= Amanita phalloides =

Amanita phalloides / æm??na?t? f??l??di?z / , commonly known as the death cap , is a deadly poisonous basidiomycete fungus , one of many in the genus Amanita . Widely distributed across Europe , A. phalloides forms ectomycorrhizas with various broadleaved trees . In some cases , the death cap has been introduced to new regions with the cultivation of non @-@ native species of oak , chestnut , and pine . The large fruiting bodies (mushrooms) appear in summer and autumn ; the caps are generally greenish in colour , with a white stipe and gills .

These toxic mushrooms resemble several edible species (most notably caesar 's mushroom and the straw mushroom) commonly consumed by humans , increasing the risk of accidental poisoning . Amatoxins , the class of toxins found in these mushrooms , are thermostable : they resist changes due to heat and so , unlike many ingested poisons , their toxic effects are not reduced by cooking . Some amatoxins will cause irritation and severe pain and even damage to the eyes and skin on contact . They can be absorbed through the skin leading to the same potentially lethal effects as ingestion or inhalation .

A. phalloides is one of the most poisonous of all known toadstools . It is estimated that as little as half a mushroom contains enough toxin to kill an adult human . It has been involved in the majority of human deaths from mushroom poisoning , possibly including the deaths of Roman Emperor Claudius in AD 54 and Holy Roman Emperor Charles VI in 1740 . It has been the subject of much research , and many of its biologically active agents have been isolated . The principal toxic constituent is ? @-@ amanitin , which damages the liver and kidneys , causing hepatic and renal failure which can be fatal .

= = Taxonomy and naming = =

The death cap was first described by French botanist Sébastien Vaillant in 1727 , who gave a succinct phrase name " Fungus phalloides , annulatus , sordide virescens , et patulus " , which is still recognizable as the fungus today . Though the scientific name phalloides means " phallus @-@ shaped " , it is unclear whether it is named for its resemblance to a literal phallus or the stinkhorn mushrooms Phallus . In 1821 , Elias Magnus Fries described it as Agaricus phalloides , but included all white amanitas within its description . Finally in 1833 , Johann Heinrich Friedrich Link settled on the name Amanita phalloides , after Persoon had named it Amanita viridis 30 years earlier . Although Louis Secretan 's use of the name Amanita phalloides predates Link 's , it has been rejected for nomenclatural purposes because Secretan 's works did not use binomial nomenclature consistently ; some taxonomists have , however , disagreed with this opinion .

Amanita phalloides is the type species of Amanita section Phalloideae , a group that contains all of the deadly poisonous Amanita species thus far identified . Most notable of these are the species known as destroying angels , namely Amanita virosa and Amanita bisporigera , as well as the fool 's mushroom (A. verna) . The term " destroying angel " has been applied to A. phalloides at times , but " death cap " is by far the most common vernacular name used in English . Other common names also listed include " stinking amanita " and " deadly amanita " .

A rarely appearing , all @-@ white form was initially described A. phalloides f. alba by Max Britzelmayr , though its status has been unclear . It is often found growing amid normally colored death caps . It has been described , in 2004 , as a distinct variety and includes what was termed A. verna var. tarda . The true Amanita verna fruits in spring and turns yellow with KOH solution , whereas A. phalloides never does .

= = Description = =

The death cap has a large and imposing epigeous (aboveground) fruiting body (basidiocarp) , usually with a pileus (cap) from 5 to 15 cm (2 to 6 in) across , initially rounded and hemispherical , but flattening with age . The color of the cap can be pale- , yellowish- , or olive @-@ green , often paler toward the margins and often paler after rain . The cap surface is sticky when wet and easily

peeled , a troublesome feature , as that is allegedly a feature of edible fungi . The remains of the partial veil are seen as a skirtlike , floppy annulus usually about 1 @.@ 0 to 1 @.@ 5 cm (0 @.@ 39 to 0 @.@ 59 in) below the cap . The crowded white lamellae (gills) are free . The stipe is white with a scattering of grayish @-@ olive scales and is 8 to 15 cm (3 to 6 in) long and 1 to 2 centimetres (3 ? 8 to 3 ? 4 in) thick , with a swollen , ragged , sac @-@ like white volva (base) . As the volva , which may be hidden by leaf litter , is a distinctive and diagnostic feature , it is important to remove some debris to check for it .

The smell has been described as initially faint and honey @-@ sweet , but strengthening over time to become overpowering , sickly @-@ sweet and objectionable . Young specimens first emerge from the ground resembling a white egg covered by a universal veil , which then breaks , leaving the volva as a remnant . The spore print is white , a common feature of Amanita . The transparent spores are globular to egg @-@ shaped , measure 8 ? 10 ?m (0 @.@ 3 ? 0 @.@ 4 mil) long , and stain blue with iodine . The gills , in contrast , stain pallid lilac or pink with concentrated sulfuric acid .

= = Distribution and habitat = =

The death cap is native to Europe , where it is widespread . It is found from the southern coastal regions of Scandinavia in the north , to Ireland in the west , east to Poland and western Russia , and south throughout the Balkans , in Italy , Spain and Portugal , and in Morocco and Algeria in north Africa . In west Asia it has been reported from forests of northern Iran . There are records from further east in Asia but these have yet to be confirmed as A. phalloides .

It is ectomycorrhizally associated with several tree species and is symbiotic with them . In Europe , these include hardwood and , less frequently , conifer species . It appears most commonly under oaks , but also under beeches , chestnuts , horse @-@ chestnuts , birches , filberts , hornbeams , pines , and spruces . In other areas , A. phalloides may also be associated with these trees or with only some species and not others . In coastal California , for example , A. phalloides is associated with coast live oak , but not with the various coastal pine species , such as Monterey pine . In countries where it has been introduced , it has been restricted to those exotic trees with which it would associate in its natural range . There is , however , evidence of A. phalloides associating with hemlock and with genera of the Myrtaceae : Eucalyptus in Tanzania and Algeria , and Leptospermum and Kunzea in New Zealand . This suggests the species may have invasive potential .

By the end of the 19th century , Charles Horton Peck had reported A. phalloides in North America . In 1918 , samples from the eastern United States were identified as being a distinct though similar species , A. brunnescens , by G. F. Atkinson of Cornell University . By the 1970s , it had become clear that A. phalloides does occur in the United States , apparently having been introduced from Europe alongside chestnuts , with populations on the West and East Coasts . Although a 2006 historical review concluded the East Coast populations were introduced , the origins of the West Coast populations remained unclear , due to scant historical records . A 2009 genetic study provided strong evidence for the introduced status of the fungus on the west coast of North America .

Amanita phalloides has been conveyed to new countries across the Southern Hemisphere with the importation of hardwoods and conifers . Introduced oaks appear to have been the vector to Australia and South America ; populations under oaks have been recorded from Melbourne and Canberra (where two people died in January 2012 , of four who were poisoned) and Adelaide , as well as Uruguay . It has been recorded under other introduced trees in Argentina and Chile . Pine plantations are associated with the fungus in Tanzania and South Africa , where it is also found under oaks and poplars .

= = Toxicity = =

As the common name suggests , the fungus is highly toxic , and is responsible for the majority of

fatal mushroom poisonings worldwide . Its biochemistry has been researched intensively for decades , and 30 grams (1 @.@ 1 ounces) , or half a cap , of this mushroom is estimated to be enough to kill a human . In 2006 , a family of three in Poland was poisoned , resulting in one death and the two survivors requiring liver transplants . Some authorities strongly advise against putting suspected death caps in the same basket with fungi collected for the table and to avoid even touching them . Furthermore , the toxicity is not reduced by cooking , freezing , or drying .

= = = Similarity to edible species = = =

In general , poisoning incidents are unintentional and result from errors in identification . Recent cases highlight the issue of the similarity of A. phalloides to the edible paddy straw mushroom , Volvariella volvacea , with East- and Southeast @-@ Asian immigrants in Australia and the west coast of the United States falling victim . In an episode in Oregon , four members of a Korean family required liver transplants . Of the 9 people poisoned in the Canberra region between 1988 and 2011 , three were from Laos and two were from China . This misidentification is a leading cause of mushroom poisoning in the United States .

Novices may mistake juvenile death caps for edible puffballs or mature specimens for other edible Amanita species , such as A. lanei , so some authorities recommend avoiding the collecting of Amanita species for the table altogether . The white form of A. phalloides may be mistaken for edible species of Agaricus , especially the young fruitbodies whose unexpanded caps conceal the telltale white gills ; all mature species of Agaricus have dark @-@ colored gills .

In Europe , other similarly green @-@ capped species collected by mushroom hunters include various green @-@ hued brittlegills of the genus Russula and the formerly popular Tricholoma equestre , now regarded as hazardous owing to a series of restaurant poisonings in France . Brittlegills , such as Russula heterophylla , R. aeruginea , and R. virescens , can be distinguished by their brittle flesh and the lack of both volva and ring . Other similar species include A. subjunquillea in eastern Asia and A. arocheae , which ranges from Andean Colombia north at least as far as central Mexico , both of which are also poisonous .

In January 2012 , four people were accidentally poisoned when death caps (reportedly misidentified as straw fungi , which are popular in Chinese and other Asian dishes) were served at a New Year 's Eve dinner party in Canberra , Australia . All the victims required hospital treatment and two of them died , with a third requiring a liver transplant .

= = = Biochemistry = = =

The species is now known to contain two main groups of toxins , both multicyclic (ring @-@ shaped) peptides , spread throughout the mushroom tissue : the amatoxins and the phallotoxins . Another toxin is phallolysin , which has shown some hemolytic (red blood cell ? destroying) activity in vitro . An unrelated compound , antamanide , has also been isolated .

Amatoxins consist of at least eight compounds with a similar structure , that of eight amino @-@ acid rings ; they were isolated in 1941 by Heinrich O. Wieland and Rudolf Hallermayer of the University of Munich . Of the amatoxins , ? @-@ amanitin is the chief component and along with ? @-@ amanitin is likely responsible for the toxic effects . Their major toxic mechanism is the inhibition of RNA polymerase II , a vital enzyme in the synthesis of messenger RNA (mRNA) , microRNA , and small nuclear RNA (snRNA) . Without mRNA , essential protein synthesis and hence cell metabolism grind to a halt and the cell dies . The liver is the principal organ affected , as it is the organ which is first encountered after absorption in the gastrointestinal tract , though other organs , especially the kidneys , are susceptible . The RNA polymerase of Amanita phalloides is insensitive to the effects of amatoxins , so the mushroom does not poison itself .

The phallotoxins consist of at least seven compounds , all of which have seven similar peptide rings . Phalloidin was isolated in 1937 by Feodor Lynen , Heinrich Wieland 's student and son @-@ in @-@ law , and Ulrich Wieland of the University of Munich . Though phallotoxins are highly toxic to liver cells , they have since been found to add little to the death cap 's toxicity , as they are not

absorbed through the gut . Furthermore , phalloidin is also found in the edible (and sought @-@ after) Blusher (Amanita rubescens) . Another group of minor active peptides are the virotoxins , which consist of six similar monocyclic heptapeptides . Like the phallotoxins , they do not induce any acute toxicity after ingestion in humans .

= = = Signs and symptoms = = =

Death caps have been reported to taste pleasant . This , coupled with the delay in the appearance of symptoms ? during which time internal organs are being severely , sometimes irreparably , damaged ? makes it particularly dangerous . Initially , symptoms are gastrointestinal in nature and include colicky abdominal pain , with watery diarrhea , nausea , and vomiting , which may lead to dehydration if left untreated , and , in severe cases , hypotension , tachycardia , hypoglycemia , and acid ? base disturbances . These first symptoms resolve two to three days after the ingestion . A more serious deterioration signifying liver involvement may then occur ? jaundice , diarrhea , delirium , seizures , and coma due to fulminant liver failure and attendant hepatic encephalopathy caused by the accumulation of normally liver @-@ removed substance in the blood . Kidney failure (either secondary to severe hepatitis or caused by direct toxic kidney damage) and coagulopathy may appear during this stage . Life @-@ threatening complications include increased intracranial pressure , intracranial bleeding , pancreatic inflammation , acute kidney failure , and cardiac arrest . Death generally occurs six to sixteen days after the poisoning .

Mushroom poisoning is more common in Europe than in America . Up to the mid @-@ 20th century , the mortality rate was around 60 ? 70 % , but this has been greatly reduced with advances in medical care . A review of death cap poisoning throughout Europe from 1971 to 1980 found the overall mortality rate to be 22 @.@ 4 % (51 @.@ 3 % in children under ten and 16 @.@ 5 % in those older than ten) . This has fallen further in more recent surveys to around 10 ? 15 % .

= = = Treatment = = =

Consumption of the death cap is a medical emergency requiring hospitalization . The four main categories of therapy for poisoning are preliminary medical care , supportive measures , specific treatments , and liver transplantation .

Preliminary care consists of gastric decontamination with either activated carbon or gastric lavage ; due to the delay between ingestion and the first symptoms of poisoning , it is common for patients to arrive for treatment many hours after ingestion , potentially reducing the efficacy of these interventions . Supportive measures are directed towards treating the dehydration which results from fluid loss during the gastrointestinal phase of intoxication and correction of metabolic acidosis , hypoglycemia , electrolyte imbalances , and impaired coagulation .

No definitive antidote is available , but some specific treatments have been shown to improve survivability . High @-@ dose continuous intravenous penicillin G has been reported to be of benefit , though the exact mechanism is unknown , and trials with cephalosporins show promise . Some evidence indicates intravenous silibinin , an extract from the blessed milk thistle (Silybum marianum) , may be beneficial in reducing the effects of death cap poisoning . A long @-@ term clinical trial of intravenous silibinin began in the US in 2010 . Silibinin prevents the uptake of amatoxins by liver cells , thereby protecting undamaged liver tissue ; it also stimulates DNA @-@ dependent RNA polymerases , leading to an increase in RNA synthesis . According to one report based on a treatment of 60 patients with silibinin , the patients who have started the drug within 96 hours of ingesting the mushroom and who have still had kidney function intact have all survived . As of February 2014 supporting research hasn ? t yet been published .

SLCO1B3 has been identified as the human hepatic uptake transporter for amatoxins ; moreover , substrates and inhibitors of that protein ? among others rifampicin , penicillin , silibinin , antamanide , paclitaxel , ciclosporin and prednisolone ? may be useful for the treatment of human amatoxin poisoning .

N @-@ Acetylcysteine has shown promise in combination with other therapies . Animal studies

indicate the amatoxins deplete hepatic glutathione ; N @-@ acetylcysteine serves as a glutathione precursor and may therefore prevent reduced glutathione levels and subsequent liver damage . None of the antidotes used have undergone prospective , randomized clinical trials , and only anecdotal support is available . Silibinin and N @-@ acetylcysteine appear to be the therapies with the most potential benefit . Repeated doses of activated carbon may be helpful by absorbing any toxins returned to the gastrointestinal tract following enterohepatic circulation . Other methods of enhancing the elimination of the toxins have been trialed ; techniques such as hemodialysis , hemoperfusion , plasmapheresis , and peritoneal dialysis have occasionally yielded success , but overall do not appear to improve outcome .

In patients developing liver failure , a liver transplant is often the only option to prevent death . Liver transplants have become a well @-@ established option in amatoxin poisoning . This is a complicated issue , however , as transplants themselves may have significant complications and mortality ; patients require long @-@ term immunosuppression to maintain the transplant . That being the case , the criteria have been reassessed , such as onset of symptoms , prothrombin time (PTT) , serum bilirubin , and presence of encephalopathy , for determining at what point a transplant becomes necessary for survival . Evidence suggests , although survival rates have improved with modern medical treatment , in patients with moderate to severe poisoning , up to half of those who did recover suffered permanent liver damage . A follow @-@ up study has shown most survivors recover completely without any sequelae if treated within 36 hours of mushroom ingestion .

= = Notable victims = =

Several historical figures may have died from A. phalloides poisoning (or other similar , toxic Amanita species) . These were either accidental poisonings or assassination plots . Alleged victims of this kind of poisoning include Roman Emperor Claudius , Pope Clement VII , the Russian tsaritsa Natalia Naryshkina , and Holy Roman Emperor Charles VI .

R. Gordon Wasson recounted the details of these deaths , noting the likelihood of Amanita poisoning . In the case of Clement VII , the illness that led to his death lasted five months , making the case inconsistent with amatoxin poisoning (p . 110) . Natalia Naryshkina is said to have consumed a large quantity of pickled mushrooms prior to her death . It is unclear whether the mushrooms themselves were poisonous or if she succumbed to food poisoning .

Charles VI experienced indigestion after eating a dish of sautéed mushrooms . This led to an illness from which he died 10 days later ? symptomatology consistent with amatoxin poisoning . His death led to the War of the Austrian Succession . Noted Voltaire , " this dish of mushrooms changed the destiny of Europe . "

The case of Claudius ' poisoning is more complex . Claudius was known to have been very fond of eating Caesar 's mushroom . Following his death , many sources have attributed it to his being fed a meal of death caps instead of Caesar 's mushrooms . Ancient authors , such as Tacitus and Suetonius , are unanimous about poison having been added to the mushroom dish , rather than the dish having been prepared from poisonous mushrooms . Wasson speculated the poison used to kill Claudius was derived from death caps , with a fatal dose of an unknown poison (possibly a variety of nightshade) being administered later during his illness .