

= *Clathrus ruber* =

*Clathrus ruber* is a species of fungus in the stinkhorn family, and the type species of the genus *Clathrus*. It is commonly known as the latticed stinkhorn, the basket stinkhorn, or the red cage, alluding to the striking fruit bodies that are shaped somewhat like a round or oval hollow sphere with interlaced or latticed branches. The fungus is saprobic, feeding off decaying woody plant material, and is usually found alone or in groups in leaf litter on garden soil, grassy places, or on woodchip garden mulches. Although considered primarily a European species, *C. ruber* has been introduced to other areas, and now has a wide distribution that includes northern Africa, Asia, Australia, and North and South America. The species was illustrated in the scientific literature during the 16th century, but was not officially described until 1729.

The fruit body initially appears like a whitish "egg" attached to the ground at the base by cords called rhizomorphs. The egg has a delicate, leathery outer membrane enclosing the compressed lattice that surrounds a layer of olive @-@ green spore @-@ bearing slime called the gleba, which contains high levels of calcium that help protect the fruit body during development. As the egg ruptures and the fruit body expands, the gleba is carried upward on the inner surfaces of the spongy lattice, and the egg membrane remains as a volva around the base of the structure. The fruit body can reach heights of up to 20 cm ( 7 @. @ 9 in ). The color of the fruit body, which can range from pink to orange to red, results primarily from the carotenoid pigments lycopene and beta @-@ carotene. The gleba has a fetid odor, somewhat like rotting meat, which attracts flies and other insects to help disperse its spores. Although the edibility of the fungus is not known with certainty, its odor would deter most from consuming it. *C. ruber* was not regarded highly in tales in southern European folklore, which suggested that those who handled the mushroom risked contracting various ailments.

= = Taxonomy, phylogeny, and naming = =

*Clathrus ruber* was illustrated as early as 1560 by the Swiss naturalist Conrad Gesner in his *Nomenclator Aquatilium Animantium*. Gesner mistook the mushroom for a marine organism. It appeared in a woodcut in John Gerard's 1597 *Great Herball*, shortly thereafter in Carolus Clusius' 1601 *Fungorum in Pannoniis Observatorum Brevis Historia*, and was one of the species featured in Cassiano dal Pozzo's *museo cartaceo* ( " paper museum " ) that consisted of thousands of illustrations of the natural world.

The fungus was first described scientifically in 1729, by the Italian Pier Antonio Micheli in his *Nova plantarum genera iuxta Tournefortii methodum disposita*, who gave it its current scientific name. The species was once referred to by American authors as *Clathrus cancellatus* L., as they used a system of nomenclature based on the former American Code of Botanical Nomenclature, in which the starting point for naming species was Linnaeus's 1753 *Species Plantarum*. The International Code for Botanical Nomenclature now uses the same starting date, but names of Gasteromycetes used by Christian Hendrik Persoon in his *Synopsis Methodica Fungorum* ( 1801 ) are sanctioned and automatically replace earlier names. Since Persoon used the specific epithet *ruber*, the correct name for the species is *Clathrus ruber*. Several historical names of the fungus are now synonyms: *Clathrus flavescens*, named by Persoon in 1801; *Clathrus cancellatus* by Joseph Pitton de Tournefort and published by Elias Fries in 1823; *Clathrus nicaeensis*, published by Jean @-@ Baptiste Barla in 1879; and *Clathrus ruber* var. *flavescens*, published by Livio Quadaccia and Dario Lunghini in 1990.

*Clathrus ruber* is the type species of the genus *Clathrus*, and is part of the group of *Clathrus* species known as the Laternoid series. Common features uniting this group include the vertical arms of the receptacle ( fruit body ) that are not joined together at the base, and the spongy structure of the receptacle. According to a molecular analysis published in 2006, out of the about 40 Phallales species used in the study, *C. ruber* is most closely related to *Aseroe rubra*, *Clathrus archeri*, *Laternea triscapa*, and *Clathrus chrysomycelinus*.

The generic name *Clathrus* is derived from Ancient Greek ????????? or " lattice ", and the specific

epithet is Latin *ruber* , meaning " red " . The mushroom is commonly known as the " basket stinkhorn " , the " lattice stinkhorn " , or the " red cage " . It was known to the locals of the Adriatic hinterland in the former Yugoslavia as *ve?ti?ije srce* or *vje?ti?ino srce* , meaning " witch 's heart " . This is still the case in parts of rural France , where it is known as *c?ur de sorcière* .

#### = = Description = =

Before the volva opens , the fruiting body is egg @-@ shaped to roughly spherical , up to 6 cm ( 2 @. @ 4 in ) in diameter , with a gelatinous interior up to 3 mm ( 0 @. @ 1 in ) thick . White to grayish in color , it is initially smooth , but develops a network of polygonal marks on the surface prior to opening as the internal structures expand and stretch the peridium taut . The fruit body , or receptacle , bursts the egg open as it expands ( a process that can take as little as a few hours ) , and leaves the remains of the peridium as a cup or volva surrounding the base . The receptacle ranges in color from red to bright pink to pale orange , and it is often lighter in color approaching the base . The color appears to be dependent upon the temperature and humidity of the environment . The receptacle consists of a spongy network of " arms " interlaced to make meshes of unequal size . At the top of the receptacle , the arms are up to 1 @. @ 5 cm ( 0 @. @ 6 in ) thick , but they taper down to smaller widths near the base . A cross @-@ section of the arm reveals it to be spongy , and made up of one wide inner tube and two indistinct rows of tubes towards the outside . The outer surface of the receptacle is ribbed or wrinkled . There are between 80 and 120 mesh holes in the receptacle . The unusual shape of the receptacle has inspired some creative comparisons : David Arora likened it to a whiffleball , while the German Mycological Society ? who named *C. ruber* the 2011 " Mushroom of the Year " ? described it as " like an alien from a science fiction horror film " .

A considerable variation in height has been reported for the receptacle , ranging from 8 to 20 cm ( 3 @. @ 1 to 7 @. @ 9 in ) tall . The base of the fruit bodies are attached to the substrate by rhizomorphs ( thickened cords of mycelia ) . The dark olive @-@ green to olive @-@ brown , foul @-@ smelling sticky gleba covers the inner surface of the receptacle , except near the base . The odor ? described as resembling rotting meat ? attracts flies , other insects , and , in one report , a scarab beetle ( *Scarabaeus sacer* ) that help disperse the spores . The putrid odor ? and people 's reaction to it ? have been well documented . In 1862 Mordecai Cubitt Cooke wrote " it is recorded of a botanist who gathered one for the purpose of drying it for his herbarium , that he was compelled by the stench to rise during the night and cast the offender out the window . " American mycologist David Arora called the odor " the vilest of any stinkhorn " . The receptacle collapses about 24 hours after its initial eruption from the egg .

The spores are elongated , smooth , and have dimensions of 4 ? 6 by 1 @. @ 5 ? 2 µm . Scanning electron microscopy has revealed that *C. ruber* ( in addition to several other Phallales species ) has a hilar scar ? a small indentation in the surface of the spore where it was previously connected to the basidium via the sterigma . The basidia ( spore @-@ bearing cells ) are six @-@ spored .

#### = = Similar species = =

*Clathrus ruber* may be distinguished from the closely related tropical species *C. crispus* by the absence of the corrugated rims which surround each mesh of the *C. crispus* fruit body . The phylogenetically close species *C. chrysomycelinus* has a yellow receptacle with arms that are structurally simpler , and its gleba is concentrated on specialized " glebifers " located at the lattice intersections . It is known only from Venezuela to southern Brazil . *Clathrus columnatus* has a fruit body with two to five long vertical orange or red spongy columns , joined together at the apex .

#### = = Edibility and folklore = =

Although edibility for *C. ruber* has not been officially documented , its foul smell would dissuade most individuals from consuming it . In general , stinkhorn mushrooms are considered edible when still in the egg stage , and are even considered delicacies in some parts of Europe and Asia , where

they are pickled raw and sold in markets as " devil 's eggs " . However , an 1854 report provides a cautionary tale to those considering consuming the mature fruit body . Dr. F. Peyre Porcher , of Charleston , South Carolina , described an account of poisoning caused by the mushroom :

" A young person having eaten a bit of it , after six hours suffered from a painful tension of the lower stomach , and violent convulsions . He lost the use of his speech , and fell into a state of stupor , which lasted for forty @-@ eight hours . After taking an emetic he threw up a fragment of the mushroom , with two worms , and mucus , tinged with blood . Milk , oil , and emollient fomentations , were then employed with success . "

British mycologist Donald Dring , in his 1980 monograph on the Clathraceae family , wrote that *C. ruber* was not regarded highly in southern European folklore . He mentions a case of poisoning following its ingestion , reported by Barla in 1858 , and notes that Ciro Pollini reported finding it growing on a human skull in a tomb in a deserted church . According to John Ramsbottom , Gascons consider the mushroom a cause of cancer ; they will usually bury specimens they find . In other parts of France it has been reputed to produce skin rashes or cause convulsions .

= = Ecology , habitat , and distribution = =

Like most of the species of the Phallales order , *Clathrus ruber* is saprobic ? a decomposer of wood and plant organic matter ? and is commonly found fruiting in mulch beds . The fungus grows alone or clustered together near woody debris , in lawns , gardens , and cultivated soil .

*Clathrus ruber* was originally described by Micheli from Italy . It is considered native to southern and central continental Europe , as well as Macaronesia ( the Azores and the Canary Islands ) , western Turkey , North Africa ( Algeria ) , and western Asia ( Iran ) . The fungus is rare in central Europe , and is listed in the Red data book of Ukraine .

The fungus has probably been introduced elsewhere , often because of the use of imported mulch used in gardening and landscaping . It may have extended its range northwards into the British Isles or been introduced in the nineteenth century . It now has a mainly southerly distribution in England and has been recorded from Cornwall , Devon , Dorset , Somerset , the Isle of Wight , Hampshire , Sussex , Surrey , and Middlesex . In Scotland , it has been recorded from Argyll . It is also known from Wales , the Channel Islands , and Ireland . The fungus also occurs in the United States ( California , Florida , Georgia , Virginia , North Carolina , and New York ) , Canada , Mexico , and Australasia . The species was also reported from South America ( Argentina ) . In China , it has been collected from Guangdong , Sichuan , Guizhou , and Tibet . Records from Japan are referable to *Clathrus kusanoi* ; records from the Caribbean are probably of *C. crispus* .

= = Biochemistry = =

Like other stinkhorn fungi , *C. ruber* bioaccumulates the element manganese . It has been postulated that this element plays a role in the enzymatic breakdown of the gleba with simultaneous formation of odorous compounds . Compounds like dimethyl sulfide , aldehydes , and amines ? which contribute to the disagreeable odor of the gleba ? are produced by the enzymatic decarboxylation of keto acids and amino acids , but the enzymes will only work in the presence of manganese . A chemical analysis of the elemental composition of the gelatinous outer layer , the embryonic receptacle and the gleba showed the gelatinous layer to be richest in potassium , calcium , manganese , and iron ions . Calcium<sup>2+</sup> stabilizes the polysaccharide gel , protecting the embryonic receptacle from drying out during the growth of the egg . Potassium is required for the gelatinous layer to retain its osmotic pressure and retain water ; high concentrations of the element are needed to support the rapid growth of the receptacle . The high concentration of elements suggests that the gelatinous layer has a " placenta @-@ like " function ? serving as a reservoir from which the receptacle may draw upon as it rapidly expands .

Pigments responsible for the orange to red colors of the mature fruit bodies have been identified as carotenes , predominantly lycopene and beta @-@ carotene ? the same compounds responsible for the red and orange colors of tomatoes and carrots , respectively . Lycopene is also the main

pigment in the closely related fungus *Clathrus archeri* , while beta @-@ carotene is the predominant pigment in the Phallaceae species *Mutinus caninus* , *M. ravenelii* , and *M. elegans* .