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Recent reports of *Fissidens fontanus* (Musci, Fissidentaceae) in Italy and some considerations on the propagation of the species

Abstract

Dickson, J. H., Aleffi, M., Lécivain, G. M-J. & Veal, R. J.: Recent reports of *Fissidens fontanus* (Musci, Fissidentaceae) in Italy and some considerations on the propagation of the species. — Borziana 2: 069-080. 2021 — ISSN: 2724-5020 online.

In Europe the moss *Fissidens fontanus* (Bach. Pyl.) Steud occurs from the Mediterranean countries to northern Sweden. Some of these occurrences particularly those in Italy and France are discussed. Sporophytes and gametangia are seldom reported and many field bryologists have never seen them. It was first discussed 180 years ago and occasionally mentioned since then that the capsules are caducous; this is sometimes unknown to European bryologists. The small capsules are the primary mode of dispersal rather than shed spores. Vegetative propagules and stem and leaf fragments are also dispersal agents.

Key words: *Fissidens fontanus*, moss dispersal, caducous sporophytes.

Introduction

From the late 18th century to the present day, *Fissidens fontanus* (Bach. Pyl.) Steud has had no more than about 20 localities widely spread in mainland Italy north of Rome as well as two in Sardinia and one in Sicily (Fig. 1). As listed below, many of the discoveries are very old, mainly dating back to the early 19th century; sporophytes were found in only two locations. In recent decades in Franche-Comté (France), in numerous localities, mainly in lavoirs (wash houses) specimens of *Fissidens fontanus* have been found, but no sporophytes have been recorded. In addition, to reporting some recent findings of *Fissidens fontanus* in Italy and France, some considerations on the ecology of the species and its reproductive methods are presented in this work. In particular, the lack of finding the sporophyte in most of the collections carried out, both in the past and recently, and, consequently, the ability of the species to spread even in places very distant from each other, is emphasized.



Fig 1. Distribution map of *Fissidens fontanus* in Italy

Distribution in Italy

There follows a list of localities in Italy where specimens of *Fissidens fontanus* have been found (Aleffi & al. 2020), sorted by year of discovery with the indication

of the presence or absence of capsules. The progressive numbers in round brackets are shown on the distribution map (Fig. 1):

Fissidens fontanus (Bach. Pyl.) Steud.

Synonyms: *Conomitrium julianum* (Savi ex DC.) Mont.; *Fissidens julianus* (Savi ex DC.) Schimp.; *Fontinalis juliana* Savi ex DC.; *Octodiceras fontanum* (Bach. Pyl.) Lindb.;

- (1) 1798. Tuscany, Bagni di San Giuliano (Pisa); Savi (Hb PI); sterile (Savi 1798).
- (2) 1818. Tuscany, no precise locality; Savi (Hb PI); sterile (Savi 1798).
- (3) 1824. Tuscany, Monte Giuliano; Pollini (Hb PI); sterile (Pollini 1824).
- (4) 1834. Lombardy, no precise locality; Balsamo, De Notaris (Hb RO); no data (Balsamo & De Notaris 1834).
- (5) 1837. Tuscany, Monte Giuliano; Montagne (Hb PI); capsules present (Montagne 1837).
- (6) 1837. Veneto, Veronese; Montagne; no data (Montagne 1837).
- (7) 1844. Lombardy, no precise locality; Garovaglio; no data (Garovaglio 1844).
- (8) 1846. Liguria, no precise locality; De Notaris (Hb RO); no data (De Notaris 1846).
- (9) 1861. Lombardy, Territorio Insubrico; Cesati; no data (Cesati 1861).
- (10) 1874. Piedmont, Val di Stura; Bagnis (Hb TO); sterile (Bagnis 1874).
- (11) 1868 and 1875. Tuscany, San Giuliano; Lange (Hb PI); sterile (Lange 1868, 1875).
- (12) 1881. Tuscany, San Giuliano; Fitzgerald, Bottini (Hb PI); sterile (Fitzgerald & Bottini 1881).
- (13) 1888. Lombardy, Prov. Pavia; Farneti; sterile (Farneti 1888).
- (14) 1897-98. Lazio, no precise locality; Brizi; no data (Brizi 1897-98).
- (15) 1915. Lombardy, Mantova; Zodda; no data (Zodda 1915).
- (16) 1967. Tuscany, Isola Capraia; Moretti & al. (Hb PERU); no data (Moretti & al. 1967).
- (17) 1994. Sicily, Lungo il fiume Ciane; Privitera, Puglisi (Hb CAT); no capsules but gametangia present (Privitera & Puglisi 1994).
- (18) 2006. Sardinia, Rio Cispiri (Tramatza, Oristano); Cogoni, Adamo, Flore (Hb CAG); no data (Cogoni & al. 2006).
- (19) 2007. Sicily, corsi d'acqua siciliani; Provenzano & al. (Hb CAT); no data (Provenzano & al. 2007).

(20) 2008. Sardinia, Rio Cannas; Frahm, Lüth, Melick (Hb Frahm, Hb Van Melick); sterile (Frahm & al. 2008).

(21) 2016. Tuscany, Golfo di Baratti; *leg.* Lécivain, Dickson, Veal, April 2016 (Hb Dickson); sterile.

Material and methods

The newest Tuscan locality was found in April 2016 by G.M.-J. Lécivain (with J.H. Dickson and R.J. Veal) at the Gulf of Baratti. There the species was present in limited quantity in a small, very shallow stone tank, fed by a spring flowing through a narrow pipe. The collected moss specimen is shown in Fig. 2. On the uppermost part of the beach, the sea is slowly washing away what is a very extensive waste heap of copper and iron smelting residues from Etruscan, Roman and later times. The water can never be deeper than about 15cm. Stormy seas must occasionally deposit salt water into the tank, but the constantly flowing fresh water will remove the saltiness. In any case, the moss is known to tolerate somewhat brackish water (Britton 1902).

The Herbarium of Turin (TO), Pisa (PI) and Rome “La Sapienza” (RO) were also consulted in order to verify the presence of sporified specimens of *Fissidens fontanus*.

Results and discussion

In Franche-Comté and elsewhere in France, J.H. Dickson and G.M.-J. Lécivain have seen the moss many times in lavoirs where there is still flowing fresh water after decades of redundancy since domestic washing machines became commonplace (Ferrez & al. 2001; Frahm 2003a; Piguet & al. 2007; Piguet 2009; Dickson & al. 2014). Only once have we seen it in the river Saône but for all we know it may be common in that river, as it has become in Dutch and German rivers (Melick 1985; Nebel & Phillipi 2000; Frahm 2001, 2003b); unless the water level is very low, it is difficult to do searches in such a large turbid river as the Saône. It is much easier to peer into washing and rinsing tanks or into livestock drinking troughs (often the external part of the lavoirs).

In France J.H. Dickson and G.M.-J. Lécivain have never seen it in such a minute body of very shallow water as in the new locality in Tuscany. Nor have we ever seen capsules or even gametangia in France. An personal communication from Vincent Hugonnot is very relevant here: “I have never seen sporophytes in France. I have seen the plant quite a lot of times, in the Mediterranean area, in Brittany, in the Jura and the Massif Central but it was always without sporophytes”. Concerning the occurrences in Poland, Bednarek-Ochyra & al. (1996) mention neither capsules nor gametangia.

The new Italian material of *Fissidens fontanus* is sterile without gametangia or capsules. No capsules have been recorded in England or the Iberian Peninsula and they are rare/very rare in Germany and France. Lohammar (1954) said that the moss has never been found fertile in Northern Europe (meaning Sweden, Norway, Denmark, Finland and Latvia). Fagerstén (1981) listed several localities in Finland scattered



Fig. 2. The specimen collected in Gulf of Baratti in 2016. The unsheathed part of the laminas is much longer than the sheathed part. These few leafy stems were made into a voucher specimen (Photo R. J. Veal).

from the southernmost coast to the far north. Hallingbäck & al. (2006) stated “Capsules currently unknown in Nordic countries, but possibly overlooked”.

However, sporophytes have been found in the last few decades in Netherlands and Belgium. van Melick (1985), commenting on the presence of the species in 80 localities and its rapid spread in Dutch rivers (Rhine and Meuse), stated that sporophytes were found only twice. According to Arne van der Plujim (pers. comm.): “Capsules are probably not rare in the Netherlands”. No sporophytes were brought back from Belgium by Lambinon & Empain (1971). However, Dirk de Beer wrote (pers. comm.): “In Belgium I have seen sporophytes twice in recent years”.

Privitera & Puglisi (1994) stated that gametangia were present on Sicilian plants but they saw no capsules. Only in two of the Northern Italian localities have sporophytes been reported dating back to the 19th century: one found in Lombardy collected by De Notaris in 1834 and the other one in Piedmont collected by Bagnis in 1874. However, the examination of the Bagnis’ samples kept at the Herbarium of Turin (TO), as well as the specimens kept at the Herbarium of Pisa (PI), do not show sporophytes. The only samples in which the capsules are present are those kept at the Herbarium of Rome “La Sapienza” (RO) (Fig. 3): it is a sample collected by A. Jäger in 1864 in Karlsruhe, a sample sent by



Fig 3. Some samples of *Fissidens fontanus* preserved in the Italian Herbaria: (1) samples of A. Jäger (Hb RO) and (2) the plant contained in the sachet; (3) detail of the capsules preserved separately, demonstrating the early fall of these from the stem; (4) Kunze sample (Hb RO); (5) detail of the plant with some sporophytes; (6) Schimper sample (Hb RO) and (7) detail of the stem with capsules; (8) sterile sample of *Fontinalis juliana* collected by Savi at Bagni di S. Giuliano and kept in the Hb PI.

Kunze ad a sample of Schimper (Hb E. Fiorini-Mazzanti) used by De Notaris for the realization of the tables designed for the *Epilogo della Briologia Italiana* (De Notaris 1869) and only recently published by Graniti & Aleffi (2011) (Fig. 4).

The actual frequency of capsules, if any, in Italy is unknown and the same can be said for large parts of Europe. It has to be emphasised that the capsules are very small (only about half a mm) and in the field a quick glance might overlook them, especially if in small numbers.

Nebel & Philippi (2000) stated that sporophytes are very seldom seen in Baden-Württemberg (Germany), and that the capsules break early and float on the water. In their 2012 book, Düll & Düll-Wunder stated that, despite the moss is monoecious, capsules are only rarely found and that, when ripe, they float on the water. Bruch & al. (1836) referred to the observation that the capsules are caducous; here is a translation from the French:

“When the capsule is nearly ripe the pedicel detaches from the vaginula and the fruit floats on the water generally still fitted with the calyptra and operculum. Mr. Noellner owns thousands of capsules, which he fished from the water when preparing specimens for the herbarium. This fugacity rather than the small size of the fruit explains why the fruit remained unknown for a long time”.

It is noteworthy that the discovery of capsules, as described in *Bryologia Europaea*, was followed so closely in such similar circumstances by the first finding in France as related by Montagne (1837); Jean-Marie Bachelot de La Pylaie found plants with capsules growing in spring in Lanegrac’h, Tie de Oussant, Brittany. La Pylaie put the plants in a vase full of water and was not a little amazed to see the pedicel detaching from the stem and the capsules floating on the surface of the liquid.

In 1902 Britton stated that “In the July number of this Journal Mr Hill has called attention to the propagation by shoots from the calyptra as recorded by Schimper & Goebel. This may be more common than is generally supposed, as it is well known that the fruits of this species fall off, just before maturity, and float to the surface, many of them being quite green, with the calyptra still attached”. This report may equally be attributed to the regeneration of vegetative shoots from the calyptra (haploid) as well as to the germination of spores within the capsule (Wynne & Budke 2012). In the 3rd edition of *Students Handbook of British Mosses* Dixon stated that “It is said to be not unusual for the capsule to fall off...”. Perhaps, the shedding of the tiny capsules partly explains why modern bryologists, unaware of what is a very unusual happening in mosses, failed to find sporophytes (Dixon 1924).

The primary mode of dispersal is capsules rather than spores. Subgenus *Octodiceras* has six species, including *F. fontanus*, three of which have caducous capsules (Pursell & Bruggeman-Nannenga 2004). Beever (1995, p. 229) considered that in the case of *F. berteroi* (Mont.) C.Müll.: “The very short setae and the deciduous sporophytes may be considered adaptations to the aquatic habitat...”. These features apply to *Fissidens fontanus*.

According to Jan-Peter Frahm (pers. comm.): “*Octodiceras* has certainly spread in Germany during the past 30 years in rivers, probably due to raised water quality and raised water temperatures. It has reached Hamburg and Berlin, which is all well documented in the literature. Concerning the distribution of the species, I have to make thoughts about. Spores of *Pottia heimii* reach every spot of salty ground outside the coast, which are sometimes only a square meter and 200 km apart from the next place; the heavy metal species *Scopelophila* and *Ditrichum plumbicola* are sterile and are found similarly in almost all possible habitats, which measure by square decimetres and are also up to hundreds of kilo-

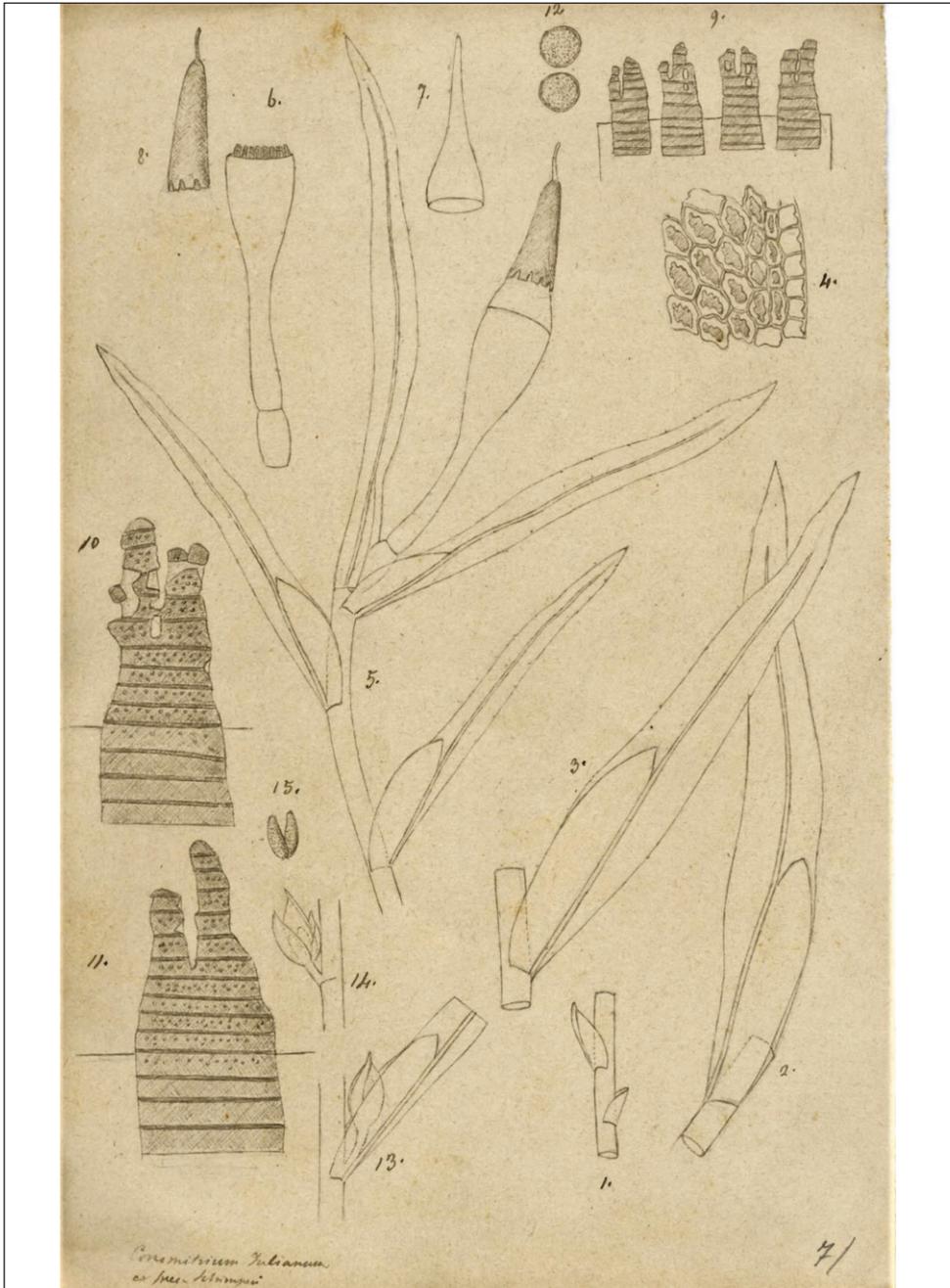


Fig. 4. Original drawing of *Conomitrium julianum* (= *Fissidens fontanus*) by G. De Notaris “ex spec. Schimperii”. In addition to the strongly elongated appearance of the leaves, a characteristic that differentiates this species from others of the genus *Fissidens*, the table describes some details of the capsule, the calyptra and the teeth of the peristome (Graniti & Aleffi 2011).

metres away. How has *Anacolia laevisphaera* reached Germany? Bryophytes are simply omnichor, so far as the habitat fits the ecological requirements of the species”.

If the spores of *F. fontanus* are released under water or floating on top, how do they get airborne? A way could be for the capsules to be swallowed by aquatic birds and then expelled later. However, J.H.D. and G.M.-J.I.L. never saw an aquatic bird in a lavoir. However, the hypothesis that along watercourses the hydrochory can influence and determine the spread of the capsules and spores and consequently the distribution of the species cannot be excluded (Nebel & Philippi 2000).

F. fontanus can also spread vegetatively; Hill (1902) stated that “Correns in an enumeration of mosses possessing brood-organs in the region of Limpricht’s flora, mentions this (as *Octodiceras julianum*) as having brood-branches”. Fagerstén (1981) illustrated propagules and leaves producing rhizoids. Much earlier than these authors, Bachelot de La Pylaie discussed vegetative propagation by side shoots with rhizoids. Without mentioning either the propagules or the deciduous capsules, Frahm was perplexed about the dispersal of *Fissidens fontanus* (Frahm 2001, 2003a). Apparently unaware of the Italian fertile specimens, in the book on Mediterranean bryophytes he stated that the moss is sterile and nobody knows how it disperses from one stretch of water to another (Frahm 2010). Despite the caducous capsules and side shoots, it is indeed difficult to fathom exactly how it got from one lavoir to another (Dickson & al. 2014). How did it reach such a very small habitat as the tank in the Gulf of Baratti? Through leaf fragments, brood bodies, capsules or released spores?

Frey & al. (2006, p.160) considered the distribution as covering “From the Mediterranean to South [*sic*] Scandinavia: formerly scattered but during recent decades with a much expanded range through Central Europe and now locally abundant”. In the light of a Finnish subfossil, perhaps about 3,000 or more years old, it had found its way to the far north of Europe as far as 66° 28’ N, virtually the Arctic Circle, at Posjarv, Overkalix, Sweden (Lindberg 1896, 1898; Gams 1932; Lohammar 1954; Dickson 1973); there, together with some localities in northern Finland, has been considered to be relict from warmer times in the Holocene (Post-Glacial) period.

The whole issue of sporophyte production and capsule and spores’ dispersal needs detailed investigation, but that is not an easy task at least in terms of searching large rivers, compared to peering into lavoirs.

Acknowledgements

For the helpful comments the authors thank Arne van der Plujim, Dirk de Beer, Johannes Enroth, Wolfgang Hofbauer, Vincent Hugonnot, Timo Koponen, Albert Piguët, Jurgen Nieuwkoop, Cristiana Viera, and especially Joop Kortselius.

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