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Research Article

Vaucheria (Heterokontophyta, Vaucheriaceae) from the Maltese Islands (Central Mediterranean)

J. Henwood[*1], **E. Lanfranco**[2], **R. Merritt**[3]
[1] *Independent Researcher, Mosta, Malta*
[2] *Institute of Earth Systems, University of Malta, Msida, Malta*
[3] *Independent Researcher, Morecambe, Lancashire, UK*

Abstract. The *Vaucheria* species list of the Maltese Islands is reviewed based on literature and collected material. Since many collections were sterile, culture was necessary for identification. Eleven species of *Vaucheria* have been found from saline and freshwater habitats, including several additions to previous lists, namely *Vaucheria cruciata*, *Vaucheria dillwynii*, *Vaucheria longicaulis*, *Vaucheria pseudogeminata* and *Vaucheria synandra*. In addition, *Vaucheria mulleola* was recorded again. Several other past records remain unidentified.

Keywords: Vaucheria, wetlands, algae.

1 Introduction

Vaucheria (Division Heterokontophyta, Class Tribophyceae) is a notable component of wetland flora frequently encountered in damp substrates in freshwater, marine, brackish water and terrestrial habitats (John et al., 2002). Rieth (1980) lists 32 species from Europe, many with world-wide distributions. It has been given widespread attention as in Cambro (1992), Calvo & Bárbara (2004), Christensen (1973, 1987), Entwisle (1988), Nemjová & Kaufnerová (2009), Schneider et al.(1993) and Woronin (1869).

There are very few in-depth published algological studies, such as (Henwood, 2004, 2006), in the Maltese Islands and therefore knowledge of Malta's non-marine algal flora is rather late in coming. The basic text outlining the Maltese species of algae is Sommier and Caruana Gatto, (1915) with subsequent records given by Lanfranco (1967), Lanfranco (1969) and Lanfranco (2002). Within these records, mention of *Vaucheria* is sparse, although it has been occasionally noted in saline wetlands, estuarine channels, coastal rockpools, valleys (both temporarily and permanently flooded) and cupular rockpools in karst habitats.

Traditional taxonomy of the genus *Vaucheria* is based on morphology of their reproductive structures. The difficulty in identifying *Vaucheria* populations to species level in nature is based on findings of sterile filaments. *Vaucheria* are composed of siphonous, multinucleate tubes filled with huge vacuoles and parietal, disc-shaped chloroplasts, usually without pyrenoid. Members of the genus propagates asexually by synzoospores, aplanospores and akinetes, whereas sexual reproduction takes place by oogamy with individual species being dioecious or monoecious and with the reproductive structures on the same short stalk (gametophore), or individually on the tube.

The aim of the present report is to compile a species list for *Vaucheria* in the Maltese Islands. This has been done through critical review of published records, namely (Lanfranco, 1967, 1969, 2002; Sommier & Caruana Gatto, 1915), and carrying out of field surveys between 2004 and 2022.

2 Materials and Methods

The Maltese Islands, located in the Central Mediterranean region, are characterised by numerous inland freshwater systems (such as ephemeral valley waters and cupular rockpools) and coastal habitats (such as lagoons, rockpools and estuaries). The semi-arid climate makes these systems predominantly temporary, though freshwater springs or sea water infiltration may prolong flooding to various degrees and vary their salinity. Only a small proportion of wetlands, both coastal and inland are therefore permanent.

Table 1 lists the areas where *Vaucheria* records have been noted in literature. It also notes the locations for

Correspondence to: J. Henwood (jonathan.henwood@gmail.com)

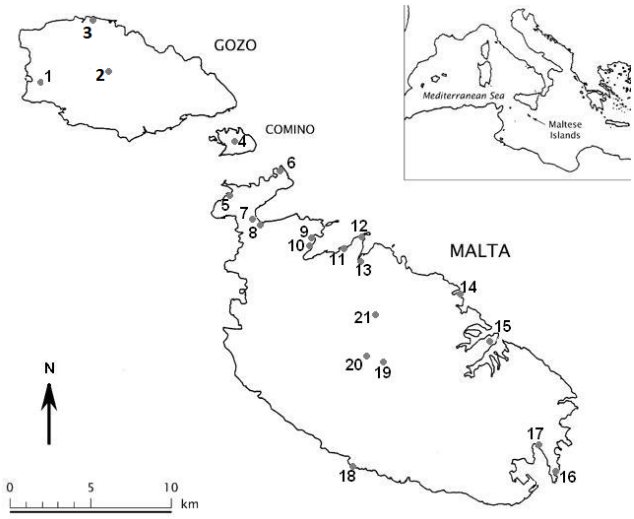

Figure 1: Location of sampling (not for interpretation).

collection of fresh material from substrata. The predominant habitat of each site is also noted in Table 1. Figure 1 depicts the general location of the sampling points.

Collected material was preserved in a moist state at 5-15°C for microscopical examination at x10- x400, in which case the field collections were examined for the presence of gametangia. Characteristic features were noted. Material without gametangia was cultured *in vitro* for a short period of time (Schneider et al., 1993) until fruiting was observed, thus enabling identification.

Voucher specimens have been deposited in the collections of JH (CJH), EL (CEL) and RM (CRM).

3 Results

Species list The following species were recorded from literature and field studies.

Order Vaucheriales

Family Vaucheriales

1. ***Vaucheria cruciata*** (Vaucher) de Candolle in Lamarck *et* de Candolle 1805 Fig. 2b

Local Record: None.
Material examined: Salina salt pans (10.12.2004, CJH) from damp substratum forming dense mats.

2. ***Vaucheria dichotoma*** (L.) Martius 1817 Fig. 2c

Local Record: Collected by Adrian Mallia (7.1992; CEL) from Qawra and from Kalanka t-Tawwalija by Sylvana Buttiġieġ (11.1992; CEL) from a depth of 5m.
Material examined: Dense mats were recorded at Salina estuary and the adjacent saltpans (06.03.2005; CJH). Also recorded at Għadira (17.01.2005 CJH) and Għadira ż-Żgħira (04.02.2005; CJH) as dense floating masses. Dense mats were recorded from il-Ponta tar-Reqqa (22.02.2009; CJH) mixed with *V. synandra*.

3. ***Vaucheria dillwynii*** (Weber *et* Mohr) Agardh 1812 Fig. 2d

Local Record: None.
Material examined: Collected from Salina salt pans from damp soil (10.12.2004, CJH). Also recorded from damp soil at Magħluq ta' Marsaxlokk (02.12.2004; CJH), il-Qaliet pools (04.02.2005; CJH) and Għadira (14.03.2005; CJH).

4. ***Vaucheria geminata*** (Vaucher) de Candolle in Lamarck *et* de Candolle Fig. 2e

Local Record: First recorded by Lanfranco (2002) from samples collected from Wied Guno (Gozo) in pool along the valley (07.12.1999; CEL). Material was also collected from damp soil in Buġibba on 17.01.2000 by Roy Merritt.
Material examined: Material was collected from Magħluq ta' Marsaxlokk (02.12.04; CEL) on damp substratum and Għadira (15.12.2004 CEL). The valley in the Qattara area yielded dense mats (21.03.2005; CEL) in a freshwater stream. Magħluq and Għadira within the lagoon yielded aerial specimens (22.10.2022; CJH).

5. ***Vaucheria longicaulis*** Hoppaugh 1930 Fig. 2f

Local Record: None.
Material examined: Recorded in Magħluq area (23.10.2022; CJH) from damp soil.

6. ***Vaucheria mulleola*** Skuja 1964

Local Record: Material was collected from a pond at Buġibba by Roy Merritt (17.01.2000; CRM).
Material examined: Recorded in Salina salt pans (10.12.2004; CRM) from damp soil.
Distribution: This species was originally described from the Swedish Lapland (Skuja, 1964) and seems to have been successively recorded only in the Maltese Islands.

7. ***Vaucheria pseudogeminata*** Dangeard 1939 Fig. 2g

Local Record: None.
Material examined: Collected in Salina salt pans (10.12.2004; CRM) from damp soil mixed with other *Vaucheria* sp. Recorded at Mistra stream and Ta' Qali (10.12.2004; CRM). Fertile siphons were detected on damp substratum at il-Magħluq ta' Marsaxlokk (02.12.2004; CJH).

Fig. 1 ref.	Site Name	Habitat type (salinity)	Coordinates (when sampled)	Sampled year, source, record
1	Wied Ġuno/ Qattara[1]	freshwater course and pool	36°3'3.71"N 14°11'32.46"E	2006, Lanfranco (2002)
2	Wied is-Seqer[1]	freshwater course	/	CEL
3	Il-Ponta tar Reqqa	valley leading to rocky coast	36°4'53.14"N 14°14'10.49"E	2009
4	Kemmuna[1]	rocky coast	/	CEL
5	Ta' Qassisu	saline pool (∼34)[2]	35°58'53.31"N 14°19'46.06"E	2004-2005, 2015
6	Daħlet ix-Xmajjar[1]	rocky coast	/	CEL
7	Għadira	saline lagoon (30-40)[2]	35°58'12.32"N 14°20'53.25"E	2004-2005
8	Għadira ż-Żgħira/ il-Ħofra	saline pool (∼30)[2]	35°57'59.12"N 14°21'6.82"E	2004-2005
9	Mistra	freshwater course meeting coast	35°57'27.58"N 14°23'21.95"E	2005
10	Rdum Irxawn[1]	rocky coast	/	CEL
11	Buġibba[1]	rocky coast and rockpools	/	Lanfranco (2002)
12	Qawra[1]	rocky coast and rockpools	/	CEL
13	Salina[1]	estuary (∼33)[2]	35°56'39.73"N 14°25'14.71"E	2004
14	Il-Qaliet pools	rocky coast and rockpools	35°55'24.34"N 14°29'37.51"E	2006
15	Valletta[1]	terrestrial	/	CEL
16	Kalanka t-Tawwalija[1]	rocky coast	/	CEL
17	Il-Magħluq ta' Marsaxlokk	saline lagoon (∼32)[2]	35°50'20.63"N 14°32'55.79"E	2005, 2022
18	Għar Lapsi[1]	rocky coast	/	CEL
19	Attard[1]	freshwater pools	/	CEL
20	Ta' Qali[1]	freshwater pools	/	CEL
21	Wied il-Għasel	freshwater course	35°55'4.55"N 14°25'37.41"E	2010, 2016

Table 1: Location name in map and habitat type. [1]Indicates old record at CEL- material deposited in collection of EL. [2]Salinity is shown in Practical Salinity Units (PSU) as per Henwood (2006).

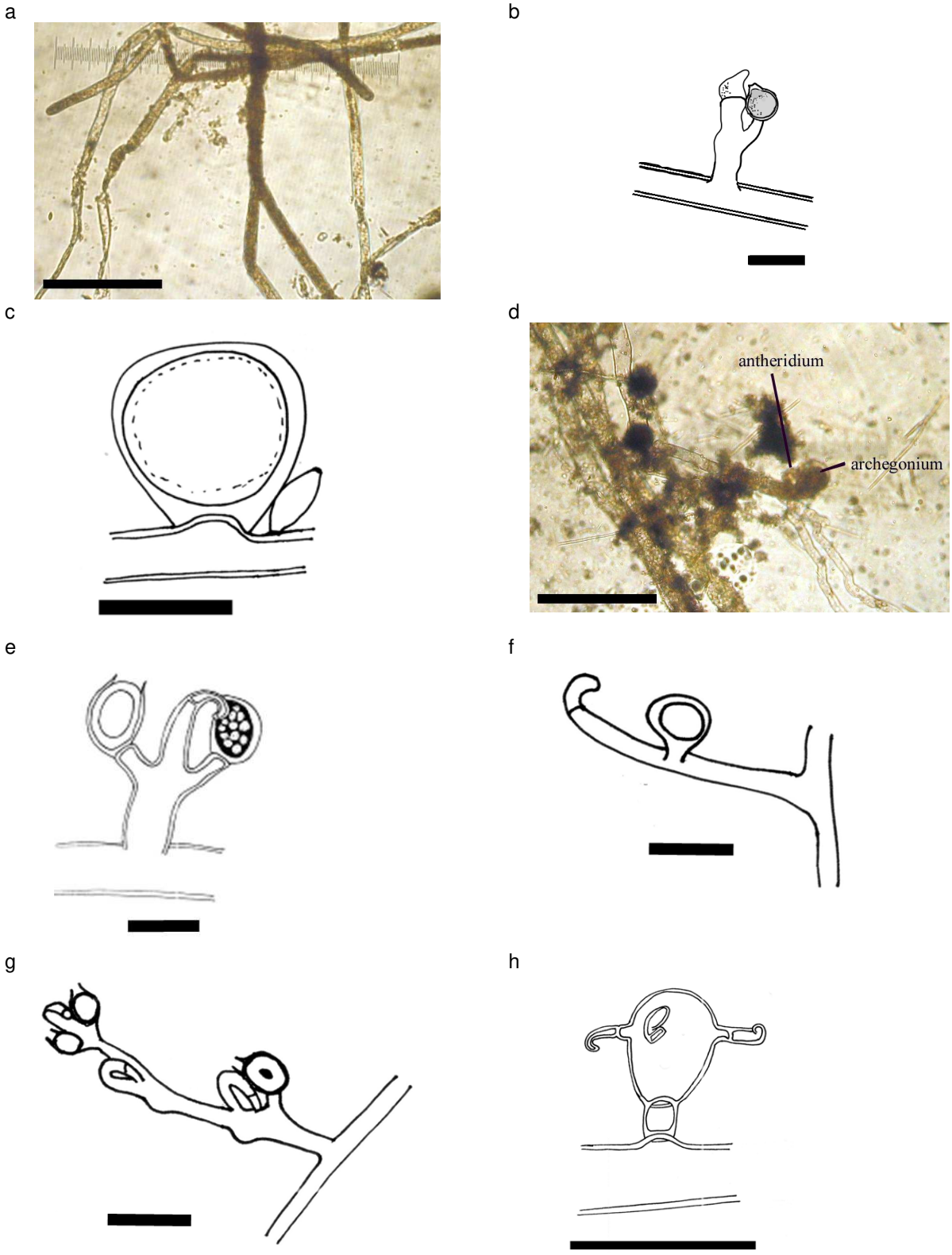

Figure 2: Plate showing specimens identified by corresponding author with scale bar of length 100µm: a. specimen as sterile siphonous filaments found within wrack, b. *Vaucheria cruciata*; c. *Vaucheria dichotoma*; d. *Vaucheria dillwynii*; e. *Vaucheria geminata*; f. *Vaucheria longicaulis*; g. *Vaucheria pseudogeminata* ; h. *Vaucheria synandra*.

8. ***Vaucheria sessilis*** (Vaucher) de Candolle in Lamarck *et* De Condolle 1805

Local Record: Recorded by Sommier & Caruana Gatto (1915), in freshwater (location not mentioned in record).
Material examined: None.

9. ***Vaucheria synandra*** Woronin 1869 Fig. 2h

Local Record: None.
Material examined: Fruiting siphons were collected Għadira reserve (03.2005; CEL). Dense fruiting mats were recorded from il-Ponta tar-Reqqa (22.02.2009; JH) mixed with *V. dichotoma*.

10. ***Vaucheria terrestris*** (Vaucher) De Candolle 1805

Local Record: Recorded by Sommier and Caruana Gatto (1915) from Valletta and Attard.
Material examined: None.

11. ***Vaucheria verticillata*** Meneghini 1837

Local Record: None.
Material examined: Collected from a pond in Buġibba (17.01.2000; CRM).

Doubtful species

12. ***Vaucheria repens*** Hassall 1843

Local Record: Recorded by Sommier & Caruana Gatto (1915) in fresh and brackish water from Imtaħleb.
Considered by many authors to be a form of *V. sessilis* named *V. sessilis* f. *repens* (Hassall) Hansdirg (see Venkataraman, 1961). Christensen (1987) places it as a synonym of *V. bursata*. This little-known species is therefore regarded as doubtful.
Material examined: None.

Other records Other records of unidentified *Vaucheria* species exist. A description of each record is given below.

- Għar Lapsi: (09.1992; CEL)
- Kemmuna (southern coast: (10.1992; CEL))
- Daħlet ix-Xmajjar: Recorded with *Jania corniculata* and *Cystoseira* (11.1992; CEL)
- Wied is-Seqer (Gozo): (10.01.1993: CEL)
- Rdum Rxawn: Several species recorded (08.1993; CEL)
- Ta' Buleben (Qawra): *Vaucheria* spp. Mixed with microepiphytes, most notably *Lyngbya rivulariorum* (7.1992; CEL)
- Wied il-Għasel: Material collected from freshwater was scanty and did not yield fruiting bodies (10.02.2005; CJH)
- Ta' Qassisu pool: Mixed with *Cladophora* sp. Material was abundant but did not yield fruiting bodies (28.02.2005; CJH)

4 Discussion and Conclusions

The checklist includes 12 species of which the following 5 are new records collected from field surveys: *V. cruciata*, *V. dillwynii*, *V. longicaulis*, *V. pseudogeminata* and *V. synandra* and other species are recorded in literature for the first time. One species is considered doubtful.

The collection sites covered the major coastal wetlands in the Maltese Islands. These were the only areas where dense turfs and mats of *Vaucheria* were noted. For example, notable turfs were examined at il-Ponta tar-Reqqa, a relatively isolated and undisturbed coastline which is flooded through surface runoff from the hinterland. Comparatively, inland areas such as temporary freshwater rockpools, though studied in detail (Henwood, 2004) did not yield any *Vaucheria* specimens. Similarly, few records of *Vaucheria* species in inland freshwater habitats occur.

When comparing the number of species with the sampling location, it is noted that the majority of species have been recorded from the largest coastal wetland in Malta- Salina and Għadira (5 species each) and Magħluq (4 species). The prolonged flood period in these sites, with differing salinity recorded at Għadira and Magħluq (Henwood, 2006) contributes to formation of dense mats of *Vaucheria*. Similarly in the salt pans at tar-Reqqa, influx of sea water and surface freshwater runoff allow prolonged flooding in a depression of circa 1 metre depth and the formation of dense mats of *V. dichotoma* and *V. synandra*, both marine species according to Guiry & Guiry (2022). The prolonged hydroperiod allows for formation of dense mats and co-occurrence with a dense population of *Ruppia drepanensis* Tineo ex Guss, a similar situation to Għadira and Magħluq.

Of the species recorded, *V. dichotoma*, a predominantly marine species, is the most widespread in the local scenario. However, a most interesting record is that of *V. mulleola* at Salina by one of the authors, which confirmed a previous unpublished sighting by the same author. This species has only been previously recorded from the Swedish Lapland and Australia. The direct connection of these sites with Malta is doubtful although records of migratory birds between Malta and Sweden exist.

In general, although the data collected is on the increase, the catalogue of species is prone to enlargement. In particular, the freshwater *Vaucheria* species of the Maltese Islands needs further investigation and the zonation patterns of *Vaucheria* along estuarine regions should be studied. In particular, in view of the temporary nature of freshwater systems in the Maltese Islands, culturing through rehydrated samples such as in Dunphy et al. (2001) would aid in identifying any propagules and species present in substrate.

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