

= *Geastrum pectinatum* =

Geastrum pectinatum is an inedible species of mushroom belonging to the earthstar family of fungi . Although young specimens are spherical , fruit body development involves the outer layer of tissue splitting open like a star into 7 to 10 pointed rays that eventually bend back to point downward , revealing a small ? 1 to 2 @. @ 5 cm (0 @. @ 4 to 1 @. @ 0 in) broad ? spore sac . The spore sac is supported by a small radially wrinkled stalk . There is a distinct conical opening (peristome) at the top of the spore sac that is up to 8 mm (0 @. @ 3 in) long . It is commonly known as the beaked earthstar or the beret earthstar , in reference to the shape of the spore sac and its prominent , protruding peristome . The mass of spores and surrounding cells within the sac , the gleba , is dark @-@ brown , and becomes powdery in mature specimens . Spores are spherical , measuring 4 to 6 micrometers in diameter , with warts on their surfaces . Although uncommon , *Geastrum pectinatum* has a cosmopolitan distribution , and has been collected in various locations in Europe , North and South America , Asia and Africa , where it grows on the ground in open woods . Like several other earthstars , crystals of calcium oxalate are found on *G. pectinatum* , and are thought to be involved in fruit body maturation .

= Taxonomy , classification , and naming =

Christian Hendrik Persoon published the first description of *Geastrum pectinatum* in 1801 . In 1860 , Miles Joseph Berkeley and Moses Ashley Curtis described the species *Geastrum biplicatum* (originally named *Geaster biplicatus*) , based on specimens sent to them by Charles Wright that he obtained from the Bonin Islands during the North Pacific Exploring and Surveying Expedition . Japanese mycologist Sanshi Imai considered this identical with *G. pectinatum* in a 1936 publication . In 1959 , mycologist J.T. Palmer reported comparing the original specimen collected by Persoon with fresh samples of what were then thought to be the distinct species *G. plicatum* and *G. tenuipes* (named by English naturalist Miles Joseph Berkeley in 1838 and 1848 , respectively) and concluded the three specimens were synonymous ; the original Persoon specimen was then designated as the neotype .

In Ponce de Leon 's classification of *Geastrum* , he placed the species in the subgenus *Geastrum* , section *Geastrum* , as the type of the subsection *Sulcostomata* , group *Pectinatum* . Other species in this group ? characterized by a determinate peristome surrounded by a groove ? are *G. xerophilum* , and *G. furfuraceum* . In Stanek 's (1958) infrageneric concept , *G. pectinatum* is placed in section *Perimyceliata* (encompassing species whereby the mycelial layer covers the entire endoperidium) , in subsection *Glabrostomata* , which includes species with plicate peristomes .

The specific epithet is derived from the Latin *pectinatum* , " like a comb " . Its common names include the " beaked earthstar " or the " beret earthstar " . Samuel Frederick Gray called it the " comblike shell @-@ puff " in his 1821 " A Natural Arrangement of British Plants " .

= Description =

Immature specimens ? 1 to 2 cm (0 @. @ 4 to 0 @. @ 8 in) diameter ? are roughly spherical and begin their development submerged in the ground , but gradually push above ground during maturation . In this state the outer surface is covered with mycelia , which forms a soft , fluffy coat that holds soil and debris to the outer surface . The young fruit bodies often have a rounded knob or protuberance . Like other members of genus *Geastrum* , *G. pectinatum* has a fruit body wall that is multilayered . At maturity , the outer layer (the exoperidium) splits open from the top in a stellate (star @-@ shaped) manner into 7 ? 9 rays that support the spore sac contained within the inner wall (the endoperidium) . The expanded specimens are up to 5 cm (2 @. @ 0 in) broad and 6 cm (2 @. @ 4 in) tall . The rays of the exoperidium bend back (reflex) , simultaneously elevating the spore sac above the ground in what is known as the fornicate condition ; this position exposes the spore sac to more air currents , aiding spore dispersal . The surface of the rays often crack to reveal

lighter @-@ colored areas , especially along the edges . Together with a well @-@ developed layer of mycelium , the rays are typically bound to fragments of earth or forest duff .

The tough and membranous endoperidium comprising the spore sac , purple @-@ brown in color and 0 @. @ 5 to 1 @. @ 5 cm (0 @. @ 2 to 0 @. @ 6 in) tall by 1 to 2 @. @ 5 cm (0 @. @ 4 to 1 @. @ 0 in) wide , is supported by a small stalk ? a pedicel ? that is 3 ? 4 mm long by 7 ? 10 mm wide and which has a grooved (sulcate) apophysis , or swelling . This ring @-@ shaped swelling is made of remnants from a tissue called the pseudoparenchymatous layer . When fresh , the pseudoparenchymatous layer is whitish in color , thick and fleshy ; it dries to become brown to dark brown while shrinking and often splitting and peeling . The endoperidium may be pruinose ? covered with fine , white , powder ? although the presence of this characteristic has been noted as being somewhat variable . The spore sac is opened by a single apical pore atop a conical " beak " , or peristome . The peristome is pectinate ? made of tissue that resembles the teeth of a comb ; the specific epithet is named after this characteristic . The peristome is 2 to 5 mm (0 @. @ 08 to 0 @. @ 20 in) long , and comprises 20 ? 32 distinct ridges . The mass of spores and surrounding cells within the sac , the gleba , is dark @-@ brown , and becomes powdery in mature specimens . Internally , the endoperidium contains a structure called the columella that is narrowly conical in shape , whitish or pale brown , and extends more than halfway into the gleba . *G. pectinatum* has no distinguishable odor or taste ; like other earthstar mushrooms , it is inedible , and of " no alimentary interest " .

= = = Microscopic characteristics = = =

The spores of *G. pectinatum* are brown and opaque . They have a roughly spherical shape and are ornamented with transparent (hyaline) , truncate warts ; the diameter is 4 ? 4 @. @ 5 μ m , or 5 @. @ 5 ? 6 @. @ 5 if the lengths of the warts is included . Spore @-@ bearing cells , the basidia , are 2- or 4 @-@ spored , while cystidia (specialized sterile cells that occur at the hymenial surface in some mushrooms) are absent . The capillitia ? a mass of thread @-@ like sterile fibers dispersed among the spores ? are light brown and 3 ? 7 μ m in diameter . They are tapered , thick @-@ walled with a narrow interior , and either smooth or slightly encrusted .

= = = Similar species = = =

Geastrum pectinatum has been mistaken for the morphologically similar but smaller species *G. schmidelii* . The latter species lacks vertical striations on the basal portions of the endoperidium , and does not have a pseudoparenchymatous collar around the stem . Another similar species , *G. berkeleyi* , has a shorter stem and is missing the ridges at the base of the spore sac . Further , the color of its spore sac is usually brown , in contrast to the gray @-@ blue of *G. pectinatum* . *G. xerophilum* also has a dusting of white powder on the surface of the spore sac , but unlike *G. pectinatum* , consistently lacks a ring at the base of the pedicel ; furthermore , in contrast to *G. pectinatum* , the spores of *G. xerophilum* are yellow and contain oil drops that are readily observable with a microscope . *G. striatum* has smaller fruit bodies than *G. pectinatum* , and a distinct collar @-@ like apophysis .

= = Distribution and habitat = =

This species has been reported to grow solitary or in groups on sandy soil or rich composted soil in both mixed and coniferous forests , often beneath cedars . In Hawaii , it is usually found growing in duff under coastal *Casuarina* and groves of *Cupressus* . The species has been noted to occur in late summer and autumn (in Britain and Europe) , but the fruit bodies may dry and persist for some time .

Geastrum pectinatum has a cosmopolitan distribution . It has been reported from Australia , and New Zealand , Africa (the Congo , South Africa) Central America (Costa Rica) , Asia (Northeastern China and Japan) , and South America (Brazil) . In Europe , it has been reported

from Belgium , Ireland , Germany , the Netherlands , Norway , and Sweden . In the Middle East , it has been recorded in Israel , and Turkey . In North America , it is known from the United States (including Hawaii) , Canada , and Mexico . It is in the Red Data Book (documenting rare and endangered species) of Latvia , and is considered a threatened species in Poland . North American sources gives its frequency of appearance as " rare " , but Stellan Sunhede , in his 1989 monograph on the Geastraceae , considers it one of the most common earthstar mushrooms of northern Europe .

= = Calcium oxalate crystals = =

Calcium oxalate is a common crystalline compound found in many fungi , including the earthstars . The presence of calcium oxalate crystals ? apparent as a whitish powder on the surface of the spore sac ? has been verified for *G. pectinatum* using scanning electron microscopy . The calcium oxalate crystals occur in the tetragonal form , known as weddellite . A study on the related species *Geastrum saccatum* has shown that these crystals are responsible for the characteristic opening (dehiscence) of the outer peridial layers . The formation of calcium oxalate crystals stretches the layers of the outer walls , pushing apart the inner and outer layers of the peridium .

= = = Cited literature = = =

Sunhede S. (1989) . Geastraceae (Basidiomycotina) : Morphology , Ecology , and Systematics with Special Emphasis on the North European Species . Synopsis Fungorum , 1 . Oslo , Norway : Fungiflora . ISBN 82 -@- 90724 -@- 05 -@- 5 .