

Key to the Funariales of the Iberian Peninsula and Balearic Islands

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Abstract – Seven genera of Funariaceae and two genera of Gigaspermaceae, representing eighteen species in all, are listed for the bryoflora of the Iberian Peninsula and Balearic Islands. A key for the species is provided, as well as illustrations and comments on the distinctive diagnostic characters, ecology and distribution in the studied area.

Balearic Islands / Funariaceae / Gigaspermaceae / Iberian Peninsula / Portugal / Spain.

INTRODUCTION

According to Buck & Goffinet (2000), the Funariales include Disceliaceae, Gigaspermaceae and Funariaceae, the two latter being represented in the Iberian Peninsula. The Gigaspermaceae have a predominantly Southern Hemisphere distribution and only two species, *Oedipodiella australis* (Wager & Dixon) Dixon and *Gigaspermum mouretii* Corb., occur in Europe, both having been reported from several Spanish localities. On the other hand, the Funariaceae include a large number of species that are spread worldwide. In the Iberian Peninsula, certain rare species have been cited such as *Goniomitrium seroi* Casas, the only Northern Hemisphere species of this genus, and, the more recently discovered African species *Entosthodon mouretii* (Corb.) Jelenc and *E. schimperii* Brugués. We also report *Funariella curviseta* (Schwägr.) Sergio and *Entosthodon durieui* Mont., both with Mediterranean distributions, as well as *E. hungaricus* (Boros) Loeske. More common European species that are here reported include *Entosthodon attenuatus* (Dicks.) Bryhn, *E. obtusus* (Hedw.) Lindb., *E. fascicularis* (Hedw.) Müll.Hal., *E. convexus* (Spruce) Brugués, *E. muhlenbergii* (Turner) Fife, *E. pulchellus* (H. Philib.) Brugués, *Funaria hygrometrica* Hedw., *Physcomitrella patens* (Hedw.) Bruch & Schimp., *Physcomitrium pyriforme* (Hedw.) Hampe and *Pyramidula tetragona* (Brid.) Brid.

In the Funariaceae the gametophyte is quite homogeneous, and for this reason the majority of the diagnostic characters are based on the sporophyte. The taxonomic treatment of this family follows Fife (1985, 1996), who considers that the species of the subgenus *Plagiodus*, traditionally accommodated in *Funaria*, are more appropriately treated as a subgenus within *Entosthodon*. The species with

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sulcate capsule, a compound, vesicular and revoluble annulus and sigmoid exostome teeth apically fused by a disc are the only ones to be included within the genus *Funaria*. In the Iberian Peninsula, only *Funaria hygrometrica* fits these characters.

Fife (1985) includes in the genus *Entosthodon* those species having non-sulcate capsules, with a simple, non-revoluble annulus and exostome teeth, when present, either sigmoid or straight, but not apically fused. These species are distributed in three subgenera. In Europe, the subgen. *Plagiodus*, characterised by inclined, asymmetric capsules and sigmoid exostome teeth, comprises *E. muhlenbergii*, *E. convexus* and *E. pulchellus* – formerly included by Crundwell & Nyhlom (1974) in the *Funaria muhlenbergii* group – and, recently added, *E. schimperi* (Brugués *et al.*, 2001). The subgen. *Entosthodon* and *Murcia* are characterised by erect, symmetric capsules and exostome teeth, when present, non-sigmoid. Plants with oblong exothelial cells, as *E. attenuatus*, *E. durieui*, *E. hungaricus* and *E. obtusus*, are placed in the subgen. *Entosthodon* and those with isodiametric exothelial cells, as *E. fascicularis* and *E. mouretti*, in the subgen. *Murcia*.

Goffinet & Cox (2000) place *Goniomitrium* in the Pottiaceae based on nucleotide sequence data, but, as stated above, treatment here follows Fife (1985), who retains this genus in the Funariaceae.

The key is complemented with illustrations and comments on the distinctive diagnostic characters, ecology and distribution in the studied area. Most of the specimens on which are based the reports in the Iberian literature have been revised by the author.

KEY TO THE SPECIES

1. Stem prostrate, rhizomatous, giving rise to erect branches
 - GIGASPERMACEAE 2
 2. Nerve absent; gemmae lacking **1. *Gigaspermum mouretii***
 2. Nerve present, excurrent; lenticular gemmae produced at stem apex **2. *Oedipodiella australis***
1. Stem erect, little branched
 - FUNARIACEAE 3
 3. Calyptra persistent, large, angled or plicate; spores large, 40-60 μm , golden to pale brown, ovoid to elliptical 4
 4. Seta 0.3-0.5 mm long; capsule emergent; calyptra mitrate, 8-plicate, lobed, not clasping the seta **3. *Goniomitrium seroi***
 4. Seta 1-1.5 mm long; capsule exserted; calyptra cucullate, distinctly 4-angled, clasping the seta **4. *Pyramidula tetragona***
 3. Calyptra deciduous, small, neither angled nor conspicuously plicate; spores less than 40 μm , reddish-brown, subreniform to nearly spherical 5
 5. Capsules cleistocarpous, spherical, and with thin-walled exothelial cells **5. *Physcomitrella patens***
 5. Capsules operculate, elongate, and with firm- to thick-walled exothelial cells 6
 6. Seta curved, as long as the capsule; capsule inclined to pendent before dehiscence, emergent **6. *Funariella curviseta***
 6. Seta straight, much longer than the capsule; capsule erect or inclined, exserted 7

7. Capsules erect, symmetric or nearly so, mouth transverse 8
 8. Operculum apiculate or rostellate; calyptra mitrate; spores spinose
 7. *Physcomitrium pyriforme*
8. Operculum convex, mostly plane, without apiculus; calyptra cucullate or mitrate; spores no spinose 9
 9. Exothelial cells isodiametric to shortly oblong; mouth less than the diameter of the moist capsule 10
 10. Nerve ending in or below apex **8. *Entosthodon fascicularis***
 10. Nerve excurrent **9. *Entosthodon mouretii***
9. Exothelial cells linear-oblong to oblong; mouth equal the diameter of the moist capsule 11
 11. Leaves distinctly bordered with 2-3 rows of narrow, incrassate, yellowish cells **10. *Entosthodon obtusus***
 11. Leaves not bordered with incrassate cells 12
 12. Peristome present, with well developed teeth; rhizoids bright to dark purple **11. *Entosthodon attenuatus***
 12. Peristome absent or rudimentary; rhizoids brown 13
 13. Leaves elliptic to obovate or spatulate, acute to obtuse; mouth equal the diameter of the dry capsule
 12. *Entosthodon durieui*
 13. Leaves oblong to obovate-lanceolate, acuminate; mouth diameter larger than the dry capsule
 13. *Entosthodon hungaricus*
7. Capsules strongly or weakly inclined, asymmetric, mouth oblique 14
 14. Capsule sulcate, deeply furrowed when dry; peristome double; exostome teeth strongly sigmoid and fused at apices **14. *Funaria hygrometrica***
14. Capsule not sulcate when dry; peristome double, single or absent; exostome teeth, if present, markedly or weakly sigmoid, not fused at apices 15
 15. Leaves entire or slightly sinuose, longly pointed; lid conical
 15. *Entosthodon pulchellus*
15. Leaves toothed, shortly or longly pointed; lid conical or convex 16
 16. Leaves shortly pointed; lid convex **16. *Entosthodon convexus***
 16. Leaves longly pointed; lid conical or convex 17
 17. Leaf apices gradually tapering; nerve excurrent; lid convex
 17. *Entosthodon schimperi*
17. Leaf apices suddenly contracted; nerve ceasing below apex; lid conical
 18. *Entosthodon muhlenbergii*

1. *Gigaspermum mouretii* Corb., *Rev. Bryol.* 40: 10. 1813. Fig. 1 (1-2).

Plants small, light to glaucous green; erect branches 2.5-5(-8) mm high, arising from a yellow, leafless and subterranean rhizome; leaves orbicular-apiculate, ecostate. Seta very short; capsule immersed, cupulate, gymnostomous. Spores reddish brown, to 130 µm, minutely verrucate, nearly smooth. It forms loose tufts on dry rocky soils.

G. mouretii, described from Morocco, has been reported from several southern Spanish localities, Mallorca and Formentera (Casas *et al.*, 1985; Oliva *et al.*, 2000).

2. *Oedipodiella australis* (Wager & Dixon) Dixon, *J. Bot. London* 60: 105.1922. Fig. 1 (3-5).

Plants small; erect branches 3-5 mm high, arising from a yellow, branching, leafless, subterranean rhizome; leaves crowded above, obovate to spatulate,

apex rounded, abruptly apiculate, costate. Scattered or loosely caespitose species that develop on small rocky ledges, to 900 m.

This species has a predominantly Southern Hemisphere distribution; in the Northern Hemisphere it occurs in the northeast of Spain (Casas *et al.*, 1985), in the south of France (Allorge, 1960; Thouvenot, 2000), in the Canary Islands (Dirkse, 1993) and Madeira (Sérgio & Fontinha, 1994).

Potier de la Varde (1958) described the var. *catalaunica* from material collected in Cap de Creus (Catalonia, northeast of Spain), this being the first European report of the species. This plant has mucronate apex leaves, with shorter leaves and lamina cells than the *typus*. But study of material from several Spanish and South African localities, shows the variation to be comparable. Consequently, the variety *catalaunica* should be rejected.

3. *Goniomitrium seroi* Casas, *Acta Phytotax. Barcinon.* 10: 13. 1972. Fig. 1 (6-11).

Plants small, to 4 mm; rhizoidal tubers present; leaves crowded and larger above, obovate to spathulate; costa long-excurrent. Capsule operculate, cupulate, with broad mouth; peristome absent. Calyptra mitrate bearing 8 radial pleats. Spores ovoid to elliptical, 40-55 μm , with minutely sculptured surface (Brugués *et al.*, 1998).

This species forms small patches after rain on ledges of volcanic rocks in very dry areas, between 150-200 m. It is the only species of this genus that occurs in the Northern Hemisphere and is located in the southeast of Spain (Casas de Puig, 1972) and in the Canary Islands (Dirkse *et al.*, 1993).

4. *Pyramidula tetragona* (Brid.) Brid., *Muscol. Recent. Suppl.* 4: 20. 1819. Fig. 1 (12-14).

Plants pale green, small, about 5 mm; leaves ovate or oblong-ovate; nerve excurrent. Capsule operculate, ovoid or pyriform, with short neck, irregularly sulcate when dry and empty; peristome absent. Calyptra cucullate, inflated, 4-angled. Spores ovoid to elliptical 50-60 μm , minutely sculptured surface.

Patches or solitary plants on temporarily moist soil in fields of several southern Spanish localities. Most of the specimens from the Iberian Peninsula were published as *P. algeriensis* Chudeau & Douin (Casas de Puig & Simó, 1972; Acuña *et al.*, 1975; Casas de Puig, 1974; Casas *et al.*, 1981; Casas & Oliva, 1982 a, 1982 b; de las Heras & Ros, 1986; de las Heras *et al.*, 1989; Gil García & Castro, 1987; Oliva, 1989 and Casas, 1993), currently considered synonymous to *P. tetragona* (Brugués *et al.*, 1998).

5. *Physcomitrella patens* (Hedw.) Bruch & Schimp., *Bryol. Eur.* 1: 13. 1849. Fig. 1 (15-16).

Plants light green or yellowish, to 3 mm; leaves oblong-lanceolate to obovate, acute, serrulate in the upper half or less; nerve ending below apex. Seta short, about 0.2 mm; capsule immerse, globose, bluntly apiculate; calyptra very small, conic-mitrate. Spores spinose.

Solitary to gregarious plants on damp soil in places subject to flooding. Reported from scattered northern Spanish localities (Heras & Infante, 1989; Álvaro Martín, 1984).

6. *Funariella curviseta* (Schwägr.) Sergio, *Orsis* 3: 5-13. 1988. Fig. 1 (17-20).

Plants small, to 5 mm, leaves oblong-obovate to spathulate, acuminate. Seta 1.2-2 mm; capsule pyriform, erect when mature, with distinct neck; mouth

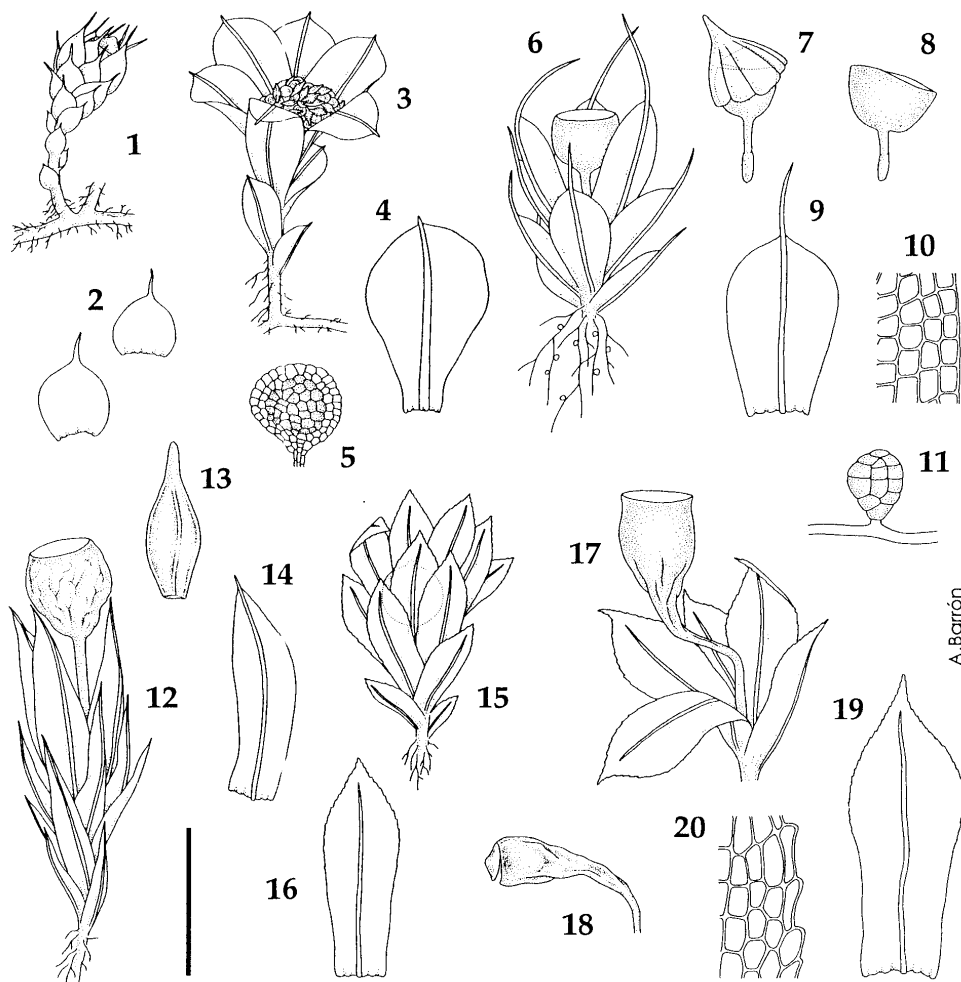


Fig. 1. **1-2** *Gigaspermum mouretii* Corb.: 1 habit; 2 leaves. **3-5** *Oedipodiella australis* (Wager & Dixon) Dixon: 3 habit; 4 leaf; 5 gemma. **6-11** *Goniomitrium seroi* Casas: 6 habit; 7 capsule with calyptra; 8 mature capsule; 9 leaf; 10 leaf margin; 11 rhizoidal tuber. **12-14** *Pyramidula tetragona* (Brid.) Brid.: 12 habit; 13 calyptra; 14 leaf. **15-16** *Physcomitrella patens* (Hedw.) Bruch & Schimp.: 15 habit; 16 leaf. **17-20** *Funariella curviseta* (Schwägr.) Sergio: 17 habit; 18 dry capsule; 19 leaf; 20 leaf margin.

Scale = 2 mm for 1, 3, 6, 7, 8, 12, 13, 15, 17, 18; scale = 1.5 mm for 2, 4, 9, 14, 16, 19; scale = 400 μ m for 5; scale = 250 μ m for 11; scale = 150 μ m for 10, 20.

equal the diameter of the moist capsule, peristome absent; operculum cells arranged in a spiral. Spores reticulate.

This Mediterranean species occurs in clefts and crevices of calcareous rocks on wet sites with maritime influence. It is distributed in the southern half of the Iberian Peninsula, being quite frequent in Portugal, as well as and in Mallorca, Menorca, Eivissa and Cabrera (Casas *et al.*, 1989).

7. *Physcomitrium pyriforme* (Hedw.) Hampe, *Linnaea* 11: 80. 1837. Fig. 2 (1-4).

Plants to 5 mm. Leaves ovate-lanceolate, oblong-lanceolate or spatulate, margin toothed above; nerve ending near the apex. Seta 5-15 mm; capsule globose to pyriform, narrowed at mouth, short distinct neck; peristome absent; exothelial cells irregular, quadrate, hexagonal or short rectangular, thin walled. Spores spinose.

This species forms small turves or scattered stems on moist, usually acidic soils in cultivated fields and stream banks. It has been reported from several Spanish and Portuguese localities from the northern half of the Iberian Peninsula (Casas *et al.*, 1996).

8. *Entosthodon fascicularis* (Hedw.) Müll.Hal., *Syn. Musc. Frond.* 1:120. 1848. Fig. 2 (5-8).

Plants to 5 mm; leaves oblong-lanceolate, acuminate, toothed, 1-2 rows of marginal cells narrower. Seta 5-7 mm; capsule pyriform with short distinct neck; exothelial cells isodiametric to shortly oblong, with thickened walls. Spores baculate-insulate.

In small patches or scattered plants usually on damp acidic soils, in arable fields and stream shores at low altitudes (Ros & Guerra, 1987; Casas *et al.*, 1996).

9. *Entosthodon mouretii* (Corb.) Jelenc, *Bull. Soc. Géogr. Archéol. Oran* 75: 76. 1952. Fig. 2 (9-15).

Leaves oblong-lanceolate or oblong-obovate, acuminate, toothed to middle of leaf with projecting cells, marginal cells scarcely differentiated; nerve excurrent in a long yellow or reddish awn, up to 0.5 mm. Spores 23-28 μm , baculate-insulate.

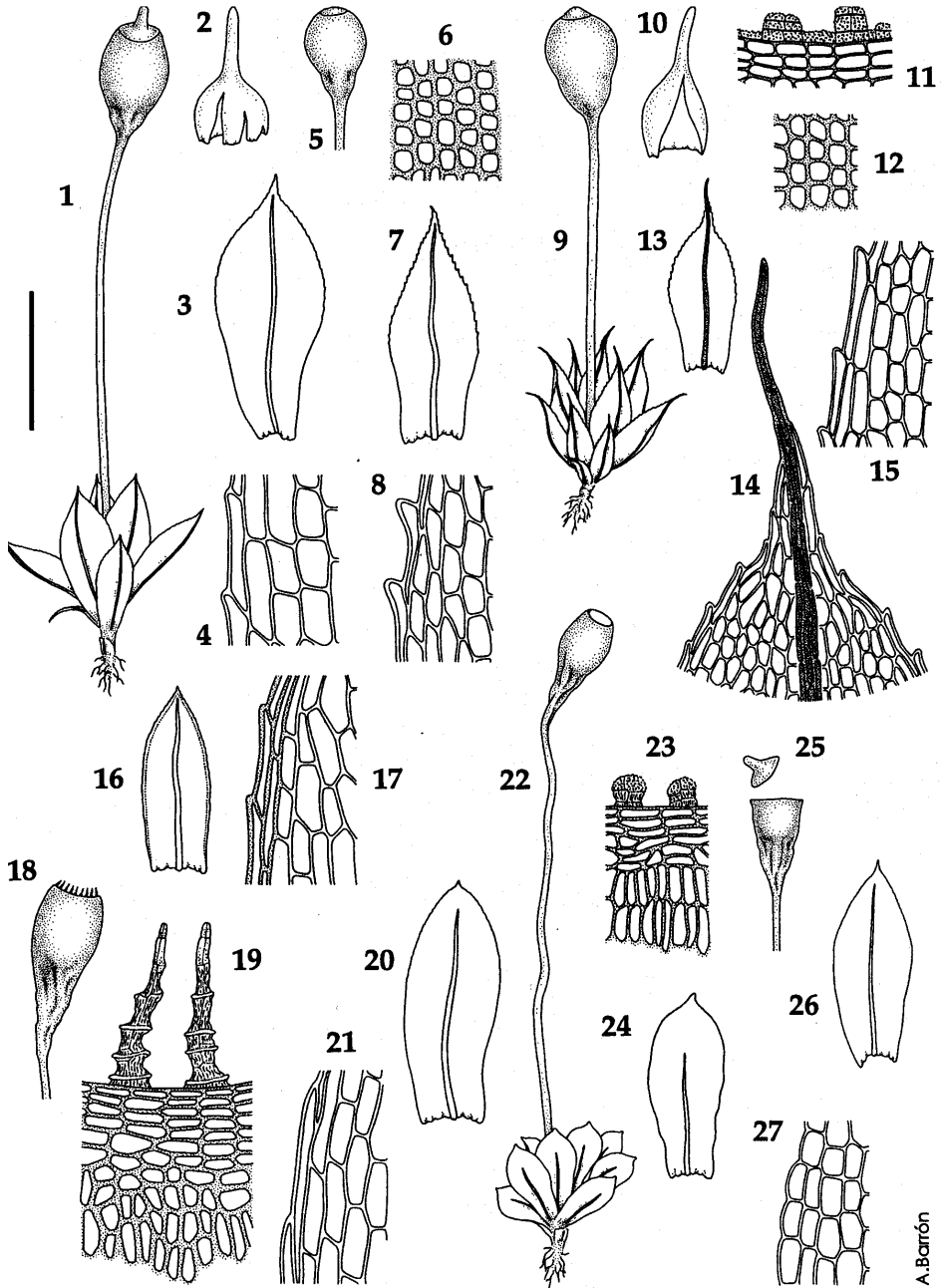
This species occurs at the margins of periodically flooded depressions, on acidic soils. It was described from the north of Africa, subsequently has only been found in the northeast of Spain (Brugués *et al.*, 1999).

10. *Entosthodon obtusus* (Hedw.) Lindb., *Öfvers. Förh. Kongl. Svenska Vetensk.-Akad.* 21: 221. 1865. Fig. 2 (16-17).

Plants to 4 mm; leaves oblong-lanceolate, acuminate; margin entire or slightly denticulate; marginal cells narrow, incrassate and yellowish, forming a distinct border nerve ending below apex. Seta to 6 mm; capsule small, pyriform; peristome rudimentary or absent; lid convex. Spores baculate-insulate.

Fig 2. **1-4** *Physcomitrium pyriforme* (Hedw.) Hampe: 1 habit; 2 calyptra; 3 leaf; 4 leaf margin. **5-8** *Entosthodon fascicularis* (Hedw.) Müll.Hal.: 5 capsule; 6 exothelial cells; 7 leaf; 8 leaf margin. **9-15** *Entosthodon mouretii* (Corb.) Jelenc: 9 habit; 10 caliptra; 11 peristome teeth; 12 exothelial cells; 13 leaf; 14 leaf apex; 15 leaf margin. **16-17** *Entosthodon obtusus* (Hedw.) Lindb.: 16 leaf; 17 leaf margin. **18-21** *Entosthodon attenuatus* (Dicks.) Bryhn.: 18 capsule; 19 peristome teeth and exothelial cells; 20 leaf; 21 leaf margin. **22-24** *Entosthodon durieui* Mont.: 22 habit; 23 peristome teeth and exothelial cells; 24 leaf. **25-27** *Entosthodon hungaricus* (Boros) Loeske: 25 capsule; 26 leaf; 27 leaf margin.

Scale = 2.5 mm for 1, 2, 5, 9, 10, 18, 22, 25; scale = 1.5 mm for 3, 7, 13, 16, 20, 24, 26; scale = 250 μm for 14; scale = 150 μm for 4, 6, 8, 11, 12, 15, 17, 19, 21, 23, 27.



A. Barrón

It grows in small loose patches on shady and humid banks within holm and beech forest, on peat soils in meadows or headlands. Fairly common in the north and the west of the Iberian Peninsula and in Menorca (Casas *et al.*, 1996).

11. *Entosthodon attenuatus* (Dicks.) Bryhn, *Kongel. Norske Vidensk. Selsk. Skr.* 1908 (8): 25. 1908. Fig. 2 (18-21).

Plants 3-5 mm; leaves obovate or oblong narrowed into short point, margin entire or almost so, with 1-2 rows of narrow elongate cells but not forming a distinct border; nerve ending in or below apex. Capsule narrowly oblong-pyriform with long neck, half of the capsule length; peristome teeth straight, to 180 µm high. Spores nearly smooth.

Scattered or tufted plants on moist acidic soils by streams, on rock crevices and rock ledges. Common between 200-1000 m in the North and West of the Peninsula, Mallorca and Menorca (Casas *et al.*, 1996).

12. *Entosthodon durieui* Mont., *Ann. Sci. Nat. Bot.*, ser.3, 11: 33. 1849. Fig. 2 (22-24).

Includes *E. pallescens* Jur., *E. mustaphae* Trabut and *E. physcomitroides* Casares-Gil & Beltrán (Brugués, 1998).

Plants 3-4 mm, light to yellow green, soft; leaf margin entire. Seta 4-8 mm; capsule pyriform; neck as long as the sporangium; lid convex; mature calyptra mitrate. Spores baculate-insulate.

This species forms small patches on calcareous rocks and artificial walls. It is reported from scattered localities of the peninsular Mediterranean area, as well as in Mallorca and Menorca (Casas *et al.*, 1996).

13. *Entosthodon hungaricus* (Boros) Loeske, *Repert. Spec. Nov. Regni Veg. Sonderbeih.* 3(2): 115. 1929. Fig. 2 (25-27).

Plants 3-4 mm; leaf margin entire or faintly denticulate. Seta 3-4 mm; capsule pyriform or ovate, long neck; lid with a short, blunt apiculus; calyptra mitrate. Spores variable in size, 19-42 µm, smooth, verrucate, insulate or verrucate-bullate.

This species grows in temporarily wet clayey ledges in calcareous areas or on gypsum and arid soils. Formerly considered to be a species typical of the central European steppes, it has been later found in several localities of the eastern half of the Iberian Peninsula (Casas *et al.*, 1985; Cano *et al.*, 1996, 1999).

14. *Funaria hygrometrica* Hedw., *Spec. Musc.*: 172. 1801. Fig. 3 (1-3).

Plants to 4 cm; leaves widely ovate-lanceolate, concave. Seta cygneous, flexuose; capsule pyriform, strongly sulcate, inclined; annulus large and revoluble. Spores verrucate.

The samples cited as *Funaria microstoma* Bruch ex Schimp., either from Spain (Casares Gil & Beltrán, 1912) or from Portugal (Luisier, 1916; Machado, 1929-1930), are in fact forms of *F. hygrometrica*.

In yellowish green or green patches or scattered plants on disturbed or cultivated soils. Can be abundant after fires. Widespread throughout the territory, mainly in lowland.

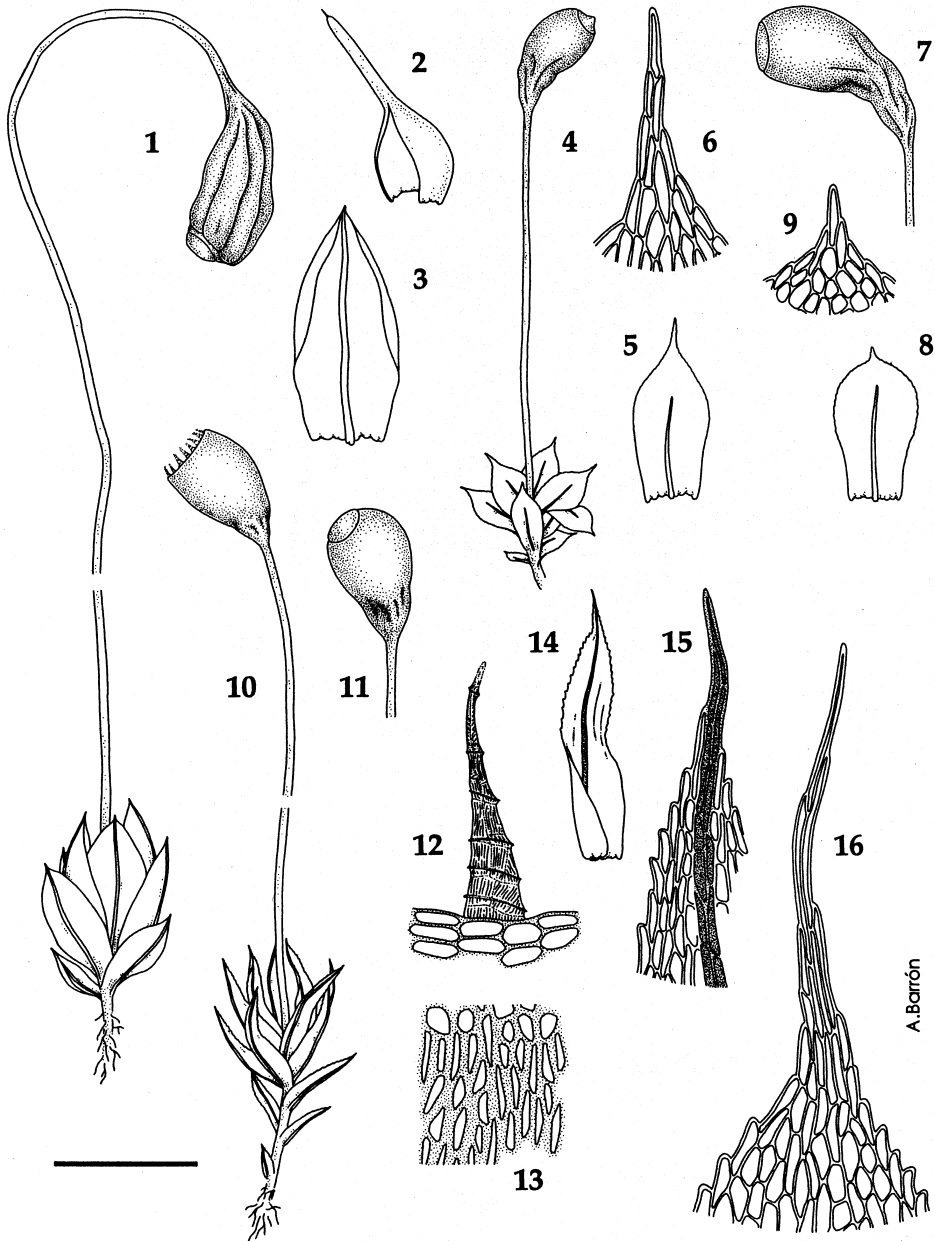


Fig. 3. **1-3** *Funaria hygrometrica* Hedw.: 1 habit; 2 calyptra; 3 leaf. **4-6** *Entosthodon pulchellus* (H. Philib.) Brugués: 4 habit; 5 leaf; 6 leaf apex. **7-9** *Entosthodon convexus* (Spruce) Brugués: 7 capsule; 8 leaf; 9 leaf apex. **10-15** *Entosthodon schimperi* Brugués: 10 habit; 11 capsule; 12 peristome tooth; 13, exothecial cells; 14 leaf; 15 leaf apex. **16** *Entosthodon muhlenbergii* (Turner) Fife, leaf apex. Scale = 2.5 mm for 1, 2, 4, 7, 10, 11; scale = 1.5 mm for 3, 5, 8, 7, 14; scale = 250 μm for 6, 9, 15, 16; scale = 150 μm for 12, 13.

15. *Entosthodon pulchellus* (H. Philib.) Brugués, *Orsis* 15: 115. 2000. Fig. 3 (4-6).

Plants to 5 mm; leaves oblong to obovate, acuminate, gradually tapered to a slender point up to 450 µm, apical cell to 280 µm; nerve usually ceasing well below the tip. Neck to half of the capsule length. Spores intermediate between the insulate type and verrucate-lirate or baculate-lirate.

In small patches or individual yellowish green plants on calcareous soils. Common between 200 to 1450 m, in the Iberian Peninsula, Mallorca and Menorca (Casas *et al.*, 1996). The majority of Spanish and Portuguese samples, that have been attributed to *Funaria calcarea* Wahlenb. or *F. dentata* Crome, both synonyms of *Entosthodon muhlenbergii* (Crundwell & Nyhlom, 1974), actually correspond to *E. pulchellus*.

16. *Entosthodon convexus* (Spruce) Brugués, *Orsis* 15: 115. 2000. Fig. 3 (7-9).

Plants to 6 mm; leaves obovate with broad apex rapidly contracted to a very short point to 150 µm, apical cell to 120 µm; nerve ceasing well below the tip. Neck nearly half of capsule length. Spores baculate-insulate.

This species grows on soil banks, rock ledges and crevices in exposed places on acidic or basic substrates. Common in the Mediterranean area of Portugal and Spain (included Mallorca and Menorca), from sea level to 1300 m (Casas *et al.*, 1996).

17. *Entosthodon schimperi* Brugués, *Cryptogamie, Bryol.* 22: 252. 2001. Fig. 3 (10-15).

Plants to 5 mm; leaves ovate-lanceolate or oblong-lanceolate, strongly toothed in upper $\frac{2}{3}$; nerve conspicuous, 80 µm wide near base, excurrent in an awn to 450 µm. Capsule weakly inclined, neck to $\frac{1}{3}$ length of capsule, operculum plane or convex. Spores baculate-insulate.

This species grows on dry and exposed soils in low calcareous mountains of the Southern Mediterranean areas of the Iberian Peninsula. It was described by Bescherelle (1882) as *Funaria durieui* from an Algerian specimen collected by Durieu de Maisonneuve. According to Fife (1985), it should be included in the subgenus *Plagiodus*. Since the epithet *durieui* has already been used for one species of *Entosthodon*, a new combination in this genus was necessary. It has recently been found in several southern localities of the Iberian Peninsula as well as in the Canary Islands (Brugués *et al.*, 2001).

18. *Entosthodon muhlenbergii* (Turner) Fife, *J. Hattori Bot. Lab.* 58: 192. 1985. Fig. 3 (16).

Plants to 5 mm; leaves obovate to oblong, fairly slender acuminate, rather suddenly contracted to a long point, up to 700 µm, apical cell to 400 µm; nerve ending well below apex. Neck nearly half of the total capsule length. Spores baculate-insulate.

This species forms yellowish green patches on ledges or crevices of calcareous rocks at high altitudes, 1000-1700 m. A more northern species than *E. convexus* and *E. pulchellus* (Crundwell & Nyhlom, 1974), it is rare in the Iberian Peninsula, where it has only been collected in scattered sites in the north, east and southeast of Spain (Casas *et al.*, 1996). Often confused with *E. pulchellus*.

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