

= Marasmius rotula =

Marasmius rotula is a common species of agaric fungus in the family Marasmiaceae . Widespread in the Northern Hemisphere , it is commonly known variously as the pinwheel mushroom , the pinwheel marasmius , the little wheel , the collared parachute , or the horse hair fungus . The type species of the genus *Marasmius* , *M. rotula* was first described scientifically in 1772 by mycologist Giovanni Antonio Scopoli and assigned its current name in 1838 by Elias Fries .

The fruit bodies , or mushrooms , of *M. rotula* are characterized by their whitish , thin , and membranous caps up to 2 cm (0 @. @ 8 in) wide that are sunken in the center , and pleated with scalloped margins . The slender and wiry black hollow stems measure up to 8 @. @ 0 cm (3 @. @ 1 in) long by 1 @. @ 5 mm (0 @. @ 06 in) thick . On the underside of the caps are widely spaced white gills that are attached to a collar encircling the stem . The mushrooms grow in groups or clusters on decaying wood such as fallen twigs and sticks , moss @-@ covered logs , and stumps .

Unlike other mushrooms known to release spores in response to a circadian rhythm , spore release in *M. rotula* is dependent upon sufficient moisture . Dried mushrooms may revive after rehydrating and continue to release spores for up to three weeks ? a sustained spore production of markedly longer duration than other typical agarics . There are several species of *Marasmius* with which *M. rotula* might be confused due to somewhat similar overall appearances , but differences in size , gill arrangement , and substrate are usually sufficient field characteristics to distinguish them . Although *M. rotula* mushrooms are not generally considered edible , they produce a unique peroxidase enzyme that is attracting research interest for possible use in bioengineering applications .

= = Taxonomy = =

The species was first described by Italian mycologist Giovanni Antonio Scopoli as *Agaricus rotula* in 1772 . In 1821 Elias Magnus Fries redescribed the mushroom in *Systema Mycologicum* , and later transferred it to *Marasmius* in his 1838 *Epicrisis Systematis Mycologici* . Synonyms include names derived from generic transfers to *Androsaceus* by Narcisse Théophile Patouillard in 1887 , and to *Chamaeceras* by Otto Kuntze in 1898 ; both of these genera are now obsolete and have since been sunk back into *Marasmius* .

In his 1821 *A Natural Arrangement of British Plants* , Samuel Frederick Gray introduced the generic name *Micromphale* , including the species *Micromphale collariatum* , which was based on William Withering 's 1796 *Merulius collariatus* . In 1946 Alexander H. Smith and Rolf Singer proposed to conserve the name *Marasmius* over *Micromphale* ; the latter had nomenclatorial priority as it was published first . The generic name *Marasmius* , with *M. rotula* as the lectotype species , was later conserved at the 1954 Paris Congress on Botanical Nomenclature . *M. rotula* is also the type species of section *Marasmius* within the genus . This grouping of species is characterized by inamyloid flesh , a cap cuticle with broom cells (finger @-@ like projections common to *Marasmius* species) ornamented with numerous warts , gills usually attached to a collar surrounding the stem , and the presence of black rhizomorphs on the stem .

Several varieties of *M. rotula* have been described . Miles Berkeley and Moses Ashley Curtis named var. *fuscus* in 1869 for its brown cap . In 1887 Pier Andrea Saccardo described var. *microcephalus* from Italy , with caps half the normal size . It is now understood , however , that fruit body morphology is variable and dependent upon environmental conditions . Joseph Schröter described var. *phyllophyla* in 1889 , but that taxon is now treated as *Marasmius bulliardii* .

Marasmius rotula is commonly known as the " pinwheel mushroom " , the " pinwheel *Marasmius* " , the " collared parachute " , or the " horse hair fungus " . This latter name is shared with other *Marasmius* species , including *M. androsaceus* and *M. crinis* @-@ *equi* . Gray called it the " collared dimple @-@ stool " . The name " little wheel fungus " is suggestive of the collar to which the gills are attached like the spokes of a wheel , like the specific epithet , which is a diminutive of *rota* , the Latin word for " wheel " .

= = Description = =

The cap of the fruit body is thin and membranous , measuring 3 to 20 mm (0 .@ 1 to 0 .@ 8 in) in diameter . It has a convex shape slightly depressed in the center , conspicuous furrows in an outline of the gills , and scalloped edges . Young , unexpanded caps are yellowish brown ; as the cap expands , the color lightens to whitish or light pinkish @-@ white , often with a darker , sometimes brown center . The variety fusca has brown caps . The white or slightly yellowish flesh is very thin , reaching about 0 .@ 25 ? 1 @. @ 5 mm thick in the central part of the cap , and even thinner at the margin .

Gills are attached to a collar , never to the stem , although some specimens have the collar pressed close enough to it that this characteristic may be less obvious . Widely spaced , they have the same whitish to pale yellow color as the flesh , and typically number between 16 and 22 . They are initially narrow , but thicken downward to about 1 ? 3 mm at the exposed edge . The stem is 1 @. @ 2 to 8 @. @ 0 cm (0 @. @ 5 to 3 @. @ 1 in) long and up to 0 @. @ 15 cm (0 @. @ 06 in) thick , with a smooth , sometimes shiny surface . It is tough , hollow , and either straight or with some curving . The color is blackish @-@ brown up to a lighter , almost translucent apex . The base of the stem may be connected to dark brown or black root @-@ like rhizomorphs 0 @. @ 1 ? 0 @. @ 3 mm thick . Mature specimens display no veil .

Details of the fruit bodies ' appearance , color in particular , are somewhat variable and dependent on growing conditions . For example , specimens growing on logs in oak and hickory forests in the spring tend to have more yellowish @-@ white , depressed caps than those found in the same location in autumn , which are light yellow brown and more convex in shape . The fruit body development of *M. rotula* is hemiangiocarpous , with an hymenium that is only partially enclosed by basidiocarp tissues . Robert Kühner showed that a cortina @-@ like tissue covers the young gills before the expanding cap breaks away from the stem . In unfavorable weather conditions , however , the mushrooms may fail to develop normally and instead produce semi @-@ gasteroid basidiocarps .

= = = Microscopic characteristics = = =

Viewed in deposit , such as with a spore print , the spores of *Marasmius rotula* appear white or pale yellow . Under an optical microscope , they are hyaline (translucent) , teardrop- or pip @-@ shaped , and have dimensions of 7 ? 10 by 3 ? 5 μ m . The basidia (spore @-@ producing cells) are four @-@ spored , club @-@ shaped or nearly so , and 21 ? 21 by 4 ? 17 μ m . Along the edge of the gill , interspersed among the basidia , are non @-@ reproductive cells , the cheilocystidia ; these are club @-@ shaped with rough wart @-@ like protuberances on the surface . The gill edges further feature broom cells , which are variably shaped , thin @-@ walled , and measure 7 ? 32 by 2 @. @ 5 ? 20 μ m . Their apical surfaces are covered with yellowish , blunt , and conical warts or incrustations 0 @. @ 2 ? 1 @. @ 5 by 0 @. @ 1 ? 1 μ m .

= = Similar species = =

There are several less @-@ common species of *Marasmius* with which *M. rotula* might be confused due to somewhat similar overall appearances , but differences in size , gill arrangement , and substrate are usually sufficient field characteristics to distinguish between them . For example , *Marasmius capillaris* has a pale tan cap with a white center , and grows on oak leaves without forming clusters . Furthermore , its cap is evenly rounded , unlike the pleated and furrowed cap of *M. rotula* , and its stem is somewhat thinner (usually less than 0 @. @ 3 mm) and slightly darker in color .

M. rotula is distinguished from *M. bulliardii* by its larger size , and greater number of gills . *M. limosus* is found in marshes , where it fruits on the dead stems of reeds and rushes . *Tetrapyrgos nigripes* (formerly treated in *Marasmius*) has white caps that are 5 to 10 mm (0 @. @ 2 to 0 @. @ 4 in) in diameter , attached gills that are sometimes slightly decurrent , a dark stem covered with tiny white hairs that give it a powdered appearance , and triangular to star @-@ shaped spores . *M.*

neorotula , described from Brazil , was considered by its discoverer Rolf Singer to be closely related to *M. rotula* . In addition to its tropical distribution , it can distinguished from *M. rotula* by its smaller size and more widely spaced gills . *M. rotuloides* , known only from montane forests of Trinidad , can only be reliably distinguished from *M. rotula* by microscopic characteristics : it has smaller , ovoid spores measuring 5 by 2 @. @ 5 µm .

Other *Marasmius* species with a pinwheel arrangement of gills are readily distinguished from *M. rotula* by differences in color , including the orange *M. siccus* , the pink *M. pulcherripes* , and the rust *M. fulvoferrugineus* . *Mycena corticola* is smaller than *Marasmius rotula* , has a pale pink @-@ brown cap , and is usually found growing singly or in small groups on bark near the base of living trees .

= = Ecology and distribution = =

Marasmius rotula is a saprobic species and as such obtains nutrients by decomposing dead organic matter . It grows in deciduous forests and fruits in groups or clusters on dead wood (especially beech) , woody debris such as twigs or sticks , and occasionally on rotting leaves . The fruit bodies , which are easily overlooked because of their diminutive size , are often present in abundance after rains . The species is relatively intolerant of low water potentials , and will grow poorly or not at all under water stress conditions . It is unable to degrade leaf litter until it becomes more fragmented and more compacted so that the water @-@ holding capacity increases in the deeper layers of the soil . The magnolia warbler has been noted to line its nests with the fruit bodies ' stems .

In 1975 American mycologist Martina S. Gilliam investigated the periodicity of spore release in *M. rotula* and concluded that spore discharge did not follow a regular circadian rhythm , as is typical of agaric and bolete mushrooms , but rather was dependent on rain . A threshold of rainfall is required to elicit a spore discharge response and the duration of peak spore discharge correlates with the amount of rainfall , rather than its duration . Furthermore , Gilliam noted that spore prints were more readily obtained if the stem ends were placed in water , suggesting that water must enter through the fruit body for discharge to occur .

Like those of many other species of *Marasmius* , the fruit bodies of *M. rotula* can desiccate and shrivel in dry periods , then revive when sufficient moisture is available again in the form of rain or high humidity . Gilliam 's study demonstrated that revived fruit bodies were capable of discharging spores over a period of at least three weeks , whereas previous studies using similar methods with other Agaricomycetes showed spore discharge occurred over a shorter period of up to six days after revival . The potential for sustained spore production and discharge may be due to the growth of new basidioles (immature basidia) during periods of growth , which then complete maturation when the mushroom revives . This may also explain why the gills become thicker as the mushroom matures .

The fungus is widespread and common in its preferred habitats in North America , Europe , and northern Asia . Although far less common in southerly locations , isolated collections have been reported from Africa (Congo , Nigeria , Sierra Leone , and Tanzania) and South Asia (India) . In North America *M. rotula* is most common in the eastern part of the continent .

= = Uses = =

Marasmius rotula is generally considered inedible , but not poisonous . The mushroom has no distinguishable odor , and its taste is mild or bitter . Louis Krieger , writing in National Geographic in the 1920s , noted that the mushroom was used as an addition to gravies and , when used to garnish venison , " adds the appropriate touch of the wild woodlands . " The fruit bodies will bioaccumulate cadmium : a study of the metal concentration of 15 wild mushroom species of India showed that *M. rotula* accumulated the highest concentration of that metal .

A peroxidase enzyme known as MroAPO (*Marasmius rotula* aromatic peroxygenase) is attracting research interest for possible applications in biocatalysis . In general , enzymes that catalyze oxygen @-@ transfer reactions are of great utility in chemical synthesis since they work selectively and

under ambient conditions . Fungal peroxidases can catalyze oxidations that are difficult for the organic chemist , including those involving aromatic substrates such as aniline , 4 -aminophenol , hydroquinone , resorcinol , catechol , and paracetamol . The *M. rotula* enzyme is the first fungal peroxygenase that can be produced in high yields . It is highly stable over a wide pH range , and in a variety of organic solvents . The enzyme has other potential for use as a biosensor for aromatic substances in environmental analysis and drug monitoring .

= = = Cited literature = = =

Gilliam MS. (1976) . " The genus *Marasmius* in the northeastern United States and adjacent Canada " . *Mycotaxon* 4 (1) : 1 ? 144 . ISSN 0093 - 4666 .