

## A world review on the genus *Trichoglossum* (Geoglossales, Ascomycota)

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### ABSTRACT

*Trichoglossum* is one of the key members of the Family *Geoglossaceae* (Class *Geoglossomycetes*) under the Division *Ascomycota*. According to the structure of the ascomata they are frequently recognized as hairy earth tongues. The genus name was first recommended by Emile Boudier and was segregated from *Geoglossum*, on the basis of presence of surface setae. It was first reported from the woodlands of North America and later on found in different regions of Europe, Asia including India, Australia, etc. The genus is mostly saprobic on humus and distinguished from others by having black or dark brown club-shaped apothecia, distinct surface setae in both sterile and fertile portions, inoperculate and amyloid asci, septate paraphyses and fusoid, long, and septate ascospores. Presently, there are 22 species of the genus reported from all over the world. The present study amalgamates detailed compiled description and worldwide distribution of most of the *Trichoglossum* species.

**Keywords:** Apothecia, Paraphyses, Septate ascospores, Setae

### INTRODUCTION

*Trichoglossum* or hairy earth tongues (Hustad *et al.*, 2013) is a noteworthy fungal genus in the Family *Geoglossaceae* (*Geoglossomycetes*) (Schoch *et al.*, 2009) of the Division *Ascomycota*. *Trichoglossum* species was first reported from woodlands in North America and further studies revealed its dominating distribution in other continents like Europe, Asia, Australia, and South America. According to Jaklitsch *et al.* (2016) and Ekanayaka *et al.* (2017) the genus is highly saprobic in soil and often present in association with mosses. The significant features of this genus are the presence of dark brown to black coloured fruiting body, hymenial setae (both in sterile and fertile zones), amyloid asci, club-shaped apothecia, septate paraphyses and ascospores (Ekanayaka *et al.*, 2017). *Trichoglossum hirsutum* (Pers.) Boud. is considered as the type species. Durand (1908) reported that *Trichoglossum* species can be separated from each other on the basis of number of spores present in the ascus, spore length and septation. According to the Index Fungorum database, presently it lists 47 names, which include different forms and varieties while Kirk *et al.* (2008) acknowledged 19 different species of *Trichoglossum*, but the number gradually increased with time as the molecular studies are being taken into consideration and also due to the advancement of scientific techniques. So far, more or less 22 species are authentically reported from at least five out of seven continents of the world. *Trichoglossum* is considered as the second most diverse genus of *Geoglossaceae* family after *Geoglossum* Pers.

Asian diversity of *Trichoglossum* also includes Indian species. However, only three evident species are reported to date. *Trichoglossum rasum* Pat. has been reported from India by Prabhugaonkar and Pratibha (2017), *T. tetrasporum* Sinden & Fitzp. is also reported from Northeast region, West Tripura of India (Debnath *et al.*, 2019), and most recently a new species, *T. benghalense* N. Chakr., Tarafder & K. Acharya was reported from lower Gangetic plain of West Bengal, India (Chakraborty *et al.*, 2022). This review will focus on the worldwide distribution of the genus *Trichoglossum* with emphasis on the detailed characteristics

of all its species and a comparison with morphologically similar taxa. An artificial key to the species is also included in the paper for a better understanding.

### Genus diversity

The genus *Trichoglossum* was segregated from *Geoglossum* by Boudier (1885) as a presence of setae in the ascoma, as they occur both in stem and ascogenous portion which gives the plant a velvety look. There are above 20 species of *Trichoglossum* all over the world identified till now.

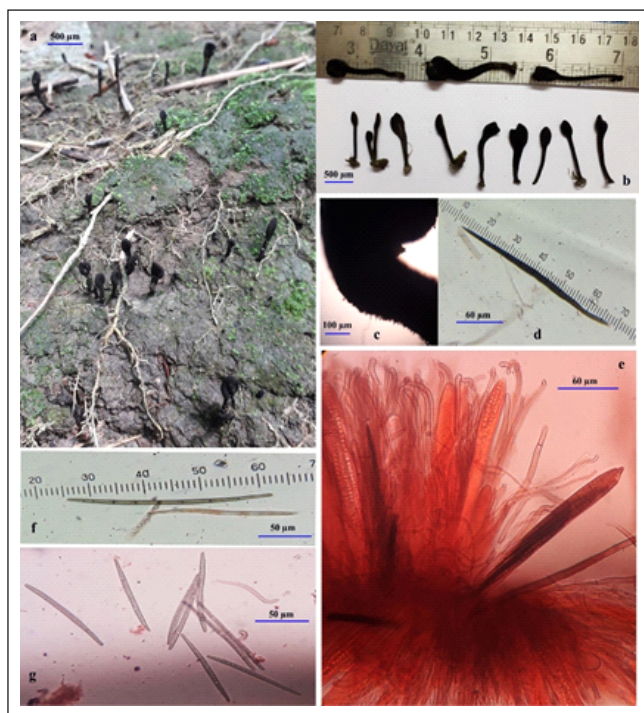
The first species of *Trichoglossum* was recorded from Italy by Sinden and Fitzpatrick (1930) from America and named as *T. tetrasporum* (*Helotiales*, *Geoglossaceae*). The detail description of each species of *Trichoglossum* is described below according to Chakraborty *et al.* (2022), Ekanayaka *et al.* (2017) and Prabhugaonkar and Pratibha (2017).

**1. *Trichoglossum tetrasporum* Sinden & Fitzp., *Mycologia* 22 (2): 60 (1930).**

**Distribution:** It is a rare species belonging to family *Geoglossaceae* and was collected as a considerable natural reserve of remarkable naturalistic interest in Melilli region. The species is commonly found in Yunnan, China and recently reported from India (Debnath *et al.*, 2019) in groups of few individuals or on mosses.

**Description:** The ascoma is up to 50 mm high and is more or less usually clavate, elongate, tongue-shaped, fusiform with circular or obtuse apex, unevenly demolished or pressed, occasionally moderately curved, 3-5 mm broad and up to 10 mm long. Hymenium is velvety black or blackish, may be wrinkled occasionally. The stalk is cylindrical in the middle measuring 1.5-2 mm in diameter and is dilated up to 3 mm near the ascogenous portion, whereas base is generally sinuous or curved, measuring up to 40 mm long; surface is hairy and the base is smooth, hymenium is concolourous. Flesh is hard, blackish and spiny when dried. Spores is 140-150 × 5-6 μm, barely fusiform or baciliform, soft, brown, straight or little bit curved, at maturity it developed 15 transversal septa and less than 15 when immature, collateral arranged in the upper part of the ascus; every single cell establish two septa is commonly unigluttulate, the oil droplets give the impression of being almost as large as the cell. Asci measures 230-250 × 24-27 μm, clavate, 4-spored at maturity,

amyloid, inoperculate. Paraphyses is sub-cylindrical at the bottom, some cells are swollen present underneath the apex, measuring 5-6  $\mu\text{m}$  wide, curved, wavy or bent at the apex, septate, brownish in colour at the upper part, with little bit longer than the asci. Setae fusiform, straight, some of them are bluntly bent near the base, asymmetrically wavy outline, rarely not enlarged, occasionally ventricose, tapering towards the apex and the base, 250-280  $\times$  6-8  $\mu\text{m}$ , and up to 10  $\mu\text{m}$  wide on the swellings, sharpened, thick-walled, without septa, soft, blackish-brown in colour. Pigments are brown in colour.



**Fig. 1.** As a reference, *Trichoglossum benghalense* (Holotype). a. Fruit body under field condition, b. Apothecia (with sterile and fertile portion), c. Hymenial setae on the surface under low power objective, d. Setae, e. Section of hymenium, f-g. Ascospores.

**2. *Trichoglossum septatum*** Ekanayaka, Q. Zhao & K.D. Hyde, *Phytotaxa* **316**(2): 163 (2017).

**Distribution:** The specimen was collected from Chiangmai province, southern Thailand on 2015 and the species name was given on 18 November 2016.

**Description:** The specific epithet name is given on the basis of ascospore septation. They are saprobic on soil. Apothecia measuring 2-4 mm in diameter and 18-35 mm high, stipitate, scanty, clavate, ovoid or dumbbell shaped, hairy, black, the ascogenous and sterile portion are easily distinguishable. Ascogenous area is flattened clavate to lanceolate, occasionally curved, black densely hairy with setae. Sterile part is tubular or sinuate, densely hairy from setae, fertile part is concolourous. Ascomatal core consists of brownish cells of texture epidermoidea. Hymenial setae measures 400-600  $\times$  15-25  $\mu\text{m}$ , blackish-brown in colour, tapering at the apex and base, thick walled, septate, occasionally project above hymenium. Paraphyses measure 7-9  $\mu\text{m}$  wide at the apex, many, filiform, septate, enlarged at the apex and bend, base is

light brown and apex is darker, walls scraped. Asci is 300-410  $\times$  25-40  $\mu\text{m}$ , 8-spored, tubularly-clavate, tapered below, apex circular, amyloid, appearing from croziers. Ascospores measures 190-270  $\times$  7-9  $\mu\text{m}$ , when immature it is light brown and greenish-brown to dark brown at maturity, fusiform to fusiform-clavate, spores are aseptate when immature while the mature spores consist of 7-15 septation, both type of variation in septation can be seen in single ascus. They are morphologically ad phylogenetically close to *T. hirsutum* but they mainly differ in asci and ascospore sizes.

**3. *Trichoglossum octopartium*** Mains, *Phytotaxa* **316** (2): 163 (2017).

**Distribution:** Though the species was first reported from Slovakia but this species has reported further from continents like: Europe Germany, Denmark, Slovakia, North and South America e.g., Trinidad, USA, Argentina, Belize, Dennis, Australia New Zealand, and Asia e.g., India, Pakistan and China (Kucera *et al.* 2010).

**Description:** Apothecia measuring 5-10 mm in diameter, 30-40 mm high, dispersed, stipitate, slim, clavate, fan to dumb bell shaped, hairy, black in colour, the ascogenous and the sterile portion are not easily distinguishable. Ascogenous portion flattened, club shaped to lanceolate, sometimes bend and branched, black, compact hirsute from setae. Sterile portion is tubular or sinuate, compactly hirsute from setae, fertile part is concolourous. Ascomatal core consists of dark brown cells of textura epidermoidea to intricate. Hymenial setae measures 140-160  $\times$  6-8  $\mu\text{m}$ , blackish-brown, sharpen taper at the apex and base, thick-walled, septate, sometimes projecting out above hymenium. Paraphyses measures 2.5-3.5  $\mu\text{m}$  wide, scanty, filiform, septate, apically enlarged and curved, base is light brown while apex is darker, walls granulate. Asci 180-220  $\times$  22-32  $\mu\text{m}$ , 8-spored, tubularly clavate, tapering below, rounded apex, amyloid, arising from croziers. Ascospores 95-105  $\times$  4-6  $\mu\text{m}$ , when immature it is hyaline while dark brown at maturity, fusoid to fusoid-clavate, spores are septate when immature while the mature spores have 9 septation, guttulate.

**4. *Trichoglossum rasum*** Pat., *Bull. Soc. Mycol. Fr.* **25**: 130 (1909).

**Distribution:** It is a rare species and was formerly reported only from New Caledonia in 1909, but was recently discovered in east Khasi hills, Meghalaya, India (Prabhugaonkar and Pratibha, 2017).

**Description:** They are saprobic on soil. Fruiting body is 3.0-4.5 cm, black, stipitate, upright, clavate to spatulate, flattened ascogenous portion, egg shaped and puffed out with clearly visible trichomes when observed under hand lens; stipe measures 1.5-3.5 cm long and 3 mm thick. Trichomes are dark brown in colour. Hymenium with setae is dark brown in colour. Setae measures 200-250  $\times$  5-12  $\mu\text{m}$ , septate, smooth, linear to flexuous, dark brown. Paraphyses measures 1.5-4.5  $\mu\text{m}$  wide, filamentous, septate, bulging and bend at the tips. Asci is about 200-240  $\times$  20-30  $\mu\text{m}$ , unitunicate, 8-spored, tubular to clavate, circular at apex, short pedicillate at the base. Ascospores measures 110-140  $\times$  5-7  $\mu\text{m}$ , generally 7 septate, but sometimes may be 6-8 septate, straight or slightly

curved, translucent in appearance when young whereas at maturity it is dark brown, narrow and circular at the both ends, slightly broad in the middle portion, smooth.

**5. *Trichoglossum walteri* (Berk.) E.J. Durand, *Annls Mycol.* **6** (5): 440 (1908).**

**Distribution:** This is a rare species and was first mentioned from the Vihorlatmts in Slovakia. According to the records *T. walteri* is an endangered species and it should be added to the red list of Slovak fungi.

**Description:** It grows on meadows and grassy sites between mosses and herb plants. *Apothecia* measures 23.0-40.9 mm in high, disperse, solitary, stipitate to clavate. Fertile part is 5.6-12 × 2.3-4.2 mm, flattened club shaped to lanceolate or widely elliptical, black or grayish black, generally vertically grooved, densely setae. Sterile part is 16-13 × 1.4-2 mm, distinctly delimited, tubular or cylindrical, occasionally flexuous or compressed. Fertile part is coloured, setae dense. Setae measures 205-254 × 7-10 μm, acuminate, thick walled, taper at the base, dark brown, septate, projecting above hymenium. Asci 181-218 × 14-18 μm, 8-spored, cylindrical clavate, tapering at below, apex circular. Spores are 81-97 × 4-5.5 μm, brown, cylindrically to cylindrical clavate, premature pigmented, 7-septate, linear or slightly curved, parallel with the ascus. Paraphyses translucent, filiform, measuring 1.5-2.5 μm in diameter, enlarged and clavate towards the apex, septate, brown-walled, apical cell measures 12-18 × 2.5-3.5 μm in diameter, generally strongly curved.

**6. *Trichoglossum rehmanium* (Henn.) E.J. Durand, *Annls mycol.* **6** (5): 439 (1908).**

**Distribution:** According to Durand it is found in Appolo Bay, Australia, Walter, in Kew herbarium.

**Description:** It grows in soil and rotting wood. Ascocarps measures 3-10 cm long, distributed, black to brownish black in colour, clavate, hairy from setae, ascomata is 15-25 × 1-1.5 mm; asci are club shaped, measures 175 × 12 μm, 8 spored; ascospores measures 55-73 × 4-5 μm, barrel shaped, tapering below, 3-7 septate, pale brown; paraphyses pale brown, cylindrical, irregularly septate, bend to oblique at the apices; setae profuse, black in colour, acuminate.

**7. *Trichoglossum hirsutum* (Pers.) Boud., *Hist. Class. Discom. Eur.* (Paris): 86 (1907).**

**Distribution:** It can be seen in the woodlands of North America, Europe, Macaronesia and Africa. In Lithuania it is listed as an endangered species. This species was also found in China.

**Description:** It grows on the ground in unimproved grasslands and in mossy dune slacks, often on acidic soil, or on rotting wood, on soil and in sphagnum. Ascomata measures 10-80 mm long and 2-5 mm wide, brownish black, clavate, consisting of a long indented fertile region, cylindrical and velvet like infertile stem. Setae measures 50-315 × 4-14 μm, blackish brown, fertile section is covered in stiff black spines measuring 150-125 μm long that extend beyond the tips of the asci. Asci is 180-275 × 18-25 μm, tubular, 8 spored, spores occur in parallel bunches; ascospores measures 80-170 × 5-7, 13-17 septate, extending

tubular to fusiform with an acute base and a rounded apex, justly thick-walled, smooth; Paraphyses are filiform, 2-3 μm in diameter and extending slightly beyond the asci tips, below hyaline and above brown; curved or coiled at the apex; 4-6 μm in diameter.

**8. *Trichoglossum velutipes* (Peck) E.J. Durand, *Annls Mycol.* **6** (5): 434 (1908).**

**Distribution:** It is distributed in North America and is also reported from China.

**Description:** It grows on soil and rotting wood. Ascocarps measures 20-50 × 2-12 mm, dispersed to crowded, black or brownish black in colour, cub-shaped, flattened, hairy from the setae; asci measures 90-160 × 6-7 μm, club-shaped, 4-spored, 0-13 septation but mostly 9 septate, brown in colour; paraphyses measures 4.5-8 μm, colourless at below, brown at the above, somewhat septate, columnar, moderately enlarged at apex, bend to circinate; setae 79-276 × 6-8 μm, dark brown in colour, copiously, taper, protruding above hymenium.

**9. *Trichoglossum farlowii* (Cooke) E.J. Durand, *Annls Mycol.* **6** (5): 438 (1908).**

**Distribution:** The species is distributed in different parts of New York, US and also been reported from Japan.

**Description:** It grows on moist to wet soil sometimes in moss and on rotten logs. Ascocarps measures 30-80 × 3-15 mm, dispersed, black, or brownish in colour, club-shaped, elongated, flattened, hairy from the setae; stipes cylindrical, 1.5-4.0 mm, thick, more or less compact, hairy from setae; asci measures 150-180 × 15-20 μm, 8-spored, club-shaped; ascospores measures 45-90 × 5-7 μm, barrel-shaped to club-shaped, 0-5 septate, very sparsely more, generally 3-septate, light brown; paraphyses 2-3 μm, tubular, a little enlarged at the apex, somewhat septate, bend to circinate above, hyaline, brownish; setae, copious, dark brown, acuminate.

**10. *Trichoglossum variabile* (E.J. Durand) Nannf., *Ark. Bot.* **30A** (no. 4): 64 (1942).**

**Distribution:** The species is distributed in different parts of New York and has also been reported from Sweden, China, and Japan. The species is globally distributed but it is quite rare almost everywhere. This species is closely related to *T. hirsutum*. This species is an endangered species and should be included in red list of Slovak fungi.

**Description:** It grows on soil in wet meadows between mosses and herb. Ascomata measuring 20-40 × 2-5 mm high, distributed solitarily or gregariously in cluster forming 2-8 branches projecting out from joined base, stipitate, clavate to sub-capitate. Fertile part is 6-13.7 × 2.4-4.8 mm, pressed, clavate to lanceolate or widely elliptic, slightly raised, generally vertically grooved, black or brownish black, not clearly setose. Sterile part is 11.9-32.9 × 1.1-2 mm (base up to 5 mm, distinctly delimited, cylindrical, flexuous, slender, occasionally compressed, slightly light toned colour than fertile part, densely setose. Setae is 73-177 × 5-8 μm, scanty, taper, dark brown generally opaque not clearly projecting out above hymenium. Asci 150-226 × 18-20 μm, 8-spored, cylindrical-clavate, tapered below, apex widely conical. Spores 80-150 × 4.5-6 μm, brown, tapered at both the ends, more on

one end, early pigmented, 4-16 septate, linear or lightly curved, parallel within the ascus. Paraphyses measuring 6-8  $\mu\text{m}$  in diameter, filiform, enlarged, clavate at the apex, apical cell 17.8-27.1  $\times$  3.7-6.2  $\mu\text{m}$ , bend or convolute, especially the asci and a bit interwoven, septate and brown walled, below colourless and above dark brown.

**11.** *Trichoglossum confusum* E.J. Durand, *Mycologia* **13**(3): 185 (1921).

**Distribution:** This species is found in North Carolina and is also reported from China.

The species grows on soil. Ascomata measures 15-25  $\times$  1-1.5 mm, black, club shaped, hairy from the setae, flattened or creased; asci measures 150-200  $\times$  12-16  $\mu\text{m}$ , tapering clavate, 8-spored; ascospores measures 45-75  $\times$  5-6  $\mu\text{m}$ , sub-tubular, 3-7 septate, generally 7-septate, brown in colour; setae are copious, hairy, slightly tapering, black in colour, acuminate; paraphyses, pale brown, tubular, moderately increasing in width upward, linear or bend, protruding beyond the asci.

Above listed are few well known species of *Trichoglossum* with their respective characteristics and distribution. In the following section a few not so popular species of this genus has been described with their documentations available still now:

**12.** *Trichoglossum cheliense* F.L. Tai, *Lloydia* **7**(2): 153 (1944).

**Distribution:** It is distributed in Yunnan, China.

**Description:** It is a critically endangered species. Ascomata size ranges from 30-60  $\times$  5-14 mm, clavate in shape, black in colour; Stipe 30-45 mm long and 1.5-3 mm in thickness, setae commonly absent but if present then is brownish black in colour; paraphyses is pale brown in colour; asci range from 200-231  $\times$  18-22  $\mu\text{m}$ , no of spores is 8-spored; ascospores size ranges from 89-151  $\times$  5-6  $\mu\text{m}$ ; septation is 13-14 septate, brown in colour.

**13.** *Trichoglossum kunmingense* F.L. Tai, *Lloydia* **7**(2): 154 (1944).

**Distribution:** It is distributed in Yunnan, China.

**Description:** It is a critically endangered species. Ascomata size ranges from 15-35  $\times$  5-8 mm, black in colour; setae dark brown in colour; paraphyses brown in colour; asci size ranges from 175-225  $\times$  19-25  $\mu\text{m}$ , 8 spored; ascospores size ranges from 104-144  $\times$  10-8  $\mu\text{m}$ , septation is 7-septate, brown in colour.

**14.** *Trichoglossum sinicum* F.L. Tai, *Lloydia* **7**(2): 156 (1944).

**Distribution:** It is distributed in Yunnan, China.

**Description:** It is a critically endangered species. ascomata size ranges from 55-70  $\times$  8-10 mm, black in colour; setae are dark brown in colour; paraphyses below is hyaline and above is brown in colour; asci size ranges from 237-281  $\times$  21-26  $\mu\text{m}$ , 8-spored; ascospores ranges from 147-175  $\times$  6-7  $\mu\text{m}$ , septation is 7-15-septate, brown in colour.

**15.** *Trichoglossum qingchengense* W.Y. Zhuang, in Zhuang

& Wang, *Mycotaxon* **63**: 309 (1997).

**Distribution:** It has been recorded from China.

**Description:** Ascomata ranges from 20-26  $\times$  3-4 mm, Black or dark brown in colour; width of the setae is 5-6.5  $\mu\text{m}$ , Brown in colour; paraphyses measures 5-7.5  $\mu\text{m}$ ; asci size ranges from 198-230  $\times$  20-24  $\mu\text{m}$ , 8-spored; ascospore measures 76-117  $\times$  6.5-7.7  $\mu\text{m}$ , septation is 6-9-septate, brown in colour.

**16.** *Trichoglossum persoonii* F.L. Tai, *Lloydia* **7**(2): 154 (1944).

**Distribution:** It is distributed in Yunnan, China.

**Description:** It is a critically endangered species. Ascomata ranges from 25-40  $\times$  3-8 mm, Black in colour; setae are Dark brown in colour; paraphyses is Brown in colour; asci size ranges from 225-275  $\times$  18-23  $\mu\text{m}$ , 8-spored; ascospore ranges from 162-200  $\times$  5-6  $\mu\text{m}$ , septation is 13-20 septate, brown in colour.

**17.** *Trichoglossum peruvianum* E.K. Cash, *J. Wash. Acad. Sci.* **48**: 259 (1958).

**Distribution:** It has been recorded from Peru so far.

**Description:** Ascomata ranges from 10-25  $\times$  1.5-2 mm, Black or dark brown in colour; setae size ranges from 150  $\times$  5-6  $\mu\text{m}$ , Black in colour; paraphyses measures 5-6 mm, hyaline below and above portion is subhyaline; asci measures 120-130  $\times$  8-11  $\mu\text{m}$  and 8-spored; ascospore size ranges from 50-75  $\times$  2.5-3.5  $\mu\text{m}$ , septation is 7-septate, olivaceous.

**18.** *Trichoglossum gracile* Pat., *Bull. Soc. Mycol. Fr.* **25**: 131 (1909).

**Distribution:** Till date it has been observed in China and California.

**Description:** *Apothecia* clavate in shape, 18-60 mm long, black in colour, ascogenous part rounded or elliptical, 2-4 mm in diameter; stipe 0.5-1 mm in thickness. Setae present, brown in colour, quite abundant in occurrence. Asci cylindrical to club shaped, 8 spored, size ranging from 168-237  $\times$  16-19  $\mu\text{m}$ ; *Ascospores* brown coloured, clavate in shape, 15 septate, 110-162  $\times$  5-6  $\mu\text{m}$ .

**19.** *Trichoglossum wrightii* (E.J. Durand) E.J. Durand, *Mycologia* **13**(3): 187 (1921).

**Distribution:** It is found from Cuba, Bermuda, Waterston (NY), Whetzel (NY) and Panama.

**Description:** Fruitbody clavate, black coloured, velvety in texture, and variable in size; *ascogonous* is also very irregular in shape. Asci 8-spored, cylindrical to clavate, size ranging from 250-265  $\times$  20-25  $\mu\text{m}$ . *Ascospores* are also cylindrical to clavate in shape, 143-187  $\times$  6-7  $\mu\text{m}$  in size, commonly 15-septate, but rarely could be 16 septate too. Presence of cystidia was also observed.

Lastly after describing all the pre-existing taxa, a special emphasis will be given to a recently documented species from lower Gangetic plain of India. This newly reported species was named as *Trichoglossum benghalense* and is diagnosed by the presence of hirsute, clavate apothecia, black in colour

and size ranging from 2-6 × 20-35 mm, hymenial setae evident. Asci long, octasporous, ascospores 0-7 septate.

**20. *Trichoglossum benghalense*** N. Chakra., Tarafder & K. Acharya, *Phytotaxa* **536(1)**: 072-082 (2022)

**Distribution:** Till date known only from India and considered as the newest species of the genus *Trichoglossum*.

**Description:** Naturally found in soil as saprobic fungi. Apothecia clavate, dumbbell or oval shaped, size ranges from 2-6 mm diam. × 20-35 mm, black in colour, hirsute. *Ascogenous* position is flattened lanceolate to clavate, colour black, and distinguishable sterile portions. Sterile portions are flexuous and cylindrical in shape, densely hirsute from setae, highly concolorous with fertile portions. Hymenial setae is dark brown to black in colour, hyaline at base, size ranging from 60-190 × 4-7.5 µm, single septate thick walled, often protruding over hymenium. Paraphyses numerous, septate in nature, filiform, 3-6 µm broad at the apices, walls are granulated, light brown in colour. Asci octasporous, clavate to cylindrical in shape, 127-227 × 13-20 µm in size, apex round, brown in colour. Ascospores are brownish grey at young stage and brownish orange to dark brown at their mature stage, 63-210 × 4-7 µm in size, mature spores are 0-7 septate whereas young spores are aseptate, fusoid to clavate in shape.

#### Molecular phylogeny in *Trichoglossum*

Majority of the species under this genus has been determined by macro- and micromorphological observations. However, on the basis of available sequence data of internal transcribed spacers (ITS1 and ITS2) segments of the nuclear ribosomal DNA region of this genus few phylogenetic studies have been conducted and the accession numbers NCBI of few uploaded ITS sequences of different species of *Trichoglossum* are listed in the **table 1**. Fedosova and Kovalenko (2015) segregate eight genera of *Geoglossomycetes* class on the basis of

**Table 1.** List of taxa and GenBank accession numbers for available specimens

Name of the species	GenBank accession no. for nrITS sequence	Reference
<i>T. hirsutum</i>	KC222133	Ekanayaka <i>et al.</i> , 2017
<i>T. hirsutum</i>	KC222132	Ekanayaka <i>et al.</i> , 2017
<i>T. hirsutum</i>	NR121205	Ekanayaka <i>et al.</i> , 2017
<i>T. hirsutum</i>	JQ256428	Prabhugaonkar and Pratibha, 2017
<i>T. cf. octopartitum</i>	KY747525	Ekanayaka <i>et al.</i> , 2017
<i>T. octopartitum</i>	KC222134	Ekanayaka <i>et al.</i> , 2017
<i>T. octopartitum</i>	JQ256429	Prabhugaonkar and Pratibha, 2017
<i>T. septatum</i>	KY747526	Ekanayaka <i>et al.</i> , 2017
<i>T. variabile</i>	KP144106	Prabhugaonkar and Pratibha, 2017
<i>T. variabile</i>	KP144105	Prabhugaonkar and Pratibha, 2017
<i>T. walteri</i>	JQ256430	Ekanayaka <i>et al.</i> , 2017
<i>T. walteri</i>	HQ222867	Ekanayaka <i>et al.</i> , 2017
<i>T. rasum</i>	KY457226	Prabhugaonkar and Pratibha, 2017
<i>T. farlowii</i>	HQ222862	Wang <i>et al.</i> , 2011
<i>T. benghalense</i>	MT573336	Chakraborty <i>et al.</i> , 2022
<i>T. benghalense</i>	MT622541	Chakraborty <i>et al.</i> , 2022

morphology and molecular data. Furthermore, Prabhugaonkar and Pratibha (2017) reported *T. rasum* from India and they have used molecular phylogeny to justify their findings. Not only that Ekanayaka *et al.* (2017), reported a new species (*T. septatum*) from Thailand on the basis of morphological and molecular data. Most recently, Chakraborty *et al.* (2022) reported a new species (*T. benghalense*) from lower Gangetic Plain of India in the same way and the phylogenetic tree can be referred.

#### Key to the *Trichoglossum* species

- 1a. Number of ascospores per ascus four or less.....2
- 1b. Number of ascospores per ascus 8.....4
- 2a. Ascus large 237-294 µm × 19-22 µm, clavate to cylindrical, frequently 4 spored, rarely 2, 15-16 septate ..... *T. yunnanense*
- 2b. Ascus moderate 175-200 µm × 20-25 µm, 4 spored, Septation 0-13 to 17, with dark brown setae.....3
- 3a. Ascospores 0-17 septate.....*T. tetrasporum*
- 3b. Ascospores 0-13 septate..... *T. velutipes*
- 4a. Ascospores portion compressed and mostly clavate.....5
- 4b. Ascogenous portion irregular in shape and size, cystidia present..... *T. wrightii*
- 5a. Ascospores normally 45-125 µm long.....6
- 5b. Ascospores normally greater than 45-125 µm long..... 10
- 6a. Ascospores 7-9 septate.....7
- 6b. Ascospores 0-5 septate, Sub-cylindric to clavate.....  
.....*T. farlowii*
- 7a. Setae abundant, dark brown, acuminate, ascospore 3-7 septate.....8
- 7b. Setae very less, brown, not acuminate, ascospore 6-9 septate.....*T. qingchengense*
- 8a. Ascogenous portion without median groove and ligule, Ascus length 150-200 µm.....9
- 8b. Ascogenous portion with prominent median groove and obtuse apex, ligulate, with thick-walled setae.....*T. walteri*
- 9a. Ascospores clavate and 60-125 µm long.....*T. rehmanium*
- 9b. Ascospores sub-cylindric and 45-75 µm long.....  
.....*T. confusum*
- 10a. Ascospores 0-15 septate or more ..... 11
- 10b. Ascospores less than 15 septate ..... 17
- 11a. Ascus clavate..... 12
- 11b. Ascus cylindric, Ascospores 140-175 µm long ..... *T. sinicum*
- 12a. Septa count range 0-15.....13
- 12b. Septa count 15-19, Ascus 300-410 µm and Ascospores 190-270 µm long..... *T. septatum*
- 13a. Ascospore 150-200 µm long..... 14

- 13b. Ascospore 80-150  $\mu\text{m}$  long.....15
- 14a. Ascogenous portion sub-globose to ovate or rounded, up to 4 cm long ..... *T. persoonii*
- 14b. Ascogenous portion mostly clavate, up to 5.5 cm long..... *T. longisporum*
- 15a. Ascogenous portion compressed, elliptic to clavate..... 16
- 15b. Ascogenous portion compressed up to 2 cm, clavate to capitate, brown black ..... *T. hirsutum*
- 16a. Fruitbody up to 6 cm, Ascus clavate, paraphyses pale brown..... *T. cheliense*
- 16b. Fruitbody up to 8 cm, Ascus clavate to cylindrical, paraphyses upper portion dark brown and lower hyaline..... *T. gracile*
- 17a. Ascospores less than 10 septate.....18
- 17b. Ascospore 10-16 septate..... *T. variabile*
- 18a. Ascus up to 200  $\mu\text{m}$  long.....19
- 18b. Ascus 200-260  $\mu\text{m}$  long, ascospores 3-9 septate..... *T. rasum*
- 19a. Setae without basal septa.....20
- 19b. Setae with single basal septa, Clavate to spoon headed ascogenous portion ..... *T. benghalense*
- 20a. Ascogenous portion cylindrical or elliptical to lanceolate.....21
- 20b. Ascogenous portion clavate, up to 4.5 cm long, ascospore 7 septate ..... *T. octopartitum*
- 21a. Ascus cylindrical, narrowed sharply at the apex, Ascus 120-130  $\mu\text{m}$  long, Ascospores 50-75  $\mu\text{m}$  long..... *T. peruvianum*
- 21b. Ascus clavate, 175-225  $\mu\text{m}$  long, Ascospores 100-140  $\mu\text{m}$  long ..... *T. kunmingense*

## CONCLUSION

Geoglossaceous fungi appear occasionally and sporadically and are rare in occurrence and that is the main reason why it is tough to find their exact geographical abundance. Thus, all the existing taxa along with the new findings under this group of fungi should be evaluated properly for better understanding. The ecology, distribution and taxonomical study will give a clear idea about the members of *Geoglossaceae*.

This study is done on the available recorded species of *Trichoglossum* from the whole World. Though the published information about this genus is inconsistent and insufficient, we had put out best leg forward to compile all the available documents, in this review. The genus *Trichoglossum* comes under *Geoglossaceae* family and can easily be separated from other existing genus of this family by the presence of hymenial setae. Considering the distribution of the genus, it could be said that different species of *Trichoglossum* is dispersed throughout the world; at least five out of seven continents have some trace of this genus. The most surprising fact is that though a quite good number of species were

reported from China and its adjacent areas, but majority of those taxa are either endangered or endemic to those regions.

The main aim of this paper is to provide the reader with the precise knowledge about different species of *Trichoglossum*, which is commonly known as earth hairy tongues. This paper consists of almost all the *Trichoglossum* species recorded so far throughout the world. Habit, habitat and other important characteristics of each species are mentioned. Apart from that an artificial key has also been provided for future research purpose. While dealing with all these species it is interesting to note that the species characteristics are vastly varying from continent to continent. Finally, from this study it is quite evident that ecological factors play an important role on the morphology and distribution of the fungal forms. From this study it is very clear that *Trichoglossum* have variety of forms which grows abundantly along the other vegetation throughout the world.

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