

= Chorioactis =

Chorioactis is a genus of fungus that contains the single species Chorioactis geaster . The mushroom is commonly known as the devil 's cigar or the Texas star in the United States , while in Japan it is called kirinomitake (?????? ?) . This extremely rare mushroom is notable for its unusual appearance and disjunct distribution : it is found only in select locales in Texas and Japan . The fruit body , which grows on the stumps or dead roots of cedar elms (in Texas) or dead oaks (in Japan) , somewhat resembles a dark brown or black cigar before it splits open radially into a starlike arrangement of four to seven leathery rays . The interior surface of the fruit body bears the spore @-@ bearing tissue known as the hymenium , and is colored white to brown , depending on its age . The fruit body opening can be accompanied by a distinct hissing sound and the release of a smoky cloud of spores .

Fruit bodies were first collected in Austin , Texas , and the species was named *Urnula geaster* in 1893 ; later it was found in Kyushu in 1937 , but the mushroom was not reported again in Japan until 1973 . Although the new genus Chorioactis was proposed to accommodate the unique species a few years after its original discovery , it was not until 1968 that it was accepted as a valid genus . Its classification has also been a source of confusion . Historically , Chorioactis was placed in the fungus family Sarcosomataceae , despite inconsistencies in the microscopic structure of the ascus , the saclike structure in which spores are formed . Phylogenetic analyses of the past decade have clarified the fungus 's classification : Chorioactis , along with three other genera , make up the family Chorioactidaceae , a grouping of related fungi formally acknowledged in 2008 . In 2009 , Japanese researchers reported discovering a form of the fungus missing the sexual stage of its life cycle ; this asexual state was named *Kumanasamuha geaster* .

= = History = =

The fungus was first collected in Austin , Texas , in 1893 by botanist Lucien Marcus Underwood , who sent the specimens to mycologist Charles Horton Peck for identification . Peck described the species as *Urnula geaster* in that year 's Annual Report of the New York State botanist , although he expressed doubt about its generic placement in *Urnula* . In 1902 , student mycologist Elsie Kupfer questioned the proposed classification of various species in the genera *Urnula* and *Geopyxis* , as suggested in an 1896 publication on the Discomycetes by German mycologist Heinrich Rehm . She considered Rehm 's transfer of the species to the genus *Geopyxis* illogical :

" Even externally the fungus does not closely answer Rehm 's own description of the genus *Geopyxis* under which he places it ; the texture of the apothecium is described as fleshy , the stem , as short and sometimes thin ; while in this plant , the leathery character of the cup and the length and thickness of the stem are its noticeable features . "

Working with Underwood 's guidance , Kupfer compared the microscopic structure of the hymenium (the fertile , spore @-@ bearing tissue) of the Texan species with a number of similar ones ? *Geopyxis carbonaria* , *Urnula craterium* , and *Urnula terrestris* (now known as *Podophacidium xanthomelum*) . She concluded that the Texan species was so dissimilar as to warrant its own genus , which she named Chorioactis . Although this taxonomical change was opposed in later studies of the fungus by Frederick De Forest Heald and Frederick Adolf Wolf (1910) and Fred Jay Seaver (1928 , 1942) , Chorioactis was established as a valid genus in 1968 by Finn @-@ Egil Eckblad in his comprehensive monograph about the Discomycetes .

= = Classification and naming = =

Historically , Chorioactis was considered to be in the family Sarcosomataceae . A 1983 monograph on the family included Chorioactis in the tribe Sarcosomateae (along with the genera *Desmazierella* , *Sarcosoma* , *Korfiella* , *Plectania* , and *Urnula*) , a grouping of fungi characterized by having spores lacking small wartlike projections (verruculae) capable of absorbing blue dye . A 1994 study of the structural features of the asci and the ascospores concluded that Chorioactis was more

closely aligned with the Sarcoscyphaceae , although it conceded that the layering of the cells comprising the walls of the ascus differed considerably from the other members of the family . It was not until 1999 that the results of phylogenetic analysis firmly challenged the traditional classification , showing *C. geaster* to be part of a distinct lineage , or clade , that includes species in the genera *Desmazierella* , *Neourula* , and *Wolfina* , taxa that were distributed among both families . This analysis was later corroborated when it was shown that the grouping of these four genera (by then called the " Chorioactis clade ") represented a sister clade to the Sarcosomataceae , and a new family , the Chorioactidaceae , was erected to contain them . Although *C. geaster* shares some characteristics with the other Chorioactidaceae genera , including dark @-@ colored superficial " hairs " on the outer surface of the fruit bodies , it is distinguished from them by its tan to orange (rather than black) hymenia .

The specific epithet *geaster* alludes to members of genus *Geastrum* , which also open to form star @-@ shaped fruit bodies commonly called ' earthstars ' . In the United States , *Chorioactis geaster* is commonly known as the Texas star , or the devil 's cigar . Regarding the origin of the latter name American mycologist Fred Jay Seaver commented : " Whether the name Devil 's Cigar refers to the form of the young specimens which resemble a bloated cigar in form , as well as in color , or to the fact that the fungus appears to ' smoke ' at maturity , we cannot say ... At any rate , the name is very appropriate . " In 1997 , Texan state Senator Chris Harris filed a bill to make *C. geaster* the official state fungus of Texas . The bill passed the Senate but did not succeed in the House . In Japan the mushroom is called *kirinomitake* (??????) , because the immature , unopened fruit body bears a superficial resemblance to the seed pods of *kiri* , the empress tree (*Paulownia tomentosa*) .

= = Description = =

Young specimens of *C. geaster* have a hollow , club @-@ shaped dark @-@ brown fruit body , connected to a stem . The stem , which is usually buried in the ground , is shorter than the hollow fruit body or equals it in length , although the stem length is somewhat variable depending on the depth of the underground root to which it is attached . The flesh of the stem and the wall of the fruit body is white , while the inner surface is yellowish @-@ white , turning light brown with age . The fruit body varies in width from 1 @. 2 to 3 @. 5 cm (0 @. 5 to 1 @. 4 in) in the thickest portion , and has a length of 4 to 12 cm (1 @. 6 to 4 @. 7 in) ; the stem is 0 @. 75 to 1 @. 5 cm (0 @. 3 to 0 @. 6 in) wide by 1 to 5 cm (0 @. 4 to 2 @. 0 in) long . Both stem and fruit body are covered by a dense layer of soft brown velvety " hairs " , or tomentum . In maturity , the fruit body splits open into 4 ? 7 rays that curve downward , similar to mushrooms of the genus *Geastrum* . The spores are borne on the inner surface of the rays , which , depending on the maturity of the specimen , may range in color from whitish to saffron to salmon to butterscotch to chestnut . The leathery rays are up to 0 @. 35 cm (0 @. 1 in) thick .

The fruit body remains closed until shortly before spore discharge ; dehiscence (fruit body opening) is caused by the pressure exerted by swollen paraphyses ? sterile (i.e. , non @-@ reproductive) cells that are interspersed between the ascospores . Dehiscence is accompanied by the release of clouds of spores , resembling smoke . The spore puffing upon rupture is thought to be caused by the sudden change in relative humidity between the interior chamber of the fruit body and the outside environment . Dehiscence is accompanied by a hissing sound , an auditory phenomenon known to occur in about fifteen other fungal species .

= = Microscopic characteristics = =

Spores are oblong to spindle @-@ shaped , and are flattened on one side ; they have dimensions of 54 ? 68 µm by 10 ? 13 µm . The spores each contain 3 ? 5 oil drops . Although the spores have been described as smooth in older literature , when viewed with transmission electron microscopy , they are seen to have minute spots or punctures . The spores develop simultaneously (synchronously) within the ascus , a developmental feature shared with the Sarcoscyphaceae genera *Cookeina* and *Microstoma* . Like other members of the Pezizales order , the asci of *C.*

geaster have an operculum ? a " lid " ? that opens when the spores are discharged . However , the operculum of *C. geaster* develops a two @-@ layered ring zone upon dehiscence , making it structurally distinct from members of both the Sarcosomataceae and the Sarcoscyphaceae families .

Similar to other Discomycetes , the fruit body consists of three distinct layers of tissue : the hymenium , the hypothecium , and the excipulum . The spore @-@ bearing hymenium , the outermost layer of cells , contains asci interspersed with sterile cells called paraphyses . In *C. geaster* , the club @-@ shaped asci are 700 ? 800 µm long and 14 ? 17 @.@ 25 µm thick ; they are abruptly constricted at the base to a narrow pedicel . The paraphyses are initially filamentous or thread @-@ like (filiform) but swell with age to resemble a string of beads (moniliform) . The swelling of the paraphyses is believed to cause the expansion of the hymenium and subsequent splitting of the fruit body into rays ; this development places the asci into an optimal position for spore release and dispersal . Supporting the cells of the hymenium is a thin layer of tightly interwoven hyphae called the hypothecium , and underneath this is a thick layer of loosely interwoven hyphae known as the excipulum . This tissue layer , analogous to parenchyma found in plants , gives the tissue a fibrous texture . The excipulum layer averages 34 µm in diameter , while the hypothecium is 10 ? 14 µm . When viewed with electron microscopy , the dark brown " hairs " on the surface of the fruit body can be seen to be adorned with conical warts or spines .

= = = Anamorph form = = =

The so @-@ called anamorphic or imperfect fungi are those that seem to lack a sexual stage in their life cycle , and typically reproduce by the process of mitosis in structures called conidia . In some cases , the sexual stage ? or teleomorph stage ? is later identified , and a teleomorph @-@ anamorph relationship is established between the species . The International Code of Botanical Nomenclature permits the recognition of two (or more) names for one and the same organisms , one based on the teleomorph , the other (s) restricted to the anamorph . In 2004 , researchers reported a connection between *C. geaster* and the appearance of blackish @-@ brown tufted structures on rotting wood . By comparing the internal transcribed spacer region of the nuclear ribosomal DNA from the two organisms , they established a phylogenetic connection between *Chorioactis* and the fungus they called *Conoplea* aff. *elegantula* . However , they were unable to induce the new organism to grow on artificial media , and did not definitively establish a teleomorph @-@ anamorph connection between the fungi . In 2009 , Japanese researchers found a similar fungus growing on rotting logs that were normally associated with the growth of *C. geaster* ; they were able to grow the organism in axenic cultures from single @-@ spore isolates of *C. geaster* . They named the anamorph *Kumanasamuha geaster* due to its morphological similarity with species in the genus *Kumanasamuha* .

= = Distribution , ecology , and habitat = =

Chorioactis geaster has a disjunct distribution , and has only been collected from Texas and Japan . The first reported collection in Japan was in Kyushu in 1937 , and then it was not collected again in that location until thirty @-@ six years later . In 2006 , it was observed in a humid forest near Kawakami , Nara Prefecture . The fungus 's natural habitat in Japan is disappearing because of the practice of deforestation and replanting with Japanese cedar (*Cryptomeria japonica*) . This rare mushroom has been put on the list of threatened species in Japan . In Texas , the fungus has been reported in Collin , Hays , Travis , Dallas , Denton , Guadalupe , Tarrant and Hunt counties . Travis , Hays , and Guadalupe counties are in central Texas , while the remainder are clustered together in the northeastern part of the state . Although the species is considered rare due to its globally restricted distribution , it may be locally abundant .

Although it is not known definitively , *Chorioactis* is believed to be saprobic , deriving nutrients from decomposing organic matter . In Texas , fruit bodies are found growing singly or in groups from roots , stumps , and dead roots of cedar elm trees (*Ulmus crassifolia*) or *Symplocos myrtilacea* ; in

Japan , the usual host is dead oak trees . Fruit bodies can be clustered together close to the base of the stump , or from the roots away from the stump ; the stem of the fruit body tends to originate from a point 5 to 10 cm (2 to 4 in) below the ground . In Texas , fruit bodies usually appear between October and April , as this period is associated with somewhat cooler weather , and the temperature and moisture conditions during this time seem to be more favorable for growth .

Scientists do not know why the fungus mysteriously lives only in Texas and Japan , locations of approximately the same latitude , but separated by 11 @, @ 000 km (6 @, @ 800 mi) . Fred Jay Seaver commented " this is only another illustration of the unusual and unpredictable distribution of many species of the fungi . It would be difficult indeed to account for it , and we merely accept the facts as they are . " In 2004 , a research study compared the DNA sequences of both populations and used a combination of molecular phylogenetics and molecular clock calculations to estimate the extent of genetic divergence . It concluded that the two populations have been separated for at least nineteen million years , ruling out the possibility of human introduction of the species from one location to the other . Although there are no consistent differences in morphology between the two populations , there are several differences in their life histories . The preferred host of Texan populations is typically roots and stumps of *Ulmus crassifolia* , while the Japanese populations tend to grow on the fallen trunks of *Symplocos myrtacea* and *Quercus gilva* . Texan species grow in areas subjected to periodic flooding , unlike their Japanese counterparts . Finally , only Japanese specimens can be grown in culture ? the spores of Texan material have not been successfully germinated on artificial media .