Chapter 51
Chara virgata

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Scientific name: *Chara virgata* Kütz. in Flora 17: 705. 1834

Lectotype (Wood, 1965: 184): Güderott-Moor near Boren/1833 Jun. 17/[no collector] (L 820940); see Fig. 51.1.

≡ *Chara globularis* Thuill. var. *virgata* (Kütz.) R. D. Wood in Taxon 11: 10. 1962, n. inv.

= *Chara diffusa* Lilj. var. *annulata* Wallman in Lilj., Utkast Sv. Fl., ed. 3, 684. 1816
Type not designated.

≡ *Chara virgata* Kütz. var. *annulata* (Wallman in Lilj.) N. F. Stewart & J. A. Bryant in J. A. Bryant, N. F. Stewart & C. A. Stace in Watsonia 24: 206. 2002.

= *Chara delicatula* C. Agardh f. *bulbillifera* A. Braun ex Mig., Charac. Deutschl.: 755. 1897
Type not designated.

Nomenclatural note: Migula (1889–1897), Krause (1997) and many others named this taxon *Chara delicatula*. But as Agardh (1824) cited "*Chara delicatula* Desv. in Loisel., Not. Fl. France: 137. 1810" as a synonym of *Chara aspera*, this name belongs to *Chara aspera* (Wood, 1965).

Local names: BELARUSIAN: Харa вытанчаная; DANISH: Busket kransnål; DUTCH: Teer kransblad; ENGLISH: Delicate stonewort; ESTONIAN: Õrn mändvetikas; FINNISH: Sironäkinparta; FRENCH: Chara délicate; GERMAN: Feine Armleuchteralge; LITHUANIAN: Gležnasis maurabragis; NORWEGIAN: Skjørkrans; POLISH: Ramienica delikatna, RUSSIAN: Харa изящная; SWEDISH: Papillsträfse (Sweden); Spädsträfse (Finnland); UKRAINIAN: Харa витончена.

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Fig. 51.1 *Chara virgata*, lectotype at University of Rhode Island. A syntype can be found at the Leiden collection. Photographs: Joop van Raam

51.1 Morphology

See Figs. 51.2 and 51.3.

Habitus: The plants are small to medium size, fresh green to greyish green, unencrusted to slightly encrusted (Figs. 51.2 and 51.3a).

Size: The height of *Chara virgata* is usually between 5 and 15 cm but can be up to 30 cm. In deeper water the size can be up to 50 cm (van Raam, 1998).

Main axis: The main axis diameter ranges between 0.3 and 0.6 mm. The internodes are usually a bit longer than the branchlets, but occasionally twice as long and noticeably rough and encrusted with lime.

Cortex: *Chara virgata* is triplostichous and slightly heterostichous-tylacanthous (Migula, 1889–1897). Also true isostichous (Corillion, 1975) and definite tylacanthous (Langangen, 2007a) appearances have been described. The cells of the secondary rows are little more than half the diameter of the primary row cells (Fig. 51.3b,c).

Spine-cells: *Chara virgata* has small spine-cells which are solitary, papillate to spherical, rarely elongated and sometimes even missing (Corillion, 1975). See Figs. 51.2c–e and 51.3b, c.

Stipulodes: *Chara virgata* is diplostephanous, in the lower row the stipulodes are small and papillate, in the upper row they are mostly larger (up to 2 mm) and acute.

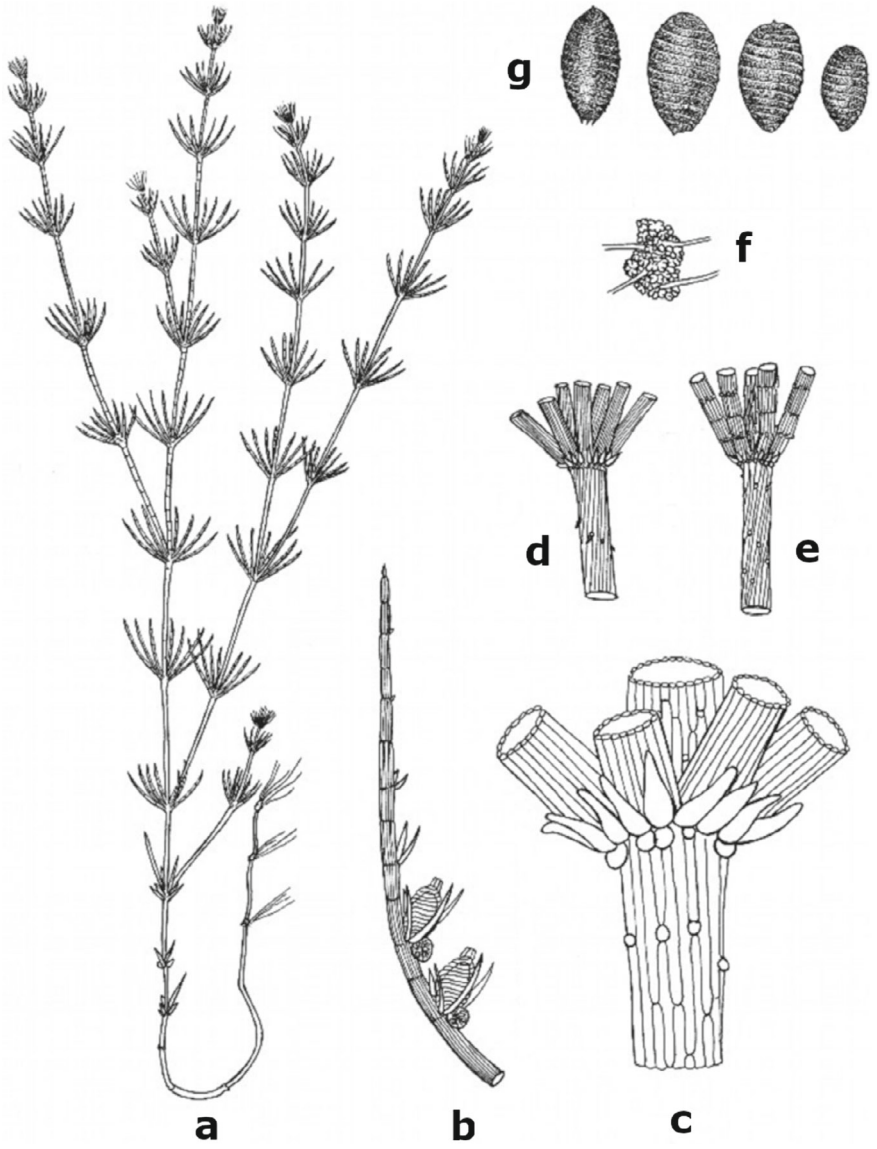

Fig. 51.2 *Chara virgata.* **a** Habitus; **b** Branchlet with two fertile nodes; **c–e** Axis with branchlet whorl; **f** Bulbils; **g** Oospores. Drawings after Werner Krause, modified by Dagmar Wassong in Weyer and Schmidt (2018)

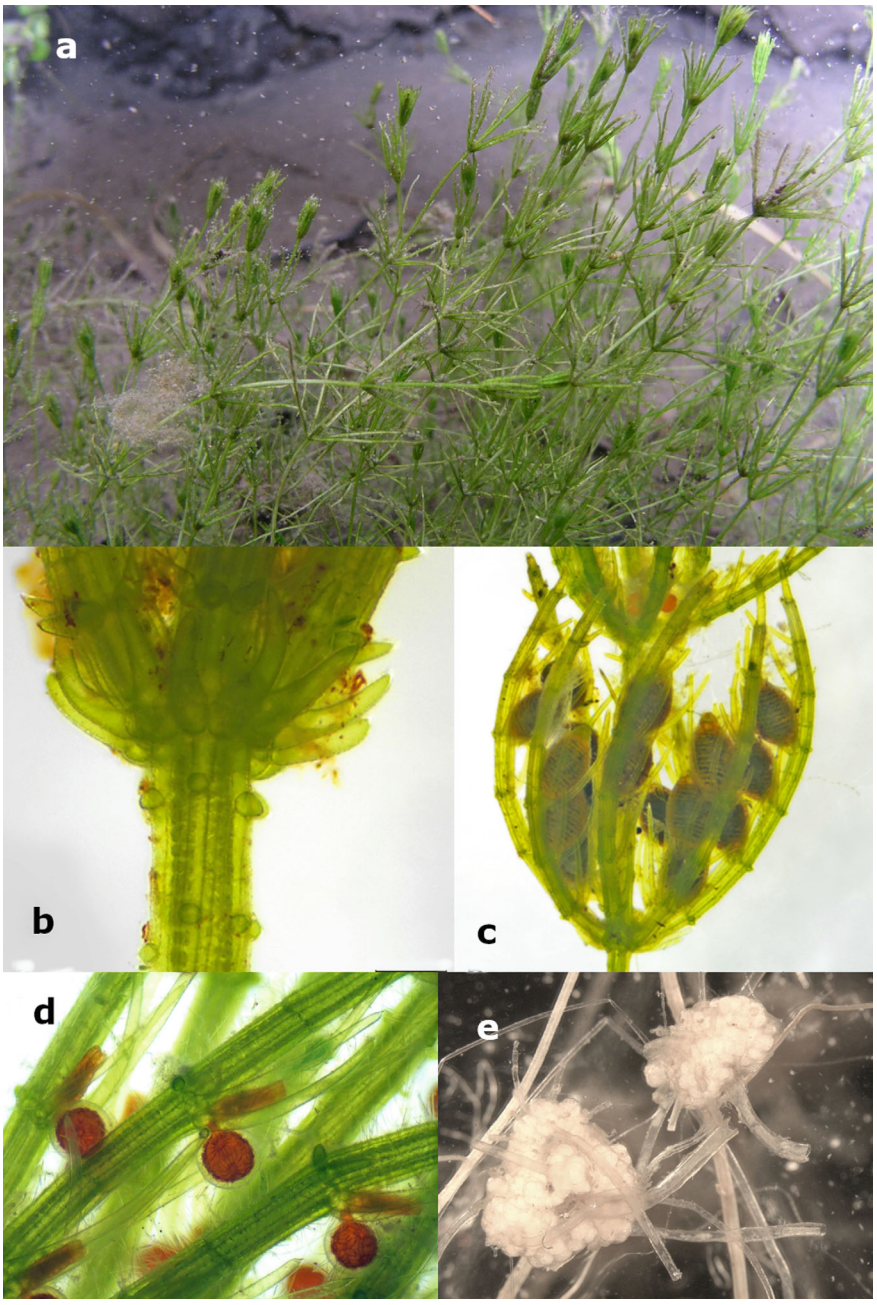

Fig. 51.3 *Chara virgata*, habitat appearance and details. **a** Typical appaerance in shallow water; **b** Stipulodes; **c** Fertile branchlets; **d** Branchlet detail with ripe antheridia and unripe oogonia; **e** Bulbils. Photographs: **a**—Klaus van de Weyer; **b**,**c**, **d**—Chris Carter; **e**—Emile Nat

Sometimes the stipulodes of plants in the same stand differ considerably. Both rows of stipulodes can be rudimentary or the stipulodes of the upper row can have different dimensions from papillate to elongated. Compare the nodes shown in Figs. 51.2c–e and 51.3b, c.

Branchlets: Whorls consist of 7–8(9) short branchlets, usually curved but they also can be stiff and standing out, with 5–9(11) segments, the upper 1–3 are ecorticated (Figs. 51.2a and 51.3b, c).

Bract-cells: *Chara virgata* develops 5–7 bract-cells per branchlet node. They are hardly formed on sterile plants, on fertile plants the adaxials are acuminate to about as long as the oogonium; the abaxials are usually rudimentary but occasionally developed. See Figs. 51.2b and 51.3d.

Bracteoles: 1–2 times as long as the oogonium. The length may differ even in one plant. See Figs. 51.2b and 51.3d.

Bractlets: As a monoecious species with conjoined gametangia, bractlets are missing.

Sexuality: *Chara virgata* is monoecious.

Oogonia: The oogonia are usually conjoined with antheridia at 1–3 lowest branchlet nodes. The oogonia are solitary. Data about quantitative morphometry are very different among between authors (see Table 51.1 and Fig. 51.2b).

Table 51.1 Oogonia morphometry

Authors	Length	Width	Coronula length	Coronula width	Number of helical stripes
Migula (1889–1897)	950	600	–	–	13–14
Groves and Bullock-Webster (1924)	750–1000	500–675	Variable	250	14–15
Corillion (1975, 1957)	750–1000	500–675	100–240	180–260	14–15
Wood 1(965)	700–900	550–600	150–210(225)	210–225(230)	12–14
Pal et al., (1962)	650–760	500–700	100–240	180–260	14–15
Hollerbach and Krassavina (1983)	750–1000	500–675	165–205	218–257	14–15(16)
Krause (1997)	750–1000	500–700	100–200	200	13–15
Schou et al., (2017)	650–1000	500–700	–	–	–
Total range	**650–1000**	**500–700**	**100–240**	**180–260**	**12–15(16)**

Length in the first column excludes the coronula, its length and width given separately; all values for length and width in μm

Oospores: The ripe oospores are mostly black or sometimes dark brown. Unripe oospores have a strong orange colour (sometimes yellow). Their shape is ellipsoidal with a narrower apical and basal area (Becker et al. 2016). The oospore-membrane is almost black, thick, semi-rigid, semi-opaque and dotted with well-defined granules of different size (Groves and Bullock-Webster, 1924). Table 51.2 gives an overview about morphometrical data available; see also Fig. 51.4.

Antheridia: The antheridia are solitary and are about 300–560 μm in diameter; morphometrical data about antheridia are presented in Table 51.3 (see also Fig. 51.3d).

Bulbils: Bulbils can be formed with a diameter up to 2 mm. Such plants have also been described as a form: *Chara delicatula* f. *bulbillifera*. In some countries, like the UK, bulbils can sometimes be developed (Moore, 1986) and in others, like the Netherlands, bulbils are hardly formed (van Raam, 1998). See also Fig. 51.2f and 51.3e. Bulbils can be seen as cartilage-like swellings of the lower nodes, typically greenish or half-translucent, present late in the season when the main axis is senescing.

Table 51.2 Oospore morphometry

Author	Length	Width	Number of striae	Colour
Migula (1889–1897)	500–600	–	11–12	Black
Groves and Bullock-Webster (1924)	625–700	350–475	12–14	Black
Corillion (1975, 1957)	625–720	340–550	12–14	Black
Wood (1965)	615–735(750)	420–450(465)	11–12	Dark brown-black
Pal et al. (1962)	625–720	340–550	12–14	Black
Hollerbach and Krassavina (1983)	(500)600–700(720)	350–475	11–12(14)	Black
Krause (1997)	600–800	400–600	11–13	Black
Dilger (2010)	(490)570–740(850)	(300)350–460(490)	(9)10–14(15)	Black, predominantly matt black
Schou et al. (2017)	500–800(850)	(300)340–600	(9)11–14(15)	Dark brown-black
Total range	**(490)500–800(850)**	**(300)340–600**	**(9)11–14(15)**	

All values for length and width in μm

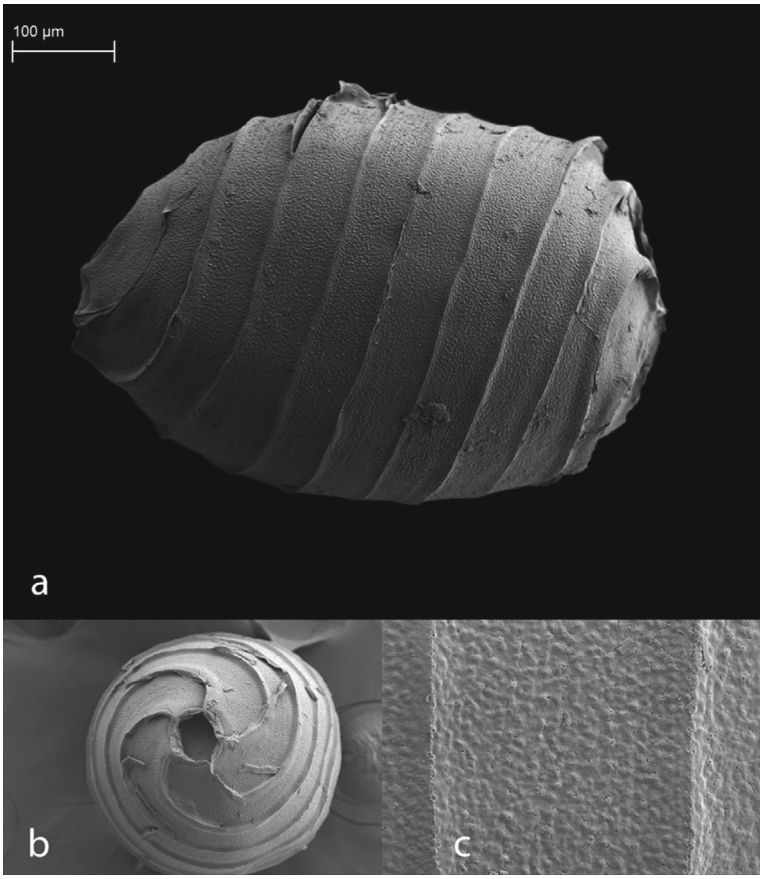

Fig. 51.4 *Chara virgata*, oospore. **a** Lateral view, **b** Basal view, **c** Oospore-membrane with well-defined granules. All oospores are taken from BM013734921, UK (w294). Photographs: Michelle T. Casanova (photo **a** is edited by Wil Leurs)

Table 51.3 Antheridia morphometry

Authors	Diameter (µm)
Migula (1889–1897)	300
Groves and Bullock-Webster (1924)	450
Corillion (1975, 1957)	350–560
Hollerbach and Krassavina (1983)	375–470
Krause (1997)	)350–550
Schou et al. (2017)	300–560
Total range	**300–560**

51.2 Phenology and Reproduction

Chara virgata is mostly an annual species but in deeper water it can be perennial. This species can be found in all months of the year. Jäger (1999, 2000) observed this species under ice during wintertime. *Chara virgata* can overwinter and in that case, plants can grow fast in Spring and can dominate large habitat areas. Oospores germinate in early Spring (March–April). Fructifying plants can be seen in May and are optimally developed during June-July but can survive well into late Autumn. When the circumstances are good the abundant oospores can germinate in Autumn (van Raam, 1998).

51.3 Habitat Conditions and Ecology

Habitat type: *Chara virgata* is common in freshwater bodies and occurs only occasionally in brackish water (Sinkevičienė et al., 2004). *Chara virgata* populates low electrolyte to calcareous lakes, small ponds and rivers, shallow water areas of larger lakes, especially in boggy areas, often acidic sites (e.g., *Isoetes*-Lakes) on silicate and limestone sediments (Doege and van de Weyer, 2016). It occurs mainly in habitats with a highly variable environment (van Raam, 1998). In the Netherlands *Chara virgata* is found in dune pools low in calcium, hardwater shallow lakes, fens and ditches (Simons and Nat, 1996). This species is able to tolerate lower pH levels than most other species of *Chara* (Moore, 1986). Wood (1965) states that it extends to higher altitudes and further into polar latitudes than most other charophytes.

Sediment: *Chara virgata* grows best on sandy, silty and organic sediments, but also on lime mud, marl and peat (Langangen, 2007a; Schmidt, 1981; van Raam, 1998).

Nutrient conditions: *Chara virgata* populates oligotrophic to mesotrophic habitats and disappears when water features deteriorate. This species is less tolerant to eutrophication than *Chara globularis* (Jäger, 2000; Melzer, 1988; Pietsch, 1982; Schmidt, 1981; Stroede, 1933; van Raam, 1998). Total nitrogen (TN) values 0.2–6.5 mg/l and total phosphorus (TP) values 0.001–0.303 mg/l are reported (Doege et al., 2016).

Water chemistry: *Chara virgata* inhabits both calcium-poor as well as calcium-rich waters (Doege and van de Weyer 2016). PH values ranging between 4.7 and 9.6, the carbonate hardness values between 0 and 12.5° dH. Total hardness ranges between 0.1 and 60.0° dH (Doege et al., 2016). The conductivity is reported from 10 up to 3000 µS/cm. According to Stroede (1933) *Chara virgata* can cope with less Ca^{2+} than other species. Sinkevičienė et al. (2004) and Langangen (2007a) reported a high degree of flexibility with regard to salinity.

Depth range: *Chara virgata* is mostly found in shallow water up to 4–6 m deep. Nevertheless some deepwater records show this species can be found at considerable

depths. Frantz and Cordone (1967) report *Chara virgata* to be found in Lake Tahoe (California and Nevada) at a depth of 200 ft (about 61 m). For Europe Krause (1997) claims 10 m to be the maximum depth.

Associated species: *Chara virgata* can form extensive monospecific vegetations described as *Charetum virgatae* Doll, 1989 corr. Täuscher (= *Charetum delicatulae* Doll, 1989, = *Chara delicatula*-society sensu Pietsch, 1987) (Felzines and Lambert, 2012). Because of its broad ecological niche, *Chara virgata* can be found in vegetations with many other (charophyte) species.

51.4 Variability

Bushy growth forms with multicellular or unicellular bulbils are common in the UK (Moore, 1986), Russia (Hollerbach and Krassavina, 1983) and the Baltic area (Sinkevičienė et al., 2004). Delicate, slightly encrusted forms with lots of bulbils were described as *Chara delicatula* f. *bulbillifera*. In deep waters *Chara virgata* can be perennial and then form a large slender plants resembling *Chara globularis* but can still be distinguished from this species by having the upper whorl of stipulodes well developed (van Raam, 1998).

51.5 Identification and Risk of Confusion

Chara virgata is closely related to *C. globularis*. It is often regarded as a variety or subspecies of *C. globularis*. These two species may occur together (Pełechaty et al., 2004) and then it can be difficult to distinguish them. The papillate spine-cells and the more or less equally tylacanthous cortex of *Chara virgata* distinguishes this taxon from *C. globularis*. The latter taxon has no developed spine-cells and stipulodes and the cortex is regularly isostichous. Distinction from *C. globularis* is possible by means of the stipulodes but it is much less reliable than the spine-cells and tylacanthy characters. In contrast to *C. globularis*, *C. virgata* has, mostly a well-developed upper row of short and pointed stipulodes. The problem is that all possible intermediate forms exist. Where to draw the line? *Chara virgata* often has a stronger smell than *C. globularis* and is always slender. *C. globularis* can be quite robust. However these are subjective attributes. Genetic research has shown *Chara globularis* and *C. virgata* are two different species (Krienitz and Nowak, 2016). Even so it is sometimes not possible to distinguish both species on a morphologic basis. As well, the ecological range is generally overlapping. *Chara globularis* is found in oligotrophic-eutrophic habitats and the range of *C. virgata* is oligotrophic-mesotrophic.

Small, less developed plants can sometimes be confused with *Chara contraria* and *C. vulgaris*. In *C. contraria* and *C. vulgaris* the upper and lower whorl of stipulodes are well developed, whereas *C. virgata* has the upper whorl of stipulodes well

developed and the lower row is rudimentary (papillate to spherical). Apart from that *C. contraria* and *C. vulgaris* are diplostichous and *C. virgata* is triplostichous.

Chara aspera var. *subinermis* always has symmetric, closely appressed stipulodes which are narrowly acute whereas the stipulodes of *C. virgata* are often more obtusely tipped to broadly acute. Also, the spine-cells in *C. aspera* var. *subinermis* are usually triangular acute rather than rounded to obtuse tipped as in *C. virgata.* Also, *C. aspera* is clearly dioecious when fertile.

Chara fragifera can also be confused with C. *virgata*. For the differences see under that species.

There is another triplostichous species with which *C. virgata* may be confused: *C. connivens*. *C. virgata* is monoecious but because of protandry it may look like the dioecious species *C. connivens*. Both species have a strong smell but *C. connivens* has two rows of rudimentary stipulodes and has no or rudimentary spine-cells. The branchlets of *C. connivens* can be strongly connivent especially in the top whorls of fertile plants whereas the branchlets of *C. virgata* mostly are slightly curved or stiff standing out.

51.6 Distribution

Chara virgata is a cosmopolitan species (Corillion, 1957; Groves and Bullock-Webster, 1924; Migula, 1889–1897; van Raam, 1998). It occurs in North America, Asia, Africa, Australia, New Zealand and Europe. In Fig. 51.5 the distribution of *Chara virgata* in Europe is presented.

51.7 Status and Threats

In comparison with other species of the genus, *Chara virgata* is one of the most common species (Doege and van de Weyer, 2016; van Raam, 1998). Like *Chara globularis* it is one of the few charophyte species not to be regarded as endangered in most countries of Europe.

51.8 Remarks

Most charophyte species have a specific smell. *Chara virgata*, like *C. connivens*, has a very distinguished (harsh) smell. Possibly the smell of *Chara virgata* makes people say charophytes are ‘skunkweeds’. Allelopathic effects have never been conclusively demonstrated for this species (Blindow and Hootsmans, 1991; Mulderij, 2006).

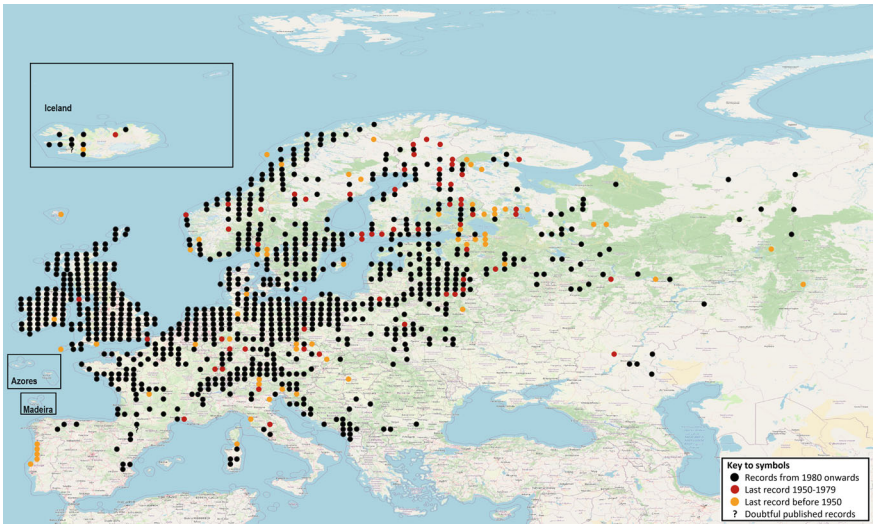

Fig. 51.5 Distribution of *Chara virgata* in Europe. For worldwide distribution see Korsch (2018). Black dots are records from 1980 on, red dots from 1950 to 1979 and yellow dots before 1950; unconfirmed/doubtful published records (if applicable) are marked with "?" on top. Map prepared by Heiko Korsch

For a long period in Europe *Chara virgata* was not distinguished from *Chara globularis*. To research its history one has to examine the literature of *C. globularis* as well.

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