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Earthstar (*Geastrum* sp., Agaricomycetes; Geastrales): First distribution report and morphological study of *Geastrum saccatum* Fries from Rajasthan, India

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ABSTRACT

The *Geastrum* genus, belonging to Geastrales, Geastraceae, is a cosmopolitan, saprophytic mushroom. The gastroid species is well known as earthstars due to the characteristic splitting appearance of exoperidium at mature stage, thus giving a star-like morphology. Several *Geastrum* species have been reported worldwide, including 28 species from India. The *Geastrum* species have been previously reported from Indian states, including Gujarat, Western Ghats, Himachal Pradesh, and Madhya Pradesh. However, *Geastrum saccatum* Fries, also known as sessile earthstar with high medicinal properties, has been reported from Gujarat and Western Ghats, but none have been recorded from Rajasthan, India. The objective of the present study is to report, identify, and study the morphological characters of *G. saccatum* Fr. from Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India. The identification was conducted based on morphological and microscopical characters, with further confirmation from previous literature data. The sample collection and research were conducted in the monsoon season (June-September) 2025 for a larger macrofungal community study. The future perspective focuses on the advanced molecular characterization with beneficial uses in sectors including agriculture and industry.

Keywords: Ajmer, *Geastrum saccatum*, Geastrales, Mushrooms, Rajasthan

The genus *Geastrum* (Basidiomycota, Geastrales), commonly known as earthstar, was first studied by Persoon (1794) (Persoon 1794; Patel et al. 2020). The genus is known to be found in diverse habitats, including grassland, saprophytic, and dry sandy areas (Wang and Bau 2023). Additionally, it is found to be a ubiquitous genus found worldwide except the Antarctica region with no reporting so far (Wang and Bau 2023). Previous data show the presence of *G. saccatum* Fr. from other states of India except Rajasthan including Gujarat (Rao 1964; Patel et al. 2020), Western Ghats and the west coast of India (Karun and Sridhar 2014), and Assam (Gogoi and Vipin 2015). However, several other *Geastrum* species have been reported from Indian states including *G. rufescens* Pers. and *G. triplex* Jungh., *G. lageniforme*, *G. pseudostriatum*, *G. schweinitzii*, *G. campestre Morgan*, *G. velutinum Morgan*, *G. floriforme Vittad.*, *G. corollinum (Batsch) Hollós*, *G. fimbriatum*, from Gujarat, Madhya Pradesh, Assam, Western Ghats and the west coast of India, and Lower Chota Nagpur Plateau (Patel et al. 2020; Verma et al. 2018; Cunningham 1944; Thind and Sharma 1989; Sharma et al. 2022). The worldwide distribution of *Geastrum* species include China (Wang and Bau 2023), the United States of America (Accioly et al. 2019), Brazil (Leite et al. 2011), Europe (Finy et al. 2021), Brazil (Barbosa et al. 2024), and several others.

The species are found across temperate areas with wide ecological locations of India, such as coffee plantations, evergreen forests, and the Western Ghats of India (Verma et al. 2018). Scientists around the globe have recognized more than 100 *Geastrum* species based on different structural, molecular, and microscopic characteristics (Sunhede 1989; Zamora et al. 2014a, 2014b; Patel et al. 2020). Medicinal importance with antioxidant, anti-inflammatory properties has been known to be present in the species worldwide (Dore et al. 2007; Patel et al. 2020). *G. saccatum* and *G. triplex* are some of the species with high medicinal and antagonistic properties reported so

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far (Dore et al. 2007; Chittaragi et al. 2013; Patel et al. 2020). Whitney and Arnott (1986) studied the presence of calcium oxalate crystals in the peridium of *G. saccatum* which revealed a major role during the basidiocarp maturation and dehiscence stage. The species has huge medicinal properties but has not been considered edible in past studies.

The objective of this research highlights the morphological, microscopical, and ecological study of *G. saccatum* Fr. from Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India. The species has been first time collected, identified, and studied from the state of Rajasthan, India.

MATERIALS AND METHODS

Sample collection

During the extensive field study at Maharshi Dayanand Saraswati University (MDS), Ajmer, Rajasthan, India in the monsoon season of India, ranging from June to September 2025, specimens of *G. saccatum* were collected. The collection site is located at 26°30'27" N and 74°40'52"E latitude and longitude, respectively, with 1630 ft elevation (Fig. 1). The city recorded 34 degrees and a minimum of 27 degrees temperature during the average three-month monsoon period. The average rainfall during June-September 2025 recorded an average rainfall of 414.48 mm with 15 days of overall average rainfall days. The average sun hours and sunny days during the monsoon season ranged from an average of 170 hrs. and 19 days, respectively. The average humidity percentage observed was 72%. The weather data of Ajmer city was obtained from online sources through the World Weather Online website.

The collection of mushroom samples was conducted aseptically in sterile poly bags. The date, location, and sample information were recorded during the field collection visit.

Figure 1. The maps showing the location of the collection site. The location of MDS University within the country India, state Rajasthan, the city of Ajmer.

Mushroom Processing and Identification

The collected mushroom samples were processed on the same day of collection in the Plant Pathology laboratory, Department of Botany, MDS University, Ajmer, Rajasthan, India. The collected samples were further cleaned and measured for identification. The data were recorded based on color, measurements, spore colors, stalk, texture, odor, and habitat. The mushroom samples were further preserved for future studies and recorded in FAA (Fomalin-Acetic-Alcohol) (Kladnik 2013). The mushroom identification was conducted based on multiple sources such as books (Roy 1973, 2016; Bessy 2015; Sethi and Walia 2018; Verma et al. 2019), literature reviews, published research and review articles (Trudell and Ammirati 2009; Verma et al. 2018; Patel et al. 2020), and online mushroom identification sites (mushroomexpert.com, mykoweb.com). The spore size was measured using the ACH Logiciels Piximetre 5.10.

RESULTS

Taxonomic description

Scientific name: *Geastrum saccatum* Fries
Common name: rounded earthstar, sessile earthstar, bowl earthstar, star of the land.
Similar species: *G. fimbriatum*

Morphological characteristics

Fruiting body: Peridium, rays, basidiocarp (spore case/sac), spore beak, ridge (Table 1; Fig 2A-F).

Peridium and rays: The covering or the skin of the species is known as Peridium. The peridium is distinguished into outer (exoperidium, golden brown to yellow color) and inner covering (endoperidium) containing the spores. The exoperidium, on maturity, splits into 5-7 rays or arms that recurve to form flat base-like, involute, saccate structure (Fig 2A).
Spore sac: round, smooth surface, sessile, greyish-brown, 1.8 cm diameter. At maturity or after spore dehiscence, the color changes to yellow brown (Fig 2D).
Spore beak: A small opening or hole in the center top of the spore sac that is prominent in morphology.
Ridge: A circular ridge-like depression surrounding the spore sac.
Spores: round, rough and thick outer surface, and dark-brown color (Fig 2E, F).
Spore size: 3.1*3.3 µm.

Collection study: On soil with saprobic conditions, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India. The samples were deposited in the Plant Pathology laboratory, Department of Botany, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India (Fig. 2B).
Edibility: Inedible, toxin unknown.

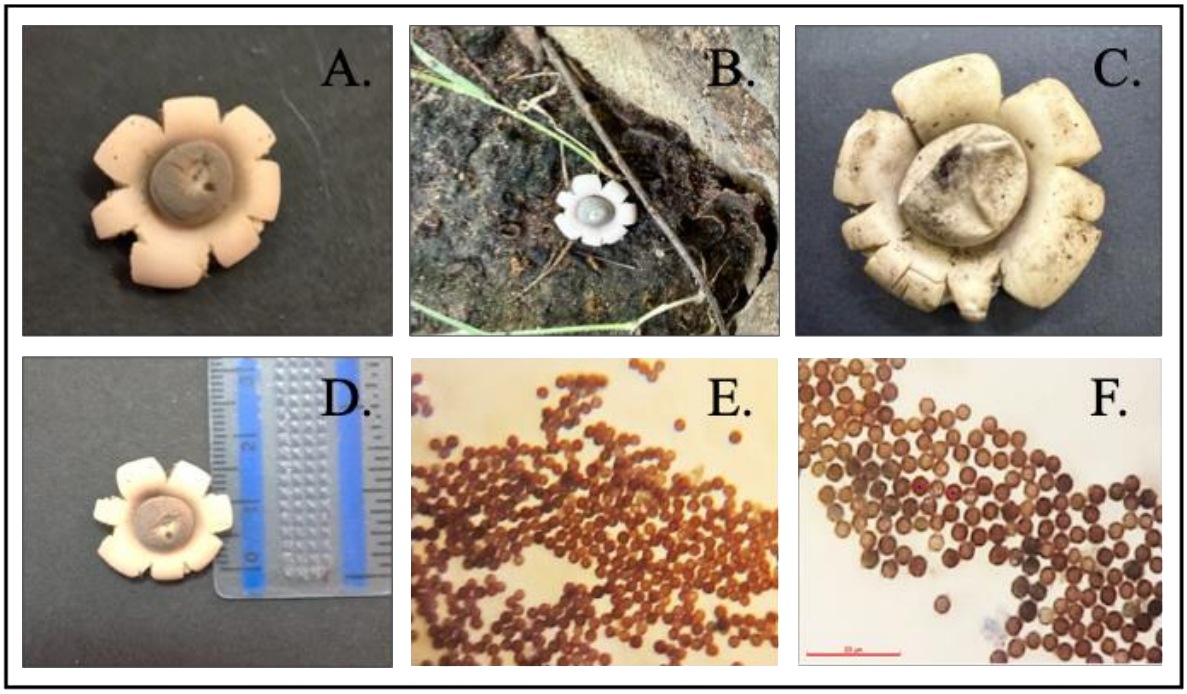

Figure 2. The morphological and microscopical study of *Geastrum saccatum* Fries. A. *G saccatum* Fr. external appearance after the collection. B. The collection site and habitat as under the tree. C. The second species samples collected in dry dehisced form. D. The size measurement and other morphological evaluations in the laboratory. E. The microscopic structure of spores at 10x power of light microscope. F. The 40x microscopic spore structure shows a thick outer wall and large size. The spore size was calculate using the software Piximetre 5.10.

DISCUSSION

The earthstars or the *Geastrum* species are known to have a partial cosmopolitan ecology with more abundance in the temperate and tropics than in the other zones across the globe (Ponce de Leon 1968; Patel et al. 2020). The name earthstar of *G. saccatum* Fr. implies the star-like appearance with outer covering called peridium splitting into a star-like pattern on maturity. The splitted segments are known as arms or rays which are usually 5-9 in number based on the species (Verma et al. 2018). The outer peridium encloses a hymenophore or a spore sac containing the spores. However, the outer and inner peridium, the number of rays, and the spore sac differs in different species of *Geastrum* (Verma et al. 2018). The spores of the same species have been previously studied and described by Karun and Sridhar (2014) from the Western ghats and west coast of India as brown, spherical, and rough surfaced. These results confirm this research with similar microscopical study of spores as shown in Fig 2E, F. From the past few years, the genus *Geastrum* has been studied mostly based on the morphological characters only (Zamora et al. 2015). However, in recent years, molecular and phylogenetic studies have been focused which highlighted the genetic data of the species with better confirmation and analysis (Jeppson 2013; Zamora et al. 2013, 2014). The species belonging to Geastrales are known to have high medicinal properties with wide anti-inflammatory and antibacterial properties (Dore et al. 2007).

Table1. Detailed description of *Geastrum saccatum* Fries

S. No.	Specifications	Descriptions
1	Taxonomic classification	Phylum: Basidiomycota Class: Agaricomycetes Order: Geastrales Family: Geastraceae Genus: *Geastrum* Species: *saccatum*
2	Cap color	Golden yellow-light brown
3	Spore sac	Grey black
4	Spore	Dark-brown, rough outer surface
5	Stipe	Absent
6	Annulus	Absent
7	Gills	Absent
8	Volva	Absent
9	Edibility	Inedible
10	Habitat	Saprobic
11	Toxins	Unknown
12	Odor	No smell

New distributional document for *G. saccatum* Fr. has been reported from MDS University, Ajmer, Rajasthan, India. This is among the first from Rajasthan and the city Ajmer, which is surrounded by Aravalli hills with moderate temperature, humidity, and rainfall during the collection time recorded. The morphological and microscopic characters confirmed the species level in this study. However, the future ITS region and rDNA research for identification and detailed study will be a useful technique for scientists.

CONCLUSIONS

The present research report of *G. saccatum* Fr. from Rajasthan state, India for the first time using morphological and microscopical structures for identification. Different species of the genus have been studied and reported for various properties including medicinal across the globe. The collection and study from Ajmer, Rajasthan, India has been conducted during the monsoon season ranging from June-September 2025 for a larger project of macrofungal community study. The structural and spore structures confirmed the presence of *G. saccatum* Fr. and thus for future study, molecular analysis will generate new perspectives for industrial and agricultural scope. The species holds great potential with high medicinal properties and therefore detailed genetic data will reveal understanding towards utilization in human life improvement and advancements.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

COMPLIANCE WITH ETHICAL STANDARDS

The field and manuscript writing process was conducted in the Department of Botany, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India. The department and university provided the consent. The authors provide consent for the research work.

INFORMED CONSENT

The research work was conducted in the field and laboratory with no involvement of animals or human study.

AUTHOR CONTRIBUTION

The original idea, manuscript writing, and sample collection was done by Shruti Ojha. The manuscript critical review, constructive feedback, study analysis, and article development was supervised by Arvind Pareek.

DATA AVAILABILITY STATEMENT
Not Applicable

SUPPLEMENTARY INFORMATION
The manuscript contains no supplementary materials.

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