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Contribution to the knowledge of red algae (Rhodophyta) of some rivers in Central Italy

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Abstract – There are no specific studies on freshwater red algae from Italy, and the few existing data are reported in broader studies on algae of rivers. The aim of this paper is to contribute to the knowledge of this algal group in Italy, providing data on their distribution, morphological features and ecology. Samples of *Lemanea fluviatilis*, *L. sudetica* and *Batrachospermum gelatinosum* were collected from 5 stations in the Tiber River basin (Central Italy). The recorded taxa are known as typical elements of European rivers' algal flora, however they were reported in a few times in Italy. Our records, therefore, have widened their geographical distribution. Morever, the finding of *L. sudetica* was, for the first time, recorded with certainty in rivers of Central Italy.

***Batrachospermum gelatinosum* / freshwater red algae / *Lemanea fluviatilis* / *Lemanea sudetica* / rivers**

Résumé – **Contribution à la connaissance des algues rouges (Rhodophyta) de certains cours d'eau en Italie centrale**. Des études spécifiques sur les algues rouges d'eau douce en Italie ne sont pas disponibles et le peu de données retrouvées proviennent d'études générales sur les algues des cours d'eau. Le but de cette étude est de contribuer à la connaissance de ce groupe d'algues en Italie, en fournissant des données sur leur répartition, leurs caractéristiques morphologiques et leur écologie. Des échantillons de *Lemanea fluviatilis*, *L. sudetica*, *Batrachospermum gelatinosum* ont été récoltés dans 5 stations situées dans le bassin du Tibre (Italie centrale). Les taxons observés sont connus comme des éléments typiques de la flore algale des cours d'eau d'Europe. Cependant ces données ont rarement été reportées en Italie, et nos données nous ont donc permis d'accroître connaissance sur la répartition géographique de ces taxons. La découverte de *L. sudetica* est intéressante car il s'agit de la première observation de cette espèce pour des cours d'eau d'Italie centrale.

algues d'eau douce rouge / *Batrachospermum gelatinosum* / cours d'eau / *Lemanea fluviatilis* / *Lemanea sudetica*

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INTRODUCTION

Freshwater red algae are a small portion, about 3%, of the total number of Rhodophyta (Sheath, 1984). Generally, they occur in running waters of small or mid-sized streams and rivers, where they grow on rocks or submerged roots and larger water plants (Sheath & Hymes, 1980). Freshwater red algae were a characteristic group of macroalgae with a world-wide distribution, found from Artic to Tropical areas (Sheath & Hambrook, 1990). Despite the fact that the majority of these algae have a wide distribution, some of them seem to be quite rare and limited to certain habitats or water conditions (Eloranta & Kwandrans, 2002).

In recent papers on freshwater red algae in Europe (Kwandrans & Eloranta, 2010; Eloranta *et al*., 2011), the scarcity of records on this algal group in many countries was highlighted. In Italy, in particular, there are no specific surveys about it but only a few data on species distribution and ecological characteristics of some taxa that are reported in broader studies on algae of Italian rivers. These studies were conducted in rivers of Central (Dell'Uomo, 1970, 1981, 1986, 1991; Del Grosso & Pogliani, 1977; Tardella *et al.*, 2009; Dell'Uomo & Torrisi, 2009; Ceschin *et al.*, 2010a), and Northern Italy (De Toni, 1897; Bignotti, 1910; Cantonati, 1995, 2008). The red algal genera that are quoted in these papers are *Audouinella*, *Bangia*, *Batrachospermum*, *Hildenbrandia* and *Lemanea*.

Considering this background, we have conducted surveys on freshwater red algae in some streams of Central Italy, providing original data on the distribution in Italy, morphology and ecological features of some taxa.

MATERIALS AND METHODS

Red algae were collected together with other algal samples from 97 stations within a broader study on macrophytes of the Tiber River basin conducted from May to October in 2008-2009 (Ceschin *et al*., 2010b). Genera *Batrachospermum* and *Lemanea* were recorded only at five stations along streams of Central Italy (Aniene, Cerfone, Tignana). The geographical coordinates of each sampling station are indicated in Table 1. The samples were taken from stones and cobbles in the riverbed and from floating algal masses. All samples were fixed and preserved in formaldehyde (4% final concentration).

The morphology of the red algal taxa was analyzed using a Leica DM RB light microscope in association with a Leica IM1000 computerized image analysis system. Taxa were identified using the following taxonomic texts: Sheath & Sherwood (2002) and Sheath (2003) for the identification of the genus and Kumano (2002) for the *Batrachospermum* and *Lemanea* species.

At each station, at the same time of the algal collection, some physico-chemical factors were analyzed twice a year. Specifically, temperature, conductivity, pH concentrations and dissolved oxygen were measured using a multi-parameter probe (WTW Multi340i/SET). Ammonium, nitrate and phosphate in water samples were measured in laboratory through spectrophotometric analysis (WTW Photometer MPM 3000). Table 1 shows the data for each of these analyzed factors.

Table 1. Geographical coordinates and mean values of physico-chemical factors for each sampling station.

River	*Geographical coordinates*		*T (C°)*	*pH*	*O_2 (mg/l)*	*cond (µS/cm)*	*NH_4^+ (mg/l)*	*NO_3^- (mg/l)*	*PO_4^{3-} (mg/l)*	*Taxon*
Aniene	41°53'10.41" N	13°19'11.19" E	10.6	8.6	10.5	415	0.05	1.50	0.10	*Lemanea fluviatilis*
Aniene	41°51'29.41" N	13°14'23.22" E	11.6	8.3	10.3	352	0.10	1.40	0.01	*Batrachospermum gelatinosum*
Aniene	41°55'22.50" N	13°5'48.35" E	11.5	8.3	10.2	320	0.20	1.37	0.30	*Batrachospermum gelatinosum*
Tignana	43°37'13.30" N	12°7'1.34" E	17.3	8.3	11.0	442	0.01	n.d.	0.05	*Lemanea fluviatilis*
Cerfone	43°29'11.60" N	12°6'58.78" E	23.8	8.2	8.4	489	0.01	0.47	0.20	*Lemanea sudetica*

RESULTS AND DISCUSSION

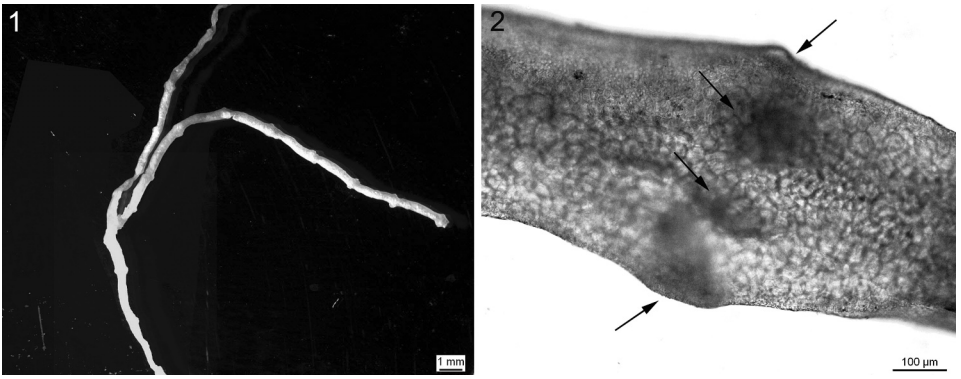
Lemanea fluviatilis (Linnaeus) C. Agardh

Lemanea is a characteristic genus of running waters with a wide Northern Hemisphere distribution. Some species of *Lemanea* are common, while others are rare and restricted to specific water conditions (Eloranta & Kwandrans, 2002). In Europe, *Lemanea* is one of the most frequently reported genera, along with *Audouinella*, *Bangia*, *Batrachospermum* and *Hildenbrandia* (Kwandrans & Eloranta, 2010).

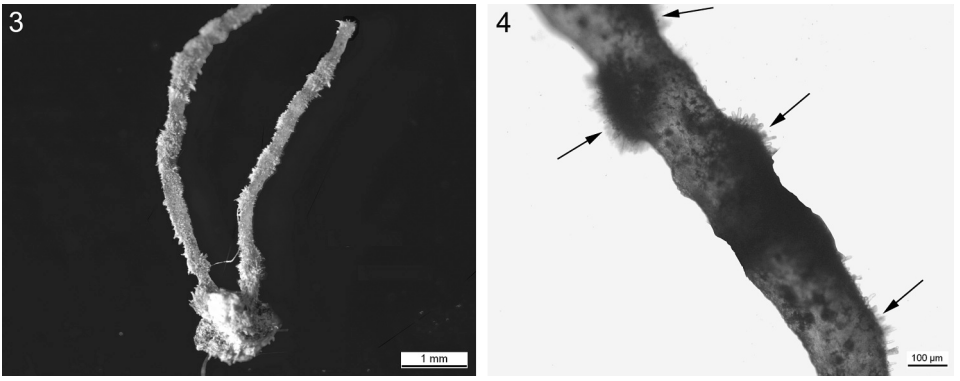
In Italy, the first records of *Lemanea fluviatilis* were for rivers of Central Italy (Bertoloni, 1862; Rabenhorst in Preda, 1909). More recently, this species was recorded in the Potenza River by Pedrotti *et al.* (1969) (although initially confused with *L. fucina* Bory) and by Dell'Uomo (1970). Dell'Uomo (1981, 1986, 1991) describes *L. fluviatilis* as a typical species of the upper stretches of the Apennine rivers, and reports it in some rivers of Central Apennines (e.g. Tenna, Chienti, Potenza, Esino and Nera). Furthermore, Dell'Uomo & Torrisi (2009) found this species in the middle stretch of some rivers flowing from the central Apennine Mountains to the Adriatic Sea.

Our samples of *L. fluviatilis* were collected in 2 stations, along the Aniene and Tignana River (see table 1). They formed visible macroscopic aggregations often in association with green algae, such as *Cladophora glomerata* (L.) Kützing. The fertile plants are up to 6-7 cm high, show tubular filaments, brownish or blackish violet colours, and are sparsely branched (Fig. 1). The filaments are 380-550 µm in diameter and narrow abruptly towards the base. Spermatangial zone is 600-850 µm in diameter with internodes 1600-1900 µm long (Fig. 2). Carposporophytes produce ellipsoidal carpospores (10-11 µm wide, 15-25 µm long) released by thallus deterioration.

In this study, *L. fluviatilis* was recorded on stones, in fast-flowing, cool, clear and, well-oxygenated waters with low nutrients (Table 1). Some researchers found this species in watera with similar conditions (Dell'Uomo, 1981, 1986; Sabater *et al*., 1989) and other described it as a species linked to oligotrophic waters (Rott *et al*., 1999) and quite sensitive to eutrophication (Newman *et al.*, 1997; AFNOR, 2003; Gutowski *et al*., 2004).



Figs 1-2. *Lemanea fluviatilis.* **1.** Filament showing one ramification. **2.** Spermatangial zone.



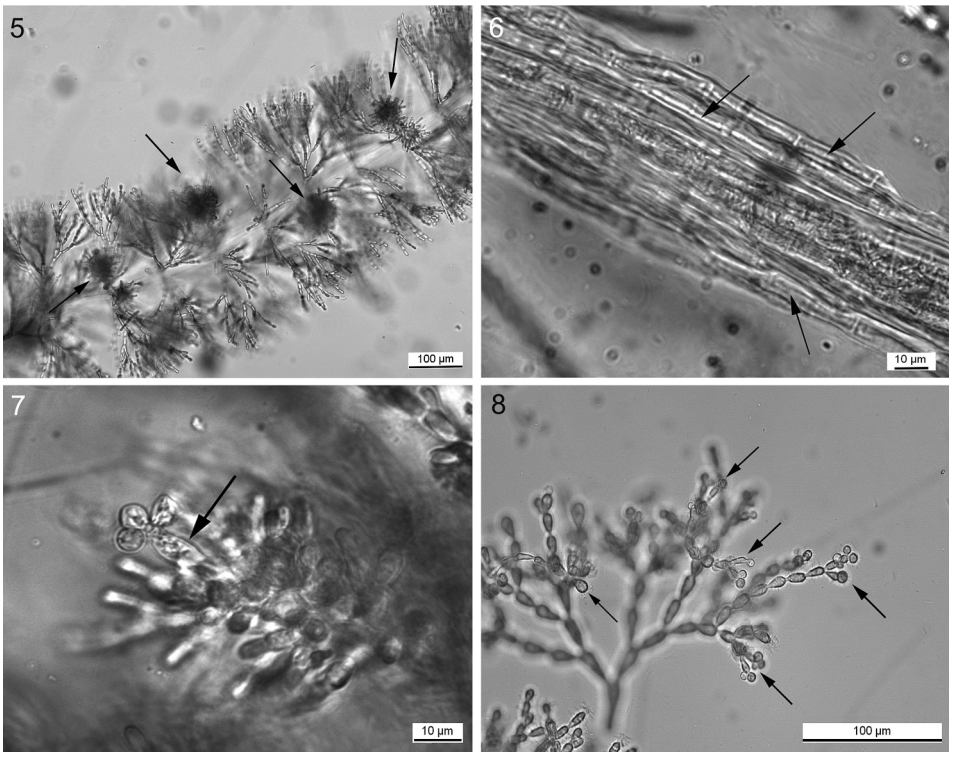
Figs 3-4. *Lemanea sudetica.* **3.** Details of the basal zone. **4.** Portion of one filament showing irregular spermatangial patches (arrows).

Lemanea sudetica Kützing

Lemanea sudetica is a rare species and it was collected only from a few locations in Europe: in Mount Sudete, type locality (Kützing, 1845), in Romania as *L. daldinii* Rabenhorst (Caraus, 2002) and in Switzerland and Poland as reported by Kumano (2002) and Kwandrans & Eloranta (2010) who, however, give no indication about sampling localities. *Lemanea sudetica* was also reported for Northern Italy by De Toni (1897), even if with some doubts.

Our samples of *L. sudetica* was from the Cerfone River (see Table 1). The plants are brownish in colour and show filaments branched, 1.8-2.3 cm long and up to 700 µm in diameter, gradually narrowed towards the base (Fig. 3). The apexes are squat and thick as well as the filaments. They show as distinguishing characteristic spermatangial patches and irregularly distributed on the branches (Fig. 4).

L. sudetica was found on stones, in fast-flowing, clear, quite warm and oxygenated waters with scarce nutrients, especially ammonia ions and nitrates (Table 1). This finding is the first report with confidence of *L. sudetica* for rivers of Central Italy.



Figs 5-8. *Batrachospermum gelatinosum* **5.** Whorl barrel-shaped containing carposporophytes (arrows). **6.** The cortication of main axis with only cylindrical cells (arrows). **7.** Fertilized carpogonium with fusiform trichogyne (arrow) and attached spermatia. **8.** Terminal spermatangia (arrows) on fascicles.

Batrachospermum gelatinosum (Linnaeus) De Candolle (1801) *emend.* Vis *et al.*

Batrachospermum gelatinosum was probably reported for the first time in Italy by Arcangeli & Mori at San Giuliano in Province of Pisa (Arcangeli, 1882) (as *B. moniliforme* Roth. var. *pisanum* Arcangeli) and then by Mattel (1888) (as *B. moniliforme* Roth. var. *eonfasum* Haas.) who observed some samples of this species in the De Notaris's Herbarium on freshwater algae of the Val Intrasca (Northern Italy). Dell'Uomo (1970) recorded *B. gelatinosum* (as *B. moniliforme*) in springs of the Potenza River and in its tributaries in Central Italy, affixed mainly to stones. He also confirmed the presence of the species in the upper stretches of central Apennine streams (Dell'Uomo, 1981). Del Grosso & Pogliani (1977) found *B. gelatinosum* in springs near L'Aquila (Central Italy), while, more recently, Cantonati (2008) reported it in springs of the Dolomiti Bellunesi National Park (Northern Italy).

Our samples of *B. gelatinosum* have mucilaginous filaments, greatly branched, up to 6 cm long, violet to brownish in colour, with barrel-shaped whorls containing numerous carposporophytes (Fig. 5). The thalli are monoecious. The cortication of the main axis is formed only by cylindrical cells (Fig. 6). The carposporophytes are spherical, scattered within the whorl at various distances

from the axis. They are pedicellate, 70-90 µm in diameter and constituted by a compact mass of gonimoblast filaments. The fertilized carpogonia show fusiform trichogynes, 6-8 µm in diameter (Fig. 7). The spermatangia are terminal on fascicle (Fig. 8). The carpospores germinate into a *Chantransia* stage, which consists of short and erect filaments.

B. gelatinosum was recorded only in stations of the upper and middle stretches of the Aniene River, on stones of the riverbed (Table 1). The species was found in stations with moderately flowing, cool, clean and well-oxygenated waters. These stations are also characterized by low conductivity and trophy. Some authors describe populations of *B. gelatinosum* under similar environmental conditions (Dell'Uomo, 1970, 1981; Carmona *et al*., 2004). However, this red alga was reported from many sites throughout Europe and North America and probably can tolerate a wide variety of water conditions.

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