

Due to their natural polyisoprene content (1 @.@ 1 ? 7 @.@ 7 % by dry weight of fruit bodies) , L. volemus fruit bodies can also be used to produce rubber . The chemical structure of rubber from the mushroom consists of a high molecular mass homologue of polyprenol , arranged as a dimethylallyl group , two trans isoprene units , a long sequence of cis isoprenes (between 260 ? 300 units) , terminated by a hydroxyl or fatty acid ester . Biosynthetically , the creation of the polyisoprene begins with the compound trans , trans @-@ farnesyl pyrophosphate , and is thought to terminate by esterification of polyisoprenyl pyrophosphate . The enzyme isopentenyl @-@ diphosphate delta isomerase has been identified as required for the initiation of rubber synthesis in L. volemus and several other milk cap species .

= = Ecology , distribution , and habitat = =

Like all milk caps , L. volemus forms ectomycorrhizae , mutually beneficial symbiotic associations with various tree species . In this association , the fungal hyphae grow around the root of the plant and between its cortical cells , but do not actually penetrate them . The hyphae extend outward into the soil , increasing the surface area for absorption to help the plant absorb nutrients from the soil . It is found growing at the base of both coniferous and broad @-@ leaved trees , although it is more common in deciduous woods . It may also sometimes be found in peat moss beds . The fruit bodies , which appear between summer and autumn , are common . They can be found growing solitarily or in groups , and are more abundant in weather that is warm and humid .

Fruit bodies can be inhabited by species of limoniid flies , such as Discobola marginata or Limonia yakushimensis , as well as several species of fungi @-@ dwelling mites . The flies are hosts for the mites in a symbiotic association known as phoresis , whereby the mites are mechanically carried by its host . Mites are small and unable to migrate the relatively long distances between mushrooms without assistance ; the insect hosts , in comparison , are large and can transfer the mites between their preferred feeding habitats .

Lactifluus volemus is found in warm temperate regions and as well as some subtropical and tropical regions of the Northern Hemisphere . The fungus is widely distributed throughout Europe , although it is in decline in some countries , and has become rare enough in the Netherlands (and Flanders) to be considered locally extinct . In the Americas , the northern limit of its distribution reaches southern Canada east of the Great Plains , and the species extends south to the East Coast of the United States and Mexico , and beyond into Central America (Guatemala) . It is also known from Asia , including China (Qinling Mountains , Guizhou Province , and Yunnan Province) , Japan , India , Korea , Nepal , and Vietnam . Collections have also been made from the Middle East , including Iran and Turkey .