

## “*Quercirhiza cumulosa*”

+ *Quercus ilex* L. subsp. *ballota* (Desf.) Samp.

MIRIAM DE ROMÁN, Departamento de Botánica, Universidad de Navarra, 31080 Pamplona, Spain; REINHARD AGERER, Sektion Mykologie, Institut für Systematische Botanik, Universität München, Menzinger Straße 67, D-80638 München, Germany; ANA DE MIGUEL, Departamento de Botánica, Universidad de Navarra, 31080 Pamplona, Spain.

### Short description

The ectomycorrhizae are characterized by black, loosely woolly, monopodial-pyramidal to irregularly pinnate systems. The outer mantle layers are pseudoparenchymatous, with angular cells and mounds of flattened cells, whereas the inner mantle layers are pseudoparenchymatous to tightly plectenchymatous. Emanating hyphae abundant, with clamps and surfaces with occasional warty patches. Dark brown rhizomorphs present, with thick central non-vessel-like hyphae surrounded by much thinner peripheral hyphae. “*Quercirhiza cumulosa*” is probably a member of the genus *Tomentella*.

**Morphological characters** (Fig. 1a): *Mycorrhizal systems* abundant, dense, 2–7 mm long, monopodial-pyramidal to irregularly pinnate, 0–2 orders of ramification. – *Main axes* 0.1 mm diam. – *Unramified ends* straight to sinuous, up to 1.7 mm long and 0.1–0.2 mm diam., colour of mycorrhizal ends and very tip dark brown to black, older parts black, not carbonizing. – *Surface of unramified ends* shiny, covered with soil particles, loosely woolly, surface distinct, not transparent, cortical cells not visible, dots lacking; emanating hyphae abundant, not specifically distributed. – *Rhizomorphs* infrequent, 0.03–0.06 mm diam., roundish in cross section, mostly originating at the distal part of the mycorrhiza, distinctly connected to the mantle, dark brown with a reddish tint, hairy, infrequently ramified. – *Sclerotia* not observed.

**Anatomical characters of mantle in plan views** (Figs. 2d, 3a–c): *Lacking are*: oily droplets, brownish and needle-like contents, blue granules, drops of exuded pigment and clamps. – *Outer mantle layers* (Figs. 2d, 3a) pseudoparenchymatous with angular cells and mounds of flattened cells (mantle type O according to AGERER, 1987–1998), membranaceously brownish, surface of cells with many soil particles; cells of mounds 9–16(18) µm diam., cells of pseudoparenchyma 9–15 µm diam. and (11)15–21(26) µm long, 5–9 cells in a square of 20 x 20 µm, walls 0.5–1 µm thick, with frequent pores between cells and less frequent cell wall projections which are even in thickness. – *Middle mantle layers* (Fig. 3b) pseudoparenchymatous, membranaceously brownish, cells (7)10–16 µm diam. and 13–26(32) µm long, cell walls 0.5–1 µm thick, 8–13 cells in a square of 20 x 20 µm. – *Inner mantle layers* (Fig. 3c) pseudoparenchymatous to tightly plectenchymatous, membranaceously brownish, cells 4–9(17) µm diam., distance of septa 11–26(30) µm. – *Very tip* with no structural differences, cells 8–15 µm diam., 5–11 cells in a square of 20 x 20 µm.

**Anatomical characters of emanating elements** (Figs. 1b, 2a–c): *Rhizomorphs* (Fig. 1b) 30–60 µm diam., slightly differentiated, central hyphae somewhat enlarged (rhizomorph type C according to AGERER, 1987–1998), although the hyphae are very loosely woven; central, non-vessel-like hyphae 4–8 µm diam., distance of septa (54)65–90(108) µm, walls 0.5–1 µm thick,

membranaceously brownish, sometimes warty, septa as thick as walls in clamps, but thinner in secondary septa; peripheral hyphae originating from the inner hyphae, irregularly sinuous, 1.5–2 µm in diam., distance of septa (15)23–60(90) µm, cell walls 0.2–0.3 µm thick, slightly membranaceously yellowish, smooth, clamps infrequent. – *Emanating hyphae* (Figs. 2a–c) straight to wavy, sometimes even tortuous, with simple to ramified hyphal ends, 3–5.5 µm thick, cells (45)50–70(80) µm long, walls 0.5–1 µm thick, membranaceously brownish, clamps thinner than its hyphae in lateral and dorsal view, elbow-like protrusions present, secondary septa infrequent, surface mostly smooth, but rough in certain patches, with hemispherical warts up to 0.2 µm wide; intrahyphal hyphae present, backwards oriented ramifications and clamps not observed, anastomoses very infrequent, one side-branch at septum at any distance from it, walls uneven in thickness, thicker at the base and in elbow-like protrusions. – *Cystidia* lacking. – *Chlamydozoospores* not observed.

**Anatomical characters, longitudinal section:** *Mantle* 24–40(44) µm thick, only one pseudoparenchymatous layer discernable, hyphae tangentially (5)8–15(19) µm, radially 3–6(8) µm, caliptra cells visible; mantle of very tip 25–30 µm thick, with no structural differences. – *Tannin cells* lacking. – *Epidermal cells* radially-oval to -elliptic, oriented obliquely; tangentially (10)13–20 µm, radially (33)45–74 µm,  $EC_t = 16$  µm,  $EC_q = 0.3$ . – *Hartig net* in section paraepidermal, with beaded hyphal cells in one row, 2–6(9) µm thick; Hartig net in plan view of a palmetti type, lobes 2–5 µm broad.

**Colour reaction with different reagents:** *Mantle and rhizomorph preparations:* cotton blue-lactic acid: bluish, cell walls become brighter; guaiac: n. r. (= no reaction); iron(II)sulfate: greenish grey; KOH 15%: n. r.; lactic acid: brighter cell walls; Melzer's reagent: n. r.; sulfovanillin: n. r.; toluidine blue: bluish.

**Reference specimen for *Quercus ectomycorrhiza*:** Spain, Navarra, Nazar, in a *Quercus ilex* subsp. *balota* forest, soil core exc., myc. isol. M. de Román, 17. 11. 2000, ectomycorrhiza MDR 4 (in Department of Botany, Universidad de Navarra, Spain). The epitheton "cumulosa" refers to the mounds of flattened cells occurring on the surface of the mantle.

**Discussion:** The ectomycorrhizae of "*Quercirhiza cumulosa*" are characterized by the presence of rhizomorphs with thin peripheral hyphae surrounding thick central hyphae, and by the structure of the pseudoparenchymatous outer mantle layers, with angular cells bearing mounds of flattened cells.

This sort of rhizomorphs have also been found in "*Quercirhiza nodulosomorpha*" (AZUL et al. 1999), *Tomentella pilosa* (JAKUCS & AGERER 1999) and *Tomentella ferruginea* (RAIDL & MÜLLER 1996), but their peripheral hyphae are more densely entwined than in "*Q. cumulosa*". Moreover, the presence of cystidia in the first two cases, and the plectenchymatous outer mantle in the last one are significant distinguishing features.

Regarding the mantle structure, the presence of mounds of cells has been recorded for "*Pinirhiza dimorpha*" (GOLLDACK et al. 1999) and "*Piceirhiza nigra*" (AGERER et al. 1995). Nevertheless, both ectomycorrhizae differ from "*Q. cumulosa*" by the presence of cystidia and the lack of rhizomorphs.

Other similarities concerning the morphology of the ectomycorrhiza and the anatomy of the mantle have been found in "*Fagirhiza spinulosa*" (BRAND 1991a), "*Fagirhiza setifera*" (BRAND 1991b), "*Quercirhiza fibulocystidiata*" (JAKUCS et al. 1997) and in the five *Tomentella* types not identified to the species level described by DANIELSON et al. (1984), DANIELSON & PRUDEN (1989) and DANIELSON and VISSER (1989). In contrast to "*Q. cumulosa*", all these ectomycorrhizae have cystidia, except for one of these *Tomentella* types, but no further comparison is possible due to the brief description given.

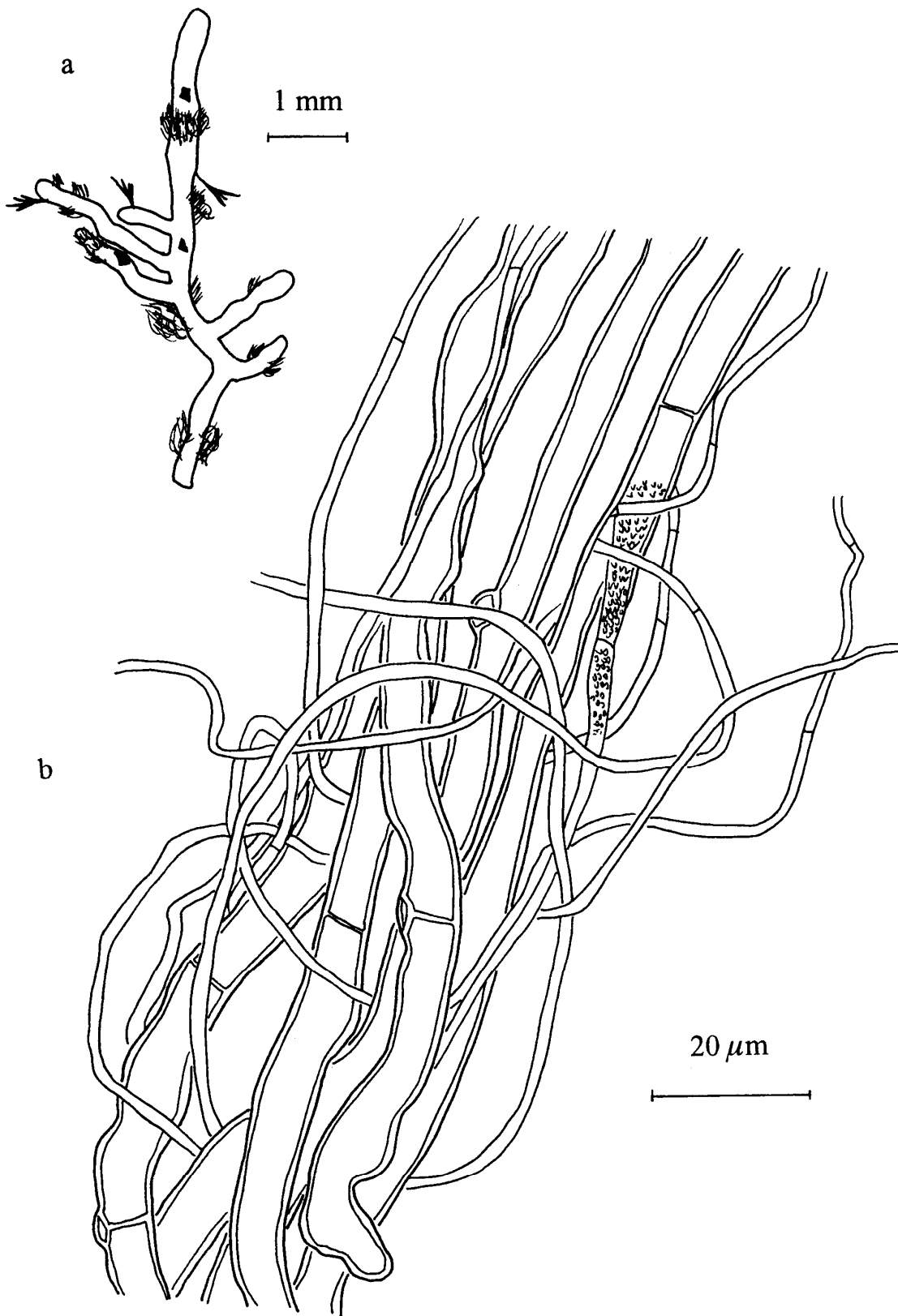
Due to the similarities of "*Q. cumulosa*" with other ectomycorrhizae either identified as *Tomentella* or unidentified, but supposedly belonging to this genus, it is suggested that "*Q. cumulosa*" may also be a member of the genus *Tomentella*.

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**References:** AGERER R, ed (1987–1998) Colour Atlas of Ectomycorrhizae. 1st–11th del. Einhorn, Schwäbisch Gmünd. – AGERER R, KLOSTERMEYER D, STEGLICH W (1995) "*Piceirhiza nigra*", an ectomycorrhiza on *Picea abies* formed by a species of Thelephoraceae. *New Phytol* 131: 377–380. – AZUL AM, AGERER R, FREITAS H (1999) "*Quercirhiza nodulosomorpha*" + *Quercus suber* L. *Descr Ectomyc* 4: 103–108. – BRAND F (1991a) "*Fagirhiza spinulosa*". In: Agerer R (ed) (1987–1998) Colour Atlas of Ectomycorrhizae, plate 54. Einhorn-Verlag, Schwäbisch Gmünd. – BRAND F (1991b) "*Fagirhiza setifera*". In: Agerer R (ed) (1987–1998) Colour Atlas of Ectomycorrhizae, plate 55. Einhorn-Verlag, Schwäbisch Gmünd. – DANIELSON RM, PRUDEN M (1989) The ectomycorrhizal status of urban spruce. *Mycologia* 81(3): 335–341. – DANIELSON RM, VISSER S (1989) Host response to inoculation and behaviour of introduced and indigenous ectomycorrhizal fungi of jack pine grown on oil-sands tailings. *Can J For Res* 19: 1412–1421. – DANIELSON RM, ZAK JC, PARKINSON D (1984) Mycorrhizal inoculum in a peat deposit formed under a white spruce stand in Alberta. *Can J Bot* 63: 2557–2560. – GOLLDACK J, MÜNZENBERGER B, HÜTTL RF (1999) "*Pinirhiza dimorpha*" + *Pinus sylvestris* L. *Descr Ectomyc* 4: 73–78. – JAKUCS E, AGERER R (1999) *Tomentella pilosa* (Burt) Bourdot & Galzin + *Populus alba* L. *Descr Ectomyc* 4: 135–140. – JAKUCS E, AGERER R, BRATEK Z (1997) "*Quercirhiza fibulocystidiata*" + *Quercus* spec. *Descr Ectomyc* 2: 67–71. – RAIDL S, MÜLLER WR (1996) *Tomentella ferruginea* (Pers.) Pat. + *Fagus sylvatica* L. *Descr Ectomyc* 1: 161–166.

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**Captions:** *Fig. 1 – a.* Habit. – *b.* Rhizomorph. – *Fig. 2 – a.* Emanating hyphae with warty surface. – *b.* Hypha emanating from outer mantle layers, note thicker walls at the base. – *c.* Emanating hyphae with ramified hyphal end, note uneven wall thickness (arrows). – *d.* Plan view of mantle surface with mounds of flattened cells. – *Fig. 3 – a.* Plan view of outer mantle layers. – *b.* Plan view of middle mantle layers. – *c.* Plan view of inner mantle layers. *All figs. from MDR 4.*



*Fig. 1 – “Quercirhiza cumulosa” + Quercus ilex subsp. ballota*

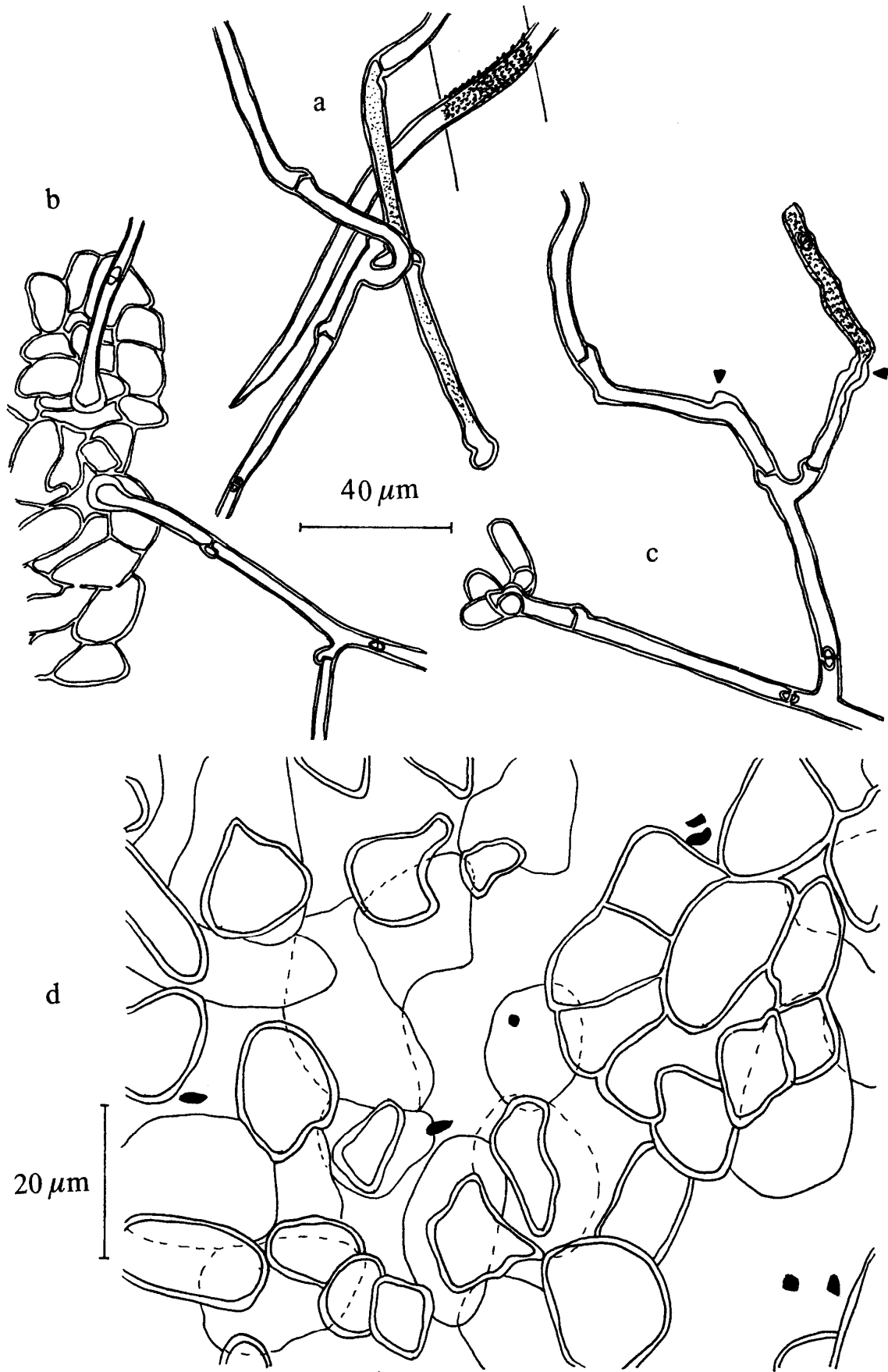
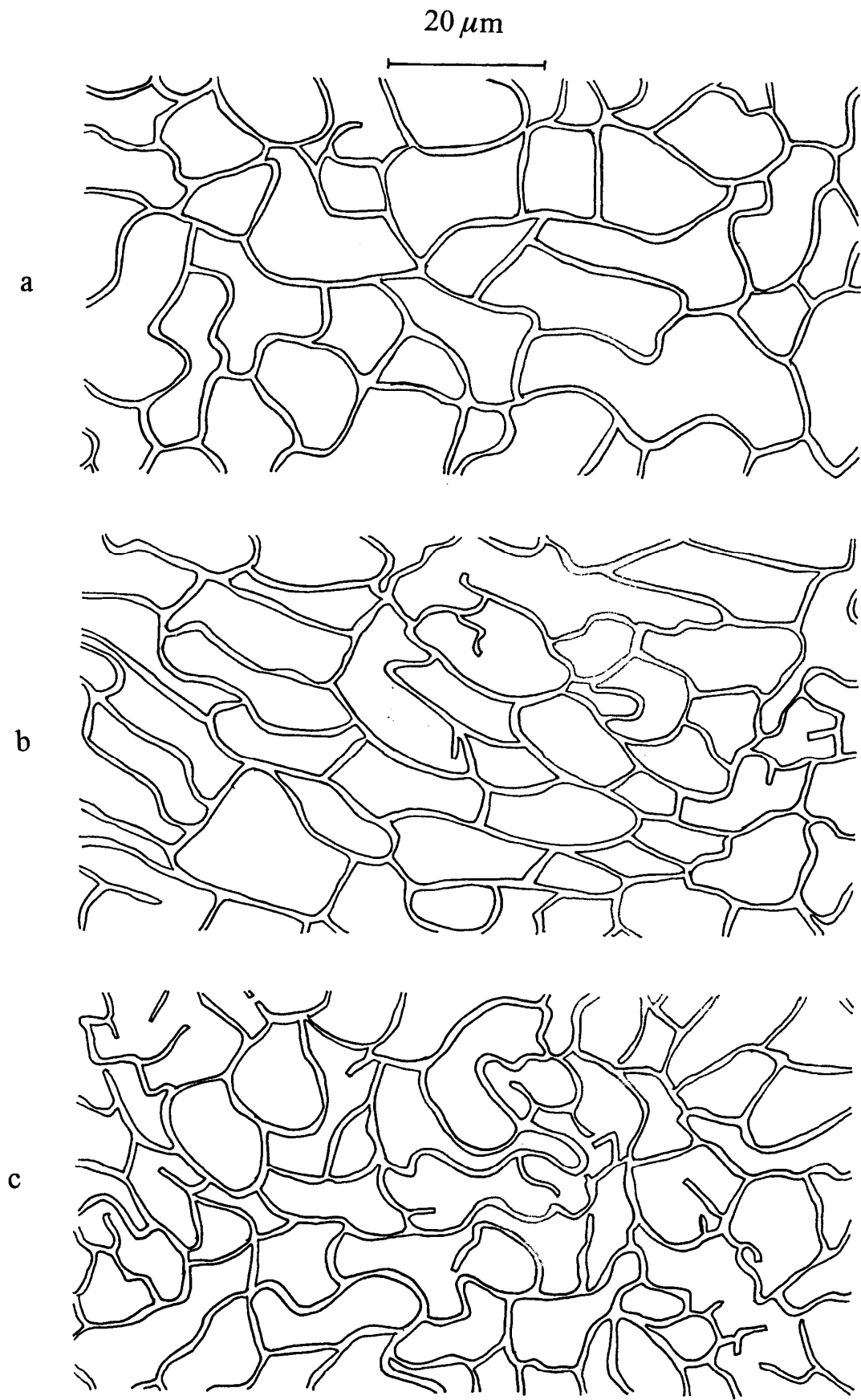


Fig. 2 - "*Quercirhiza cumulosa*" + *Quercus ilex* subsp. *ballota*



**Fig. 3 - "*Quercirhiza cumulosa*" + *Quercus ilex* subsp. *ballota***