= Calostoma =

Calostoma is a genus of 29 species of gasteroid fungi in the suborder Sclerodermatineae . Like other gasteroid fungi , Calostoma do not have the spore discharge mechanism associated with typical gilled fungi (ballistospory) , and instead have enclosed spore @-@ bearing structures . Resembling round , orange to red gelatinous puffballs on thick stalks , species have been collected in regions of deciduous , temperate , tropical or subtropical forests . They have a worldwide distribution , including eastern North America , Asia , and Australasia . The common name given to some species , " prettymouth " , alludes to the bright red fruit bodies with openings that may somewhat resemble lips .

The unusual fruit body structure has historically led mycologists to suggest various classification schemes based on presumed relationships to other puffball or " stomach mushrooms " . Phylogenetic analyses performed in the 2000s show the genus to be evolutionarily related to the Bolete mushrooms . Calostoma species are ectomycorrhizal , forming symbiotic associations with trees from various families . The type species , Calostoma cinnabarinum , is ectomycorrhizal with oak .

= = Taxonomy = =

The original genus description , based on the type species Calostoma cinnabarinum (synonymous with cinnabarina) , was published by French botanist Nicaise Auguste Desvaux in 1809 . Before the advent of modern genetic analysis , the Calostoma was considered to be part of the Gasteromycetes , a grouping of fungi with enclosed spore @-@ bearing structures . Specifically , it was classified in the order of stalked puffballs , although some mycologists have suggested that the genus Calostoma should be merged with Tulostoma (xerophilic stalked puffballs) , Scleroderma (hard puffballs) , Geastrum (earthstars) , or Pseudocolus (stinkhorns) . Some authors have placed Calostoma in its own family , the Calostomataceae .

In the 2000s , a phylogenetic analyses using nuclear and mitochondrial ribosomal gene sequences helped to clarify the phylogeny of Calostoma . Using the species C. cinnabarinum and C. ravenelli as representative examples , the research showed the genus evolutionarily related to the monophyletic Boletales clade , and separate from clades containing most of the gilled mushrooms , puffballs , stalked puffballs , earthstars , stinkhorns and non @-@ bolete Gasteromycetes . Calostoma belongs to the suborder Sclerodermatineae in the Boletales order . The Boletales comprise the following genera : Boletinellus , Calostoma , Gyroporus , Phlebopus , Pisolithus , Scleroderma , and Veligaster . Calostoma is thought to have diverged evolutionarily from the other Boletales between 52 ? 115 million years ago .

The genus name Calostoma is derived from the Greek kallos or " beauty " , and stoma (??ó??) or " mouth " ; similarly , several species are referred to in the vernacular as " prettymouths " . In Korea , it is called Yongi , or " red cheeks " .

= = Description = =

Fruit bodies , technically known as gasterocarps , form spherical spore @-@ bearing heads with a peridium (outer tissue layer) made of two to four clearly defined layers of tissue . The outermost peridial layer is a thick gelatinous or shiny cuticle , which during maturity peels away to reveal the brightly colored peristome that has a star @-@ shaped pore through which spores may escape . The innermost layer of the peridium is papery and membranous , and remains attached to the outer layers only at the apex of the star @-@ shaped apical pore or slit . The fruit bodies may either have no stalk (sessile) , or be atop a stalk . The stalk , made of thick , intertwined and fused cords of hyphae , is hygroscopic , and will expand upon absorbing moisture . The spore mass in the head , the gleba , is pale , and initially has thick @-@ walled skeletal hyphae called capillitia . Clamp connections are present in the fungal hyphae .

= = = Spores = = =

The spores are spherical to elliptical in shape , and typically have surfaces that are reticulate (with interconnected grooves resembling a net) or pitted . The variations in the elaborate pitted @-@ spore reticulations have inspired investigation with techniques such as scanning electron microscopy and atomic force microscopy . The latter technique was used to distinguish subtle details (at the nanometer scale) and differences in the fine structure of the spores of various Calostoma species . The spore reticulations have purpose : they become entangled and interwoven with nurse cells and scaly hyphae , the net effect of which is to prevent the spores from being blown away simultaneously .

= = Development = =

When grown in humid conditions , such as might typically be found in a temperate deciduous forest , Calostoma species develop a thicker , more gelatinous exoperidium (the outermost peridial layer) . As the stalk expands , the exoperidium becomes sloughed off , exposing the endoperidum and a raised peristome ? the ridge of tissue around the opening suggestive of the common name , " prettymouth " . The exoperidium may help to protect the maturing gleba of late @-@ fruiting species from harmful variations in temperature or humidity , or from insect predation .

= = Habitat and distribution = =

The species in Calostoma have been collected in regions of deciduous , temperate , tropical or subtropical forests , containing tree species from the families Fagaceae , Nothofagaceae , Myrtaceae , and Dipterocarpaceae . The type species C. cinnabarinum was shown to form ectomycorrhizae with Quercus species , using isotopic labeling , molecular and morphological analyses . Southeast Asian Calostoma have also been described as ectomycorrhizal . Calostoma sarasinii forms ectomycorrhizae with species of Lithocarpus (Fagaceae) while Calostoma retisporum forms ectomycorrhizae with species from the Myrtaceae . The ectomycorrhizal mode of nutrition is predominant in the Sclerodermatineae suborder . Historically , it had been assumed to be saprobic , due to its taxonomic uncertainly , and presumed relatedness to other saprobic fungi like the stalked puffballs and the earthstars .

The distribution of the genus is limited to Australasia (Australia , New Zealand , Papua New Guinea) , Southeast Asia , Asia , and North and Central America . Species have been described from Indonesia (Borneo , Java , Sumatra , New Guinea) , Ceylon , Himalaya , Nepal , Taiwan , China , New Zealand , North America , and Latin America . Australian species include C. fuhreri , C. fuscum , C. insigne , C. rodwayi , and C. viride . David Arora mentions a preference for humid forests in eastern North America , particularly in the southern Appalachian Mountains .

= = Uses = =

= = = Edibility = = =

In general , Calostoma species are not considered edible ; because they typically begin their development underground , by the time fruit bodies appear they are too tough for consumption . However , a 2009 study reported that in the community of Tenango de Doria (Hidalgo state , Mexico) , Calostoma cinnabarinum used to be collected by children and consumed " like a tidbit " , although the tradition seems to have been abandoned in recent years . Locals called the young fruit bodies " yemitas " .

= = = Bioactive compounds = = =

Calostoma cinnabarinum contains a pigment named calostomal that is responsible for its red color . The chemical structure is all @-@ trans @-@ 16 @-@ oxohexadeca @-@ 2 @,@ 4 @,@ 6 @,@ 8 @,@ 10 @,@ 12 @,@ 14 @-@ heptaenoic acid .

= = Species list = =

The following species list is compiled from Index Fungorum as well as species published in the literature , but missing in Fungorum , specifically C. formosanum , C. junghuhnii , and C. sarasinii . The name listed under the species binomial is the authority ? the author of the original description of that species , followed by the year of publication .