Join *Tulostoma* sampling campaign!

Project FunDive

In FunDive we work towards putting fungal diversity on the map to enhance European conservation efforts. Fungi are essential for our ecosystems but have often been neglected in monitoring efforts and conservation practices, leaving them vulnerable to threats and habitat loss. We would like to engage you to change this.

For more information, please visit https://fun-dive.eu/

FunDive is a pan-European initiative funded by Biodiversa+ that brings together 33 partners in 22 countries to improve fungal monitoring across the continent. The goal of FunDive is to close the knowledge gap dealing with fungal distributions to improve fungal conservation using the help from you and other citizen scientists.

Why is fungal monitoring important?

Fungi are generally under-studied. Their global distribution patterns are poorly resolved. Also in Europe, despite centuries of fungal research, there is a lack of the distribution patterns of many fungal species. However, this knowledge is very important for effective conservation practices. For example, assessments of species for the IUCN Red List require an understanding of the distribution of said species.

What can you do?

FunDive is structured in different projects, each focusing on a specific target group of fungi. You can engage in each project by documenting and collecting fungal specimens. The process is simple:

- find a representative of a target species from project list: https://fun-dive.eu/get-involved/current-projects/
- make a photo and record your specimen in PlutofGO app https://plutof.ut.ee/go following our instructions https://fun-dive.eu/get-involved/how-to-engage/
- send it to your national point of contact https://fun-dive.eu/get-involved/fundive-national-points-of-contact/
- your specimen will be processed and identified based on molecular information
- you can follow your fungus on FunDive records: https://fun-dive.eu/dataportal/.

For more information on how to document your records, please visit https://fun-dive.eu/get-involved/how-to-engage/

Tulostoma

is one of the target genera for the 2024 FunDive projects which aim to support evaluation of gasteromycetes for the European IUCN Red List

Fungi in the genus ***Tulostoma*** – also referred to as "stalked puffballs" – have the appearance of small puffballs but differ in having a thin and woody stalk that raises the more or less globose spore sac (endoperidial body) a couple of centimetres above ground. The endoperidial body is normally whitish, greyish or brown and has the size of a pea. The stalk is ochraceous to brown or dark brown, 2-10 x 0.4-0.8 mm.

Fig. 1. Representatives of *Tulostoma* genus (from the left): *T. dunense*, *T. kotlabae* (photo Mikael Jeppson).

Stalked puffballs occur in many types of habitats but continental and often sandy steppe areas and other types of dry and open grasslands in temperate regions seem to house the highest number of species. However, the genus is also represented in temperate woodland ecosystems as well in the tropics.

Although ***Tulostoma*** fungi can be all easy to recognise as a genus, much trickier is the identification of species. In many cases DNA sequencing will be necessary to confirm identifications.

The genus *Tulostoma* contains more than a hundred species worldwide. Recent results from DNA-sequencing have shown that the species diversity is much higher than previously known, based on traditional morphological species limits. Descriptions of several new species are currently underway but the real number of species world-wide remains unknown.

All ***Tulostoma*** species known from Europe are listed below. They are grouped according to readily observed morphological features, although this grouping may not always reflect their phylogenetic relationships. There are no comprehensive modern identification keys based on recent molecular results. Wright (1987) is the classical monographic treatment of the genus with thorough morphological descriptions of most species, based type studies. Recent phylogenetic results based on a combination of morphology and molecular data are presented by Jeppson et al. (2017), Rusevska et al. (2019), and Finy et al. (2023).

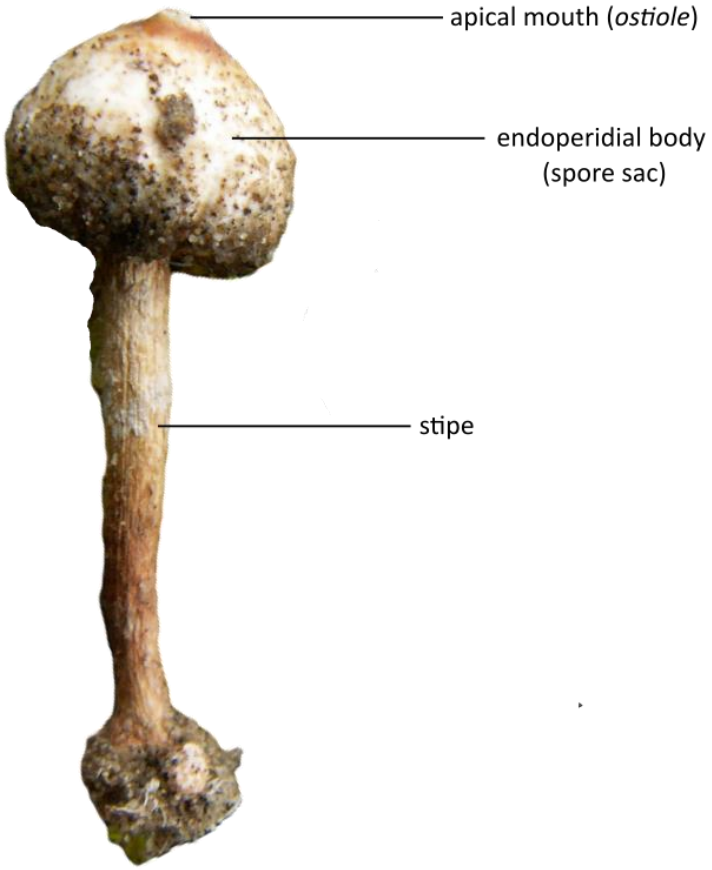
By reporting your findings, you will add to the knowledge of this species group and your records will be important contributions to nature conservation.

Morphological terminology and visualisation of features important for *Tulostoma* species identification

To identify *Tulostoma* you should focus on: the type of apical mouth (*ostiole*) through which spores are dispersed, the morphology of the exoperidium (outer hyphal sheath), the colour and outer structure of the stipe, and of course the size and ornamentation of the mature spores. Also, characters of the *capillitium* (i.e the thin hyphal filaments found among the spores in a mature fruitbody) should be observed. A microscope with a magnification of up to 1000x is needed to properly observe some of the characters.

Basidioma (also called basidiocarp or basidiome) is the sporocarp (also known as fruitbody) of a basidiomycete (fungus producing spores on basidia), the multicellular structure where the spores are borne.

Basidioma of *Tulostoma*



Exoperidium (outer hyphal sheath) is a protective layer that encloses a spore sac.

Capillitium is composed of thin hyphal filaments found among the spores inside a mature spore sac (endoperidial body).

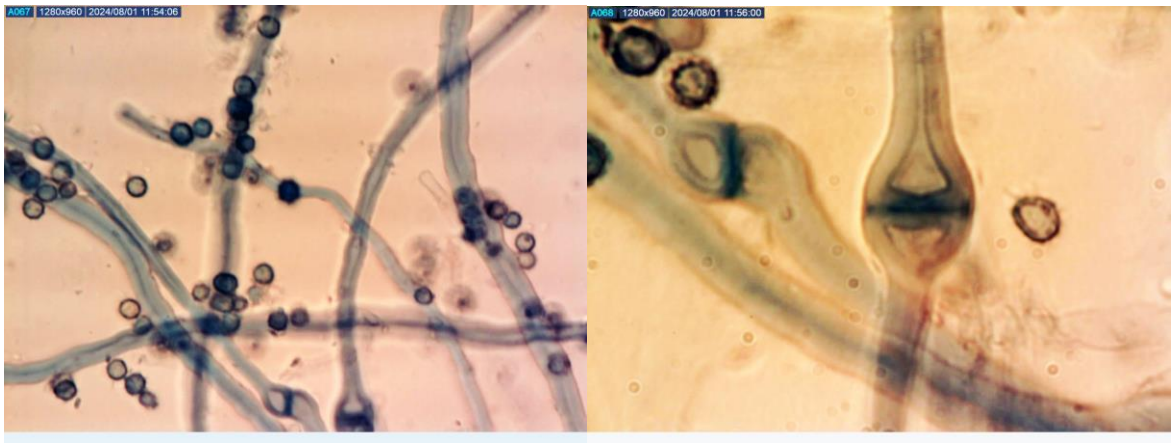


Fig. 2. *Capillitium* of *Tulostoma brumale* in lactophenol/cotton blue; on the right - detail of widened septum (photos Mikael Jeppson).

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1. Species with a regularly circular more or less tubular mouth

Tulostoma beccarianum

It is a large and robust species with a stipe length of up to 120 mm and a spore sac up to 22 mm in diameter. The exoperidium is thinly hyphal, gradually wearing off to expose a whitish-greyish endoperidium. The mouth is shortly raised with no evident grey or brown colours around it. The stipe is brownish and has a distinct volva-like structure at its base. The spores are subglobose, 4-5 µm, irregularly verrucose. The capillitial inner wall is undulating, and the septa are slightly widened. It has been recorded in sandy steppe habitats as well as on littoral sand dunes. It was originally described from Italy and has recent records verified by DNA-sequences from Spain, Hungary and Slovakia.

Tulostoma brumale

It is characterised by a slender, light brown stipe, a white membranous exoperidium that detaches as the fruitbody grows older. Young fruitbodies have a brown endoperidium that becomes pale brown – white with age, except for a narrow zone around the mouth that long remains brown (Fig. 3). The spores are subglobose –ellipsoid, 3-4 µm, verrucose. The capillitium is provided with abundant small crystals adhering to the outer walls and strongly widened septa. One of the more common and widespread species of *Tulostoma.* It is known from most parts of Europe except for the Arctic-alpine areas and can be found in dry sandy places, on calcareous dry grasslands, among mosses on rocks and boulders or on stone walls. It can easily be confused with the much less abundant *T. simulans*, distinguished by a hyphal exoperidium and slightly bigger spores.

Fig. 3. *Tulostoma brumale* (photo Mikael Jeppson).

Tulostoma calcareum

This species is closely related to *T. squamosum* but differs in having a thinner, hyphal to thinly membranous exoperidium that detaches with age, but sometimes remains as scattered small whitish flakes on the spore sac, without tendency to form a reticulum. The mouth is slightly protruding and surrounded by a brownish-greyish zone. The colour of the endoperidium is brownish-ochraceous, with age fading to greyish white. The stipe is slender, orange-brown – reddish brown, longitudinally furrowed, smooth to fissured or appressed scaly (Fig. 4). The spores are subglobose, 4-6 µm, verrucose-echinate. The capillitial septa are not or only slightly widened. It occurs in calcareous sandy habitats as well as on rupicolous steppe- localities. It is a rare species with a wide distribution in Europe, currently known from Hungary, Norway, Spain and Sweden.

Fig. 4. *Tulostoma calcareum* (photo Jörgen Jeppson).

Tulostoma eckbladii

This is a little-known species related to *T. niveum*. It can be distinguished by its ochraceous spore sac and its rather stout, light brown stipe. Like *T. brumale* it has a brown zone around the mouth. The spores are subglobose, 4.5–5.5 µm, and verrucose. The capillitial septa are slightly widened. No crystals adhering to the capillitial wall or dispersed among the capillitial threads have been observed. There are only two records worldwide, both from northern Norway where it has been found attached to mosses on calcareous boulders in subalpine birch woodland. *Tulostoma eckbladii* is unique by the fact that it apparently has a distribution restricted to northern subalpine habitats. It should be looked for in northern regions. Identifications need to be verified by DNA-sequencing.

Tulostoma giovanellae

This is whitish or greyish Tulostoma with a robust aspect with a hyphal exoperidium that gradually wears away. The mouth is shortly tubular, and the stipe is ochraceous – greyish white (Fig. 5). The spores are subglobose, 4-5 µm, faintly asperulate with small warts arranged in longitudinal lines. The lines may be difficult to observe; mounting in lactophenol/Cotton blue and a magnification 1000x is needed. The inner wall of the capillitium is often undulating ("moniliform") and the septa are scarce. It is a widespread Mediterranean species with northern outposts in East Central Europe. It grows in dry and exposed places on sandy or salty soils.

Fig. 5. *Tulostoma giovanellae* (photo Mikael Jeppson).

Tulostoma kotlabae

A species with pale ochraceous – pale grey - almost white spore sac and a concolorous slender stipe. The exoperidium is hyphal but often inconspicuous (Fig. 6). The spores are subglobose –ellipsoid, 4.5-5.5 µm, finely verrucous. The capillitial septa are only slightly widened and the capillitial walls lack crystals. It grows on calcareous sandy soil, among mosses and lichens on sand dunes (grey dune vegetation), sand fields and sandy steppe habitats. It has a wide distribution in southern and central Europe and has rare outposts in southernmost Sweden and Denmark. In the Mediterranean area and in continental sand steppe regions in Central Europe several closely related, similar taxa occur. They have been recovered using DNA-sequencing, but further study based on barcoding sequences from more collections will be needed to formally describe them.

Fig. 6. *Tulostoma kotlabae* (photo Mikael Jeppson).

Tulostoma melanocyclum

It is similar to *T. brumale* in stature and the two are sometimes found growing together. In contrast to *T. brumale,* it has a hyphal exoperidium and an orange-brown – dark blackish stipe. The endoperidium is brown in young specimens but turns greyish white with age. The mouth is protruding and has a characteristic dark brown – greyish brown zone surrounding it (Fig. 7). The spores are subglobose – ellipsoid, 4-6 µm, echinate. The capillitium is provided with rare, non-widened septa. Crystals on the capillitial walls are lacking. It is a widespread and abundant species in Central Europe (reaching northern outpost localities in Sweden, where it is rare and considered declining); it is particularly abundant on maritime sand dunes along the Atlantic coast and in dry sandy habitats of Central and East Central Europe. In the Mediterranean vegetation it seems to be very rare.

Fig. 7. *Tulostoma melanocyclum* (photo Jörgen Jeppson).

Tulostoma niveum

This is a small *Tulostoma* species, its spore sac being 4-8 mm in diameter and typically onion-shaped, pure white to slightly ochraceous. Exoperidium is strongly membranous, usually long remaining as scattered whitish patches on the outside of the spore sac. The mouth is conically protruding, the stipe slender, whitish to pale ochraceous (Fig. 8). The spores are subglobose, 5-6 µm, and verrucose. The capillitial septa are not or only slightly widened. The capillitium sometimes has regularly shaped small crystals adhering to its walls or dispersed among the capillitial hyphae. It typically occurs in small swarms among low mosses growing directly on basic rocks and boulders, sometimes on stone walls. It occurs in semi-shaded situations in light deciduous woodland, often in the vicinity of lakes and seashores. So far it has been recorded from Finland, Norway, Scotland, Sweden and Switzerland, but may also be present elsewhere if carefully looked for.

Fig. 8. *Tulostoma niveum* (photo Mikael Jeppson).

Tulostoma palatinum

It is a little-known species that shares some morphological features with *T. simulans*. Molecular data are needed to verify its status. It was described from near Mannheim in southern Germany and has so far not been detected elsewhere. Dedicated search is encouraged but identifications with the help of DNA must be pending a reference sequence from the type material.

Tulostoma simulans

A rare species with a white, hyphal exoperidium that first sticks to the endoperidium but wears away with age. The endoperidium is pale brown – snow white, sometimes with a brownish zone around the mouth. The stipe is light brown (Fig. 9). The spores are subglobose –ellipsoid, 4-5 µm, verrucose. The capillitium is provided with only weakly to moderately widened septa and normally lacks crystal adhering to its walls. It is found in dry grasslands, sand steppe vegetation and rupicolous steppe habitats on calcareous soil. It is a widespread species in southern and central Europe and has rare and isolated outposts in southernmost Sweden. It may, however, be overlooked due to its similarities with *T. brumale.* Identifications must be verified with microscopy of spores and capillitium, in some cases also DNA-sequencing will prove necessary.

Fig. 9. *Tulostoma simulans* (photo Mikael Jeppson).

Tulostoma squamosum

It forms fruitbodies with an ochraceous- pale brownish spore sac. The exoperidium is membranous-warty and detaches with age but remains as a faint, dark brown reticulum on parts of the endoperidial surface. The mouth is slightly protruding, often surrounded by a greyish pruina (Fig. 10). The slender stipe can reach 7 cm in length and is dark reddish brown and mostly longitudinally fissured or scaly. The spores are subglobose, 4-6 µm, echinate. The capillitial septa are not- or slightly widened. This is a widespread species in the southern and central parts of Europe. It is mostly found in somewhat shaded habitats, under bush, at forest margins and in light deciduous woodland on sandy, calcareous soil.

Fig. 10. *Tulostoma squamosum* (photo Mikael Jeppson).

Tulostoma subsquamosum

It recalls both *T. squamosum* and *T. calcareum* but differs in having a whitish, thinly membranous exoperidium that gradually wears off to reveal a white – pale ochraceous endoperidium. The mouth is shortly protruding and does not show any grey or brown colours around it. The stipe is slender, smooth to finely scaly, warm brown – greyish brown (Fig. 11). The spores are subglobose – irregularly ellipsoid, 4-6 µm, verrucose – echinate. The capillitial septa are scarce and not or only slightly widened. In Europe it has been recorded in dry and warm steppe or steppe-like habitats in Spain, Hungary, North Macedonia and Slovakia.

Fig. 11. *Tulostoma subsquamosum* (Mikael Jeppson).

2. Species with a fimbriate or indistinct mouth

Tulostoma calongei

A medium-sized species with a hyphal – thinly membranous exoperidium and a greyish – ochraceous endoperidium. The mouth is irregularly fimbriate and the stipe is short and slender, reddish brown (Fig. 12). The spores are subglobose, 3.5-4.5 µm, verrucose-echinate. It is a rare species with only a few records to date: Central Spain and Corse (France), on acidic sandy soil in exposed habitats. In the field it is likely to be misidentified for *T. fimbriatum*. Identifications must thus be confirmed with microscopy and DNA-sequencing.

Fig. 12. *Tulostoma calongei* (photo Mikael Jeppson).

Tulostoma cyclophorum

A medium-sized species with a distinctly membranous exoperidium that flakes off from above when the fruitbody is mature. The endoperidium is white – greyish white and tomentose due to its being covered with irregularly shaped, elongate – rounded cells called mycosclerids (microscope needed). The mouth is prominent, conically protruding. The stipe is slender, brown (Fig. 13). The spores are subglobose, 3-4 µm with an asperulate look under a light microscope, characteristically subreticulate under SEM. The capillitial septa are widened. *Tulostoma cyclophorum* is a species that is easy to recognize. It could potentially be confused with *T. pulchellum* and *T. striatum* due to the strongly membranous exoperidium. When in doubt the very small spores and the mycosclerids are diagnostic features. It has been reported from a handful localities in south and central Europe, mostly in habitats under human influence (plantations and lawns in urban parks). Identifications should be confirmed by microscopy.

Fig. 13. *Tulostoma cyclophorum* (photo Elena Ferreira; source: https://www.inaturalist.org/observations/220749007; CC-BY-NC).

Tulostoma dunense

It is a robust species with a large spore sac and a slender stipe. It recalls *T. obesum* but can be distinguished on its white – greyish white spore sac. The exoperidium is hyphal and the mouth is an irregularly shaped rupture. In older specimens the exoperidum often splits into rays in a star-like manner. The stem is slender, whitish – pale grey – ochraceous brown, with a volvalike structure at the base and a prominent rhizomorph (Fig. 14). The mature spore mass is dark brown – chocolate brown. The spores are subglobose – ellipsoid, 3.7 -5.5 µm, completely smooth. The capillitium is frequently breaking up at the septa. The disarticulated parts have blunt and somewhat widened ends. *Tulostoma dunense* was recently described from calcareous sand steppe habitats in Central Hungary, in which country it is a protected species. There are to date no records elsewhere. A closely related and undescribed taxon (*T.* aff. *cretaceum*) appears in dry Mediterranean grassland on calcareous soil in Spain. To further resolve the species limits and ecological requirements between *T. dunense* and related species, collections and photographs in situ along with notes on the habitat are encouraged when found outside of Hungary (from Hungary photos only; species protected by law). All collected samples must be subject of DNA-sequencing. *Tulostoma dunense* was previously confused with *T. obesum*, the latter being a species with browner colours and a restricted distribution in SE Spain.

Fig. 14. *Tulostoma dunense* (photo Mikael Jeppson).

Tulostoma fimbriatum

A medium-sized species with a hyphal exoperidium. The endoperidium is greyish – ochraceous. The mouth is irregularly fimbriate and the stipe is normally rather stout and greyish brown – deep brown (Fig. 15). The spores are subglobose –ellipsoid, 4-6 µm, finely ornamented with anastomoses and ridges between the warts (can normally be observed in 1000x magnification, using lactophenol/Cotton blue as mounting medium). The capillitial septa are not or slightly widened. This is a wide-spread and abundant species in Europe. It is found in calcareous grasslands, maritime sand dunes, dry and sandy wasteland and sand steppe habitats. The exact distribution, however, is not fully known due to confusions with similar species, e.g. *T. winterhoffi*, *T. calongei* and *T. punctatum.* Identifications need to be confirmed with microscopy.

Fig. 15. *Tulostoma fimbriatum* (photo Mikael Jeppson).

***Tulostoma fulvellum* (syn. *T. armillatum*)**

A medium-sized species with a hyphal or an indistinctly membranous endoperidium covered with sand grains and soil particles. The underlaying endoperidium is brown – orange brown – grey brown and the mouth is fimbriate, plane or weakly protruding. The stipe is brown, appressed scaly with a broad mycelial bulb at the base (Fig. 16). The spores are 2-4 µm, ellipsoid – tear-shaped with a distinct apiculus (light bulb-shaped), completely smooth. The capillitial septa are slightly widened. *Tulostoma fulvellum* is a rare species found in humid deciduous woodlands, often along streams and rivers. There are only a few records from southern and central Europe. It should be searched for in suitable habitats.

Fig. 16. *Tulostoma fulvellum* (photo Filip Fuljer; source: https://www.inaturalist.org/photos/250258793; CC BY-NC).

Tulostoma grandisporum

This is a small (spore sac up to 8 mm) whitish – greyish species with a hyphal exoperidium. The stem is slender, whitish to pale yellowish brown, at the base with a conspicuous rhizomorph (Fig. 17). The spores are subglobose, 5.5-7.0 µm, smooth. The capillitium has scattered septa that are not or only weakly widened. The inner wall of the capillitial hyphae are characteristically undulating. It is to date only known from Hungary and Bulgaria, where it is found in sand steppe vegetation. The large, smooth spores are characteristic features, and all identifications must be verified by microscopy.

Fig. 17. *Tulostoma grandisporum* (photo Mikael Jeppson).

Tulostoma hungaricum

A very small species with a spore sac reaching 6 mm. The exoperidium is hyphal and the endoperidium is greyish white and pitted from detached sand grains. The stem is slender, whitish and has a basal rhizomorph. The spores are subglobose, 4.5-5.7 µm, finely verrucose. The capillitial septa are not widened. This is the smallest of the European Tulostomas. It is reminiscent of *T. pannonicum* but differs in its hyphal exoperidium, larger spores with ornamentation visible under a light microscope. It grows in open sandy areas in steppe vegetation and is to date only known from a few sites in Central Hungary. All identifications must be verified by DNA-sequencing.

Tulostoma lloydii

A medium-sized species with a distinctly membranous exoperidium, flaking off from above. The endoperidium is snow white and slightly pruinose and the mouth is fimbriate, somewhat protruding. The stipe is reddish brown – dark brown (Fig. 18). The spores are subglobose, 3-5 µm, smooth. The capillitial hyphae have scattered crystal plaques, and the septa are somewhat widened. It is a rare species with records in the Mediterranean area. In contrast to most other *Tulostoma* species it occurs in shaded places under bushes in light woodlands. Due to its distinct membranous exoperidium, it could potentially be mistaken for *T. cyclophorum* but differs in spore ornamentation and lack of mycosclerids. Identifications must be verified with microscopy.

Fig. 18. *Tulostoma lloydii* (photo jorgemartin71; source: https://www.inaturalist.org/photos/181804283; CC BY-NC).

Tulostoma lusitanicum

A little known and rare species recalling *T. fimbriatum* in stature. The type material from a maritime sand dune system in Portugal (Estremadura, Pinhal do Rei; collected in 1991) has been sequenced but there are currently no other sequenced collections matching it. The sand dune vegetation of Portuguese Estremadura should be surveyed for its rediscovery.

Tulostoma obesum

It is a rare species with a large spore sac (10-15 mm). The exoperidium is hyphal and the endoperidium is copper brown – brownish grey, almost grey in old and weathered specimens. The mouth is wide and irregular, and the stipe is slender, pale brown to chocolate brown with a volva-like structure at the base and a distinct rhizomorph (Fig. 19). In contrast to most other *Tulostoma* species the mature spore mass is dark chocolate brown. The spores are subglobose – ellipsoid, 4-5.5 µm, completely smooth. The capillitium is fragile, normally breaking up at the septa. *Tulostoma obesum* was originally described from N. America but modern studies using DNA-sequencing have shown that it also occurs on maritime sand dunes and halophytic steppe habitats in SE Spain. Due to morphological similarities with *T. dunense* and an undescribed species (*T*. aff. *cretaceum*), all identifications must be verified by DNA-sequencing.

Fig. 19. *Tulostoma obesum* (photo Jörgen Jeppson).

Tulostoma pannonicum

This is a small (spore sac 4-7 mm) and slender species with a thinly membranous exoperidium. The endoperidium is greyish white and often pitted from detached sand grains. The stipe is ochraceous and has a conspicuous basal rhizomorph (Fig. 20). The spores are subglobose – broadly ellipsoid 3.5-4,5 µm, smooth under a light microscope (rugulose under SEM). The capillitial hyphae have an even inner wall and abundant, strongly widened septa. It is to date only found in the sand steppe vegetation of Central Hungary. In the field it is reminiscent of *T. grandisporum* and *T. hungaricum*. Microscopy and DNA-sequencing are needed for reliable identification.

Fig. 20. *Tulostoma pannonicum* (photo Mikael Jeppson).

Tulostoma pseudopulchellum

A small and slender species reminiscent of *T. pulchellum* from which it differs in its smaller size and almost smooth spores under LM. The spores are globose and measure 4-6 µm. The stipe is slender, whitish cream to light brown. This species is to date only known from its type locality in a dry and exposed gypsum slope with sparse steppe vegetation in central Spain. All potential new records must be verified by DNA-sequencing.

Tulostoma pulchellum

It is a species forming middle-sized fruitbodies with a strongly membranous exoperidium flaking off from above to expose a pure white endoperidium. The exoperidium often remains as white flakes or lobes at the base of the spore sac. The mouth is fimbriate and surrounded by a delimited peristome. The stipe is light brown – yellowish brown (Fig. 21). The spores are subglobose, 4.5 – 6 µm, almost smooth to asperulate under a light microscope. The capillitial septa are not widened. This is a characteristic but rare species recorded in sandy habitats (sand steppe vegetation, light sandy pine forests) in central Europe. It strongly recalls the closely related *T. striatum*, hence all identifications need microscopy for verification.

Fig. 21. *Tulostoma pulchellum* (photo Mikael Jeppson).

Tulostoma punctatum

A rare species recalling *T. fimbriatum* and *T. calongei* in micromorphology. It is a medium-sized species with a hyphal exoperidium. The endoperidium is silvery greyish – ochraceous. The mouth is irregularly fimbriate and the stipe is rather stout and nut brown – dark brown (Fig. 22). The spores are subglobose, 3 – 5 µm, verrucose-echinate. The capillitial septa are not or only slightly widened. It is to date known from Slovakia and North Macedonia, growing on dry, sandy soil. It should be searched for in dry and sandy places in Central Europe. Under the microscope it is easily separated from the similar *T. fimbriatum* due to its smaller spores. All identifications must, however, be verified with DNA-sequencing to avoid misidentifications.

Fig. 22. *Tulostoma punctatum* (photo Mikael Jeppson).

Tulostoma sacchariolens

It is a newly described species with a hyphal exoperidium and white – dirty white endoperidium pitted at maturity due to detached sand grains. The stem is slender, whitish, conspicuously blackening towards the base, often with reddish or orange longitudinal fibres (Fig. 23). The spores are subglobose, 4-5 µm, with coarse elongated warts. The capillitial septa are slightly widened. An unmistakable feature of this species when mature and fresh is the strong floral smell (like *Freesia* flowers or that of the agaric *Hebeloma sacchariolens*). It has to date only been recorded in sandy steppe habitats in Central Hungary but should be looked for elsewhere in suitable habitats.

Fig. 23. *Tulostoma sacchariolens* (photo Mikael Jeppson).

Tulostoma shaihuludii

It is a medium-sized, rather stout species with a greyish white spore sac. The exoperidium is hyphal. The stipe is yellowish brown - orange brown – dark brown, up 70 mm in length, stout, often curved and with a short basal rhizomorph (Fig. 24). The spores are globose – subglobose, 3.5-4.7 µm appearing almost smooth under a light microscope. SEM-photos show an asperulate ornamentation of fine warts forming a dense network. This species was recently described and is to date only known from the sandy steppe vegetation of Central Hungary. Although the species is fairly characteristic, all identifications should be verified by DNA-sequencing.

Fig. 24. *Tulostoma shaihuludii* (photo Mikael Jeppson).

Tulostoma striatum

It is a species forming middle-sized fruitbodies with a strongly membranous exoperidium, flaking off from above to expose a whitish - greyish endoperidium. The exoperidium often remains as white flakes or lobes at the base of the spore sac. The mouth is fimbriate and surrounded by a delimited peristome. The stipe is light brown – yellowish brown. The spores are subglobose - ellipsoid, 4-6 µm, distinctly striate. The capillitial septa are not widened. Tulostoma striatum is a rare species in Europe, with a single DNA-sequenced collection from Central Spain. It may well be present also in Central Europe and should be looked for. Due to its similarity with *T. pulchellum* all future finds need to be verified by microscopy and DNA-sequencing.

Tulostoma winterhoffii

A medium-sized species with a hyphal exoperidium. The endoperidium is greyish – ochraceous. The mouth is irregularly fimbriate and the stipe is normally rather stout, reddish brown – dark brown, often somewhat banded (Fig. 25). The spores are subglobose –ellipsoid, 4 – 9 µm, distinctly verrucose without anastomoses. A characteristic feature is the variation in spore size: small spores (ca 4-5 µm) being intermixed with larger ones (6 – 9 µm). It seems to be a wide-spread species in Europe, but the distribution and frequency is unclear due to confusion with *T. fimbriatum*. It is found on sandy soil on sand dunes and sand steppe habitats as well as in calcareous grasslands. Identifications must be confirmed by microscopy as the variable spore size makes identifications easy.

Fig. 25. *Tulostoma winterhoffii* (photo Jörgen Jeppson).

Additional information and identification keys:

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