

A significant northward extension of the area of *Aloina bifrons* in Europe (Bryophyta, Pottiaceae)

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Abstract – *Aloina bifrons* (De Not.) Delgad. is recorded for the first time in France in the Limagne, Puy-de-Dôme department, Auvergne region. This is a significant northward extension of the species' known range. It grows there on sunny marlaceous lime with gypsum traces on a south-facing steep slope. The French habitat differs significantly from the situation recorded in other parts of the Mediterranean and Irano-Turanic areas, where *Aloina bifrons* is a typical inhabitant of gypsum soils with a rich assemblage of Xeropottioid elements.

Mosses / ecology / distribution / gypsum / conservation

INTRODUCTION

Aloina bifrons (De Not.) Delgad. is a bipolar species. In the Southern hemisphere it has a scattered distribution and is reported from Chile (Weber, 1979), South-Africa (Magill, 1981; O'Shea, 2006), Australia (Catcheside, 1980) and New Zealand (Fife, 1995). It is much more widespread in the Northern hemisphere, where it is mentioned from North America (Gallego *et al.*, 1999; Delgadillo, 2007), Central America (Delgadillo, 1975, 1994), South-Western Asia (Kürschner & Frey, 2011; Ros *et al.*, 2013), Northern Africa (Ros *et al.*, 1999, 2013) and Southern Europe (Gallego *et al.*, 1999; Ros *et al.*, 2013), including southern Russia (Dagestan, Fedosov, 2010). The latter author provides also a map of its worldwide distribution. It appears to be a rare element of the bryoflora of Southern Europe as it is only mentioned in Spain and Sardinia [Italy] (Ros *et al.*, 2013). The records from Hungary (Düll, 1984, 1992) are erroneous (Erzberger & Papp, 2004).

MATERIAL AND METHODS

A survey of the bryoflora in the Limagne (Puy-de-Dôme department, Auvergne region, France) was carried out. Pottiaceae is a family of special interest in Limagne because of the occurrence of a wide variety of geologic substrates and climatic characteristics. Volcanic and sedimentary outcrops are particularly rich and were the subject of our study.

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The Limagne is a large flat plain stretching 90 km long along Allier valley, east to Clermont-Ferrand, Puy-de-Dôme department. It is bounded by the granitic plateau on which volcanoes are settled to the west and by monts du Forez to the east. The landscape is dotted with rocky extrusions and plateau of volcanic origin. The climatic characteristics of the Limagne are marked by some continental features. The North-South oriented mountains located to the west (locally known as “Chaîne des Puys”) form a wall to oceanic perturbations and are responsible for the relative aridity of the Limagne. The locality where *A. bifrons* were gathered is recognized as one of the driest of France with precipitation less than 600 mm/year.

All the samples were collected by the authors and are deposited in the bryological herbarium of the Conservatoire Botanique National du Massif Central. Nomenclature of mosses follows Ros *et al.* (2013).

RESULTS

A significant number of *Pottiaceae* species were found during our surveys. Among the interesting species collected in the studied area, *Aloina bifrons* (De Not.) Delgad. turned to be one of them, being a new report for the bryophyte flora of France.

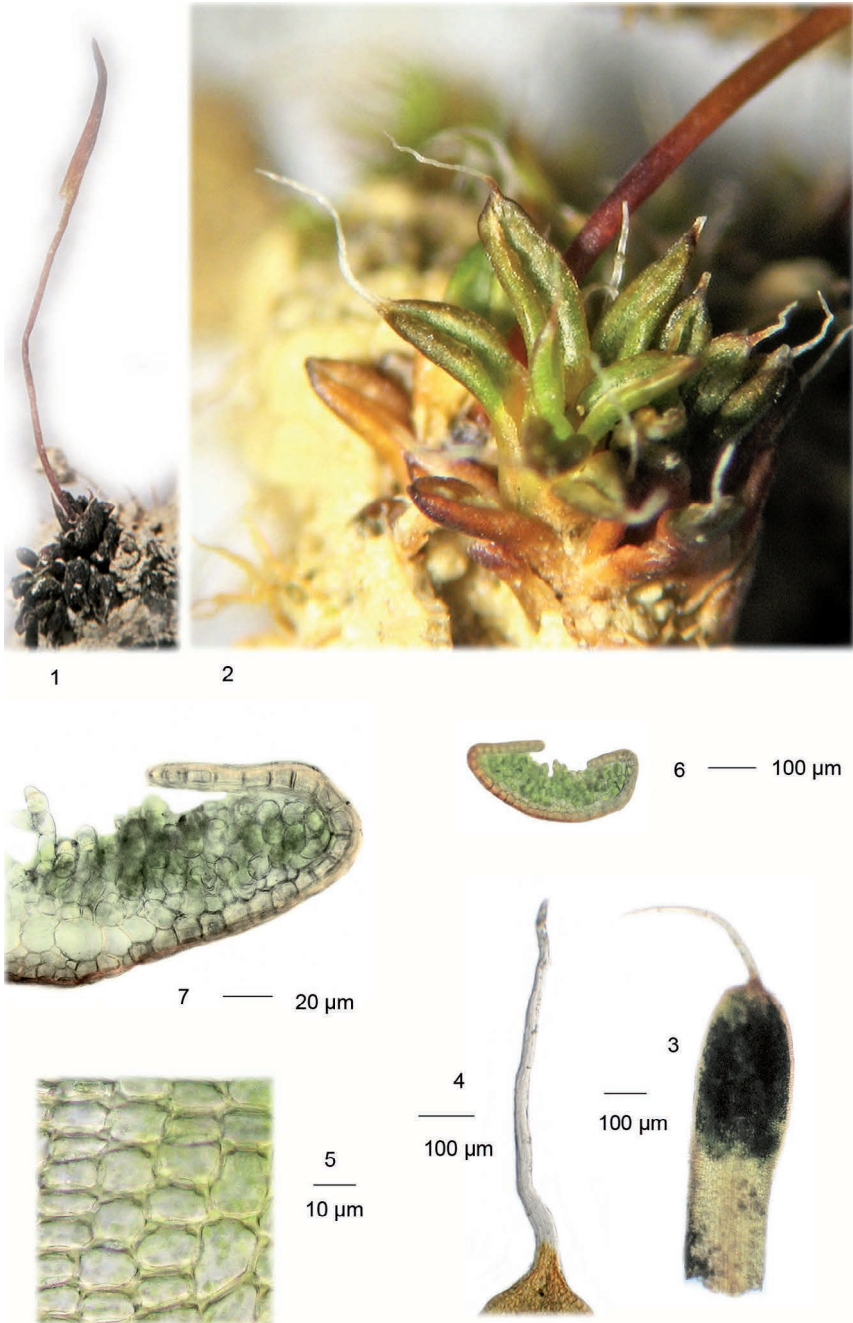
FRANCE. Auvergne region, Puy-de-Dôme department, Montpensier, 434 m a.s.l., 46° 02' 07,0" N; 3° 13' 05,8" E, Hugonnot, 11 January 2014, Herbarium Conservatoire Botanique National du Massif Central, n. 6113.

Aloina bifrons was growing almost totally embedded in granular limestone (marlaceous lime) with gypsum seams, leaving only a bunch of apical piliferous leaves to emerge from the substrate (Figs 1-2). The individuals were widely and regularly spaced and formed loose colonies. Immediate associates included: *Acaulon triquetrum* (Spruce) Müll. Hal., *Bryum argenteum* Hedw., *Bryum dichotomum* Hedw., *Didymodon cordatus* Jur., *D. rigidulus* Hedw., *D. vinealis* (Brid.) R.H. Zander, *Pterygoneurum ovatum* (Hedw.) Dixon, *Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr var. *ruralis* and *Tortula lindbergii* Broth. Other species not directly associated with *Aloina bifrons* were: *Barbula unguiculata* Hedw., *Microbryum davallianum* (Sm.) R.H. Zander, *M. floerkeanum* (F. Weber & D. Mohr) Schimp. Whereas the marlaceous lime outcrop reaches a surface of roughly 100 m², the *Aloina bifrons* population occupies less than 2 m² in two patches of approximately the same size.

Male and female gametophytic individuals and immature sporophytes could be observed. In February 2014, five mature and well conformed sporophytes could be spotted whereas approximately 20 abortive sporophytes were found. The great majority of individuals were totally sterile.

DISCUSSION

The genus *Aloina* consists of 6 taxa in France from which only *Aloina aloides* (Koch ex Schultz) Kindb. and *A. ambigua* (Bruch & Schimp.) Limpr. are known in Auvergne region (Hugonnot & Celle, 2013). *Aloina bifrons* is a



Figs 1-7. Habit photographs and LM micrographs of *Aloina bifrons* (De Not.) Delgad. from France (all from n. 6113 in herbarium of Conservatoire Botanique National du Massif Central). **1-2.** Habit. **3.** Phyllidium; **4.** Piliferous apex of phyllidium; **5.** Areolation in the basal half of phyllidium; **6-7.** Transverse section of phyllidium in the middle part.

remarkable addition to the Auvergne bryoflora since the genus is locally poorly represented. Within the genus *Aloina*, the identification of *A. bifrons* is very easy owing to the presence of a long hyaline hairpoint, which is missing in all other European species. *Aloina bifrons* may have a strong superficial resemblance to species belonging to the genera *Crossidium* and *Pterygoneurum* due to the small plants with long hair points being buried in substrate, then could be difficult to tell apart. *Aloina bifrons* is characterized by a succulent-fleshy habit, a poorly differentiated flat nerve in transverse section, occurrence of filaments over the lamina, the pad of filaments being encapsulated by strongly infolded margins and strongly incurved phyllidia (Figs 1-7). By contrast, *Crossidium* and *Pterygoneurum* species are not especially fleshy plants and have clearly differentiated semicircular nerve in transverse section. The leaf margin in *Crossidium* species is never strongly infolded and the filaments are never over the lamina, but are located on the nerve. *Pterygoneurum* species bear distinct lamellae over the nerve.

All species of the genus *Aloina* are adapted to xeric conditions and are typical elements of arid climates (Gallego *et al.*, 1999). In Europe, they are mostly well represented in the Mediterranean region. Several species extend significantly northwards, *A. brevirostris* (Hook. & Grev.) Kindb. reaching 83°N in the Arctic (Brassard, 1971). On the contrary *A. bifrons* was not known to occur in Europe farther North of Catalan countries. Then the locality of Limagne represents a remarkable extension range of approximately 450 km and demonstrates that the species penetrates the temperate zone. The locality appears very isolated since it is the only one recorded in France.

Aloina bifrons is known from sunny sandy soil or soil over limestone in dry areas at moderate elevations in North America (Delgadillo, 2007) and is reported from semiarid steppes of Northwestern North America (McIntosh, 1989). The ecology appears to be quite similar in Mexico where it grows on dry, sandy soils among rocks (Delgadillo, 1994). The ecological requirements and sociology of the species have received much attention in North Africa (Pócs, 2007), Israel, Jordan and the Judean desert (Frey *et al.*, 1990; Brullo *et al.*, 1991; Frey & Kürschner, 1992) and Spain (Ros & Guerra, 1987; Cano *et al.*, 1997). Ros & Guerra (1987) proposed to erect a new syntaxon at order level (*Tortulo brevissimae-Aloinetalia bifrontis* Ros & Guerra 1987 *nom. inval.*) which was not subsequently accepted in Marstaller (2006) but considered a synonym of *Barbuletalia unguiculatae* v. Hübschmann 1960. On the contrary the Alliance *Aloino bifrontis-Crossidium crassinervis* Ros & Guerra *ex* Marstaller in Marstaller 2006 was accepted in Marstaller (2006) and corresponds to soil-dwelling Mediterranean and Irano-Turanic bryophytic communities which grow under arid or semiarid climate. *Aloina bifrons* together with other Pottiaceous taxa as *Acaulon casasianum* Brugués & H.A. Crum, *Crossidium crassinerve* (De Not.) Jur., and *Tortula brevissima* Schiffn., are considered character species of this vegetation unit. The *Acaulo triquetri-Tortuletum brevissimae* Ros & Guerra 1987 is the holotypus. Most included associations are typical of low rainfall climatic regimes (often 100-150 mm/year), steep slopes, on non compacted marlaceous lime or gypsum and well protected from direct insolation (north facing or shaded by superior vegetation) (Ros & Guerra, 1987; Frey *et al.*, 1990; Brullo *et al.*, 1991; Frey & Kürschner, 1992; Cano *et al.*, 1997) and are not present in the study area. At least 8 bryosociological associations are known to host *Aloina bifrons*, among which *Aloino bifrontis-Tortuletum atrovirentis* Brullo *et al.* 1991 and *Crossidium squamiferi-Aloinetum bifrontis* Pócs 2007 are the most significant because *Aloina bifrons* is considered to be a character species in these two associations. Interestingly, Montpensier site is a unique example of south-facing gypsum

outcrop in the Limagne and the fact that it hosts an isolated population of one gypsum-dwelling *Aloina* reinforces its interest.

The life-form of *Aloina bifrons*, with the greatest part of plant buried in soil and emerging hair-points, is considered to be adaptive (Pócs, 2007) and together with the occurrence of encapsulated adaxial filaments are referred to the Xeropotoid life syndrome (Frey & Kürschner, 1988). Although sharing a marked physiognomic similarity (the steep slope, the life-form, the limestone substrate) the ecological context is significantly different in France compared with that observed in the main part of the species' range. None of the mosses considered characteristically associated with *Aloina bifrons* is recorded in the Limagne locality. This species colonizes there one of the driest and sunniest area of the entire region, which should be considered as an ecological refugium at the northern limit of its range.

The substrate, made of very erodible material, implies that the species is compelled to move from one suitable micro-site to the other with a periodicity which is difficult to determine with accuracy but which is certainly relatively short due to the strong winter frosts. Since gemmae or tubers are unknown in *Aloina bifrons* (Gallego *et al.*, 1999), the reproductive investment is likely to be mostly sporal, involving fecundation events. The species is dioicous and male and female individuals were observed locally which means that the sexual reproduction is theoretically possible. In fact sporophyte embryos were found in January but they were in very poor condition, made of only dry seta and barely discernible theca, reflecting abortion. Later in the year, in February, mature sporophytes were very few but produced apparently viable spores. The majority of sporophytes aborted at an early stage of development. Pronounced winter drought may explain why sporophytes frequently fail to produce spores. Then spore formation likely experiences considerable variations from year to year. This makes *A. bifrons* a very threatened species in Auvergne especially since erodible limestone outcrops are of very rare occurrence there and are threatened by human activities (eutrophication, urbanisation, quarries...). An aggravating factor is the small size of the colony, reaching a total of less than 2 m². The origin of the species is impossible to trace without the implementation of molecular methods. An ancient origin cannot be ruled out because of the current lack of reproductive dynamism of the species and the strong isolation of the locality. The relic status hypothesis of the species deserves to be tested using modern methods which could also uncover unsuspected genetic originality due to a long isolation period. An alternative origin would be a long-distance colonization event due the small size of the spore which makes them good candidates for wind-transport.

The new record of *Aloina bifrons* and the cooccurrence of rare and locally threatened taxa like *Acaulon triquetrum* (CR in Auvergne), *Didymodon cordatus* (VU), *Microbryum davallianum* (CR), *M. floerckeanum* (not previously recorded in the region) or *Pterygoneurum ovatum* (CR) (Hugonnot & Celle, 2013) underlines the importance of more detailed studies of the dry areas of mostly very humid Auvergne.

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