Chapter 1
History and Current Importance

Enrico Biancardi and Robert T. Lewellen

Abstract The ancestors of *Beta maritima were* known from prehistory. After domestication, beet became more important not only for food and drug source, but also as sugar (sucrose) producer. The cultivation for leaves and root to be used as vegetable or cattle feed retains its economic value. *Beta maritima* was described by several authors, becoming in the last century crucial as source of traits disappeared in the beet crops after domestication. The research has led to important results, especially in the field of resistance to severe diseases. An increasing numbers of publications are dedicated to *Beta maritima* because it fits well into studies concerning breeding in general, population genetics, natural selection, colonization, speciation, gene flow, transgenes pollution, and so on. The discovery of new useful qualities in the wild germplasm is expected by the application of molecular biology.

Keywords *Beta maritima* · Origin · Domestication · History · Crop evolution · Breeding

Beta maritima,[1] commonly named "sea beet", is a very hardy plant that tolerates both high concentrations of salt in the soil and severe drought conditions (Shaw et al. 2002). Thus, it can also grow in extreme situations such as along the seashores almost in contact with saltwater "frequently between the high tide zone and the start of the vegetation, or where the wastage of the sea is deposited" (Figs. 1.1 and 1.2). On the contrary, sea beet is sensitive to competition with weeds especially under water and nutritional deficiency (Fig. 1.3) (Coons 1954; de Bock 1986). Sea beet seems to take advantage of its salt and drought tolerance to reduce the presence of competitor plants in the neighborhood (Coons 1954; Biancardi and de Biaggi

[1] *Beta maritima*, now classified *Beta vulgaris* L. subsp. *maritima* (L.) Arcang, is called for the sake of brevity "*Beta maritima*" or "sea beet".

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Fig. 1.1 Sea beet on a stone bank at the mouth of Po di Levante River, Italy. The plant grew on a few grams of sea debris and was able to flower and set seeds notwithstanding being surrounded by salty water. Any other superior plant can survive in these conditions, thus demonstrating the very high environmental adaptability and stress tolerance of the species. Due to the uneven distribution of rains and the limited water supply, *Beta maritima* can be observed in this site only after rainy season, that is, once in about a decade. Therefore, the survival of the populations, at least in the mentioned location, implies also a longlasting germination ability under high salt concentration and unknown interactions with the seed dormancy (Biancardi, unpublished)

Fig. 1.2 Site with optimal growing conditions for *Beta maritima*: vicinity to the seawater; sandy/stony soil; low presence of competing weeds; tourism connected activities; grazing cattle; etc. Baja California USA (Courtesy, Bartsch)

Fig. 1.3 *Beta maritima* competing against weeds (Torcello, Italy)

1979). Salty soils, frequently caused by seawater spray, tidal flows, storms, and so on, also induce relatively low pathogen pressure, thus may be helpful for the survival of the species. von Proskowetz (1910) referred to having never seen cysts of nematodes on sea beet roots, likely due to their very high woodiness. Conversely, Munerati et al. (1913) observed severe attacks of *Cercospora beticola*; *Uromyces betae*; *Peronospora schachtii*; and *Lixus junci* along the Italian-Adriatic seashores. Bartsch and Brand (1998) referred to the absence of beet necrotic yellow vein virus (BNYVV), the causal agent of rhizomania, as likely related to the high salt content in soils.

Saltwater plays an important role in the dispersal of the species. Less frequently, also for this reason, sea beet populations are localized in interior areas, in the presence or absence of beet crops in the vicinity. In the first case, the wild populations are likely to be feral or ruderal beets[2] that are more or less aged offspring of beet cultivation (Ford-Lloyd and Hawkes 1986; Bartsch et al. 2003).

1.1 Predomestication

The first use of sea beet (or one of its earlier relatives) goes back to prehistory, when the leaves were gathered and used as raw vegetable or pot herb (von Boguslawski 1984). The leaves, shiny and emerald green even in winter (Fuchs 1551), were unlikely confused with those of other plants, a feature that was very important for the first harvesters. The separation of the sub-family Betoideae (to which the genus *Beta* belongs) from the ancestral family Chenopodiaceae is estimated to have occurred between 38 and 27 million years ago (Hohmann et al. 2006). Therefore, it is possible that sea beet already was known to our ancestors in their remote African dawn.

Further confirmation of sea beet's ancient and widespread use are the remains of desiccated seed stalks, carbonized seeds, and fragments of root parenchyma found in the sites of Tybrind Vig and Hallskow, Denmark, dated from the late Mesolithic (5600–4000 BC) (Kubiak-Martens 1999, 2002; Robinson and Harild 2002). Pals (1984) reported on the discovery of similar remains in the Neolithic site (around 3000 BC) at Aartswoud, Holland. In agreement with Kubiak-Martens (1999), evidence of harvest and use of sea beet also are present at the Neolithic site at Dabki, Poland. Pollen of *Beta* wild plants was recognized in sediments sampled at Lake Urmia (Iran), Lake Jues (Germany), and Adabag (Turkey) dated around 10,000 years BC (Voigt et al. 2008; Bottema 2010).

The presence of fragments of root in the sites suggests that this part was used as frequently as the leaves. It is important to remember that in northern regions, the roots of sea beet are much more regular and developed than in southern environments. Therefore, the root better lends itself to harvest (Fig. 1.4) most likely beginning in

[2]Feral beets originate by a "dedomestication" of the crop. The process starts with the early flowering (bolting) of some cultivated beets before harvest.

Fig. 1.4 Atlantic *Beta maritima* with regular and swollen root (Smith 1803)

August, whereas the leaves were collected mainly in winter through spring (Kubiak-Martens 1999). After the discovery of fire, leaves and roots were eaten after cooking (Turner 1995). The frequent presence of remains of other wild plant species in these sites suggests the key role that vegetables played in the hunter–gatherer's diet even in pre-agrarian times (Kubiak-Martens 2002).

Charred remains of sea beet seeds were identified in late Mesolithic sites located in the northern region of the Netherlands, demonstrating the ancient presence of the species along the North-Atlantic seashores (Perry 1999), as it was further confirmed by the remains of sea beet found at the site of Peins, the Netherlands, dated to the first century BC (Nieuwhof 2006). Collecting data from 61 archeological sites in different parts of Egypt dated from predynastic to Greco-Roman times, Fahmy (1997) recognized 112 weed species including sea beet. Macro remains of the plant (seeds, leaves, stalks, etc.) were preserved by desiccation in sites dated from 3100 BC until the middle of the Pharaonic period (2400 BC).

As to the area of origin of the species, de Candolle (1885) wrote: "beets originated from Central Europe or from nearby regions, due to the large amount of wild species of the genus *Beta* present throughout the area". Some years later, de Candolle (1884) asserted that the beet crop, "which is the more easily [plant] to be improved by selection", was derived from the species now classified *Beta cicla* (or *Beta vulgaris* L. subsp. *vulgaris* Leaf Beet Group), very similar to sea beet. He also affirmed that *Beta cicla* expanded from the Canary Islands along the North-Atlantic coasts to the Mediterranean areas, up to the countries around the Caspian Sea, Persia, and Mesopotamia. The hypothesis of de Candolle, perhaps reasonable because of the numerous *Beta* species present today on Canary Islands, has not been confirmed by later authors (Meyer 1849; Pitard and Proust 1909; Francisco-Ortega et al. 2000). According to Coons (1954), the origin of sea beet could be located to the areas delimited by Ulbrich (1934) some decades before (Fig. 1.5).

Southwest Asia could be the area of origin, not only of sea beet and many other important crops (wheat, barley, etc.), but also of the family Chenopodiaceae (now Amaranthaceae), in which the genus *Beta* is included. Avagyan (2008) suggested that the species could have originated in Armenia. A number of authors: Honaker, Koch, Boissier, Bunge, Radde, and others reviewed by von Lippmann (1925), agree in locating the origin of the genus *Beta* in the area comprising the shores of the Caspian Sea, Transcaucasia, the East and South coasts of the Black Sea, Armenia, Asia Minor, the shores of the Red Sea, Persia, and India. Analyses of cytoplasmic diversity confirmed that the area of origin of sea beet should be the Mediterranean countries, where it is widely diffused even today (de Bock 1986; Cheng et al. 2011).

Fig. 1.5 Distribution of the species and sub-species of genus *Beta* according to Ulbrich (1934)

1.2 Domestication

Domestication can be described as the changes necessary to adapt plants to habitats especially prepared by man (van Raamsdonk 1993). Based on the rudimentary tools found in settlements of Neolithic age, the first farming of wheat (*Triticum* spp.) and barley (*Hordeum* spp.) is thought to have arisen in the Near East, perhaps earlier than 8500 BC (Zohary and Hopf 2000). The agricultural practices then would have spread into the Mediterranean areas through the ship routes of that time, and more slowly toward Central Europe. At least three millennia were necessary for agriculture to arrive in the British Islands, Scandinavia, and Portugal (Zohary and Hopf 1973, 2000): that is spreading at a rate of about 1 km per year (Cavalli-Sforza and Edwards 1967).

Beet cultivation may have begun, perhaps more than once, in Mesopotamia around 8000 BC (Simmonds 1976; McGrath et al. 2011). According to Krasochkin (1959), the first beet cultivation occurred in Asia Minor, mostly in localities at relatively high altitude with a cool growing season. Subsequently, the practice spread to Mediterranean areas, developing a great diversity of primitive forms of beet still existing today. The wild ancestor may have resembled types currently present in western Anatolia and Afghanistan, characterized by short life span, large seed-balls, elongated and fangy roots, tendency to flower very early, and so on (Krasochkin 1959, 1960). Using analyses of mitochondrial DNA, Santoni and Bervillè (1992) confirmed the hypothesis that cultivated beets likely originated from a unique ancestor quite different from the one currently known. After domestication, sea beet has continued to be harvested in wild sites and to be used as a vegetable, a custom still widespread in many coastal areas (Thornton 1812). According to Magnol (1636) "*Nihil in culinis Beta frequentius est*" (nothing is more used in the kitchen than beet). Rivera et al. (2006) consider the sea beet among the most gathered wild plants for food (GWP) in the Mediterranean and Caucasian regions. In the mentioned paper, the local names of sea beet are listed in 25 languages.

van Zeist and de Roller (1993) argued that beet farming had spread throughout much of Egypt by the time of construction of the pyramids of Giza (around 2700 BC). This hypothesis is supported by Herodotus (von Lippmann 1925). Because of the large quantity of beet that would have been required, the vegetable must have been domesticated. According to Buschan (1895), some wall paintings (Fig. 1.6) inside the tombs of Beni Hassan near Thebes, and dating to the 12th Dynasty (2000–1788 BC), represent beet and not horseradish (*Cochlearia armoracia*), as speculated by others. In a second painting inside the same tomb (Fig. 1.7) the farmer seems to have a beet in his hand, while the plants on the ground most likely are garlic (*Allium sativum*) (Woenig 1866). In both paintings, the regular shape of the root suggested that should be a cultivated variety of beet. Given the extensive spread of sea beet along the northern Egyptian coasts, Buschan (1895) speculated that its cultivation in the region had begun much earlier. In Fig. 1.8, the word meaning "beet" is written in ancient Egyptian (Kircher 1643; Veyssiere de la Croze 1755). Other findings dating from the third Dynasty (2700–2680 BC) have been made at Memphis, Egypt (Zohary

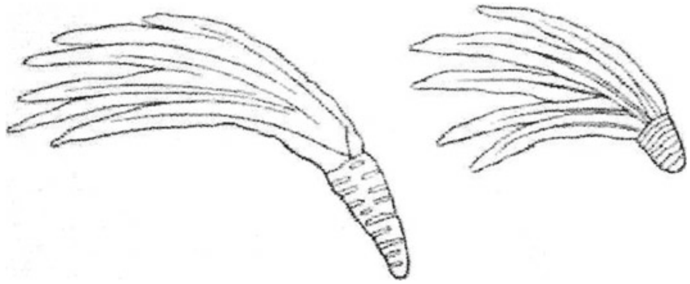

Fig. 1.6 Sea beet (or something similar) drawing at Beni Hassan, Egypt (Buschan 1895)

Fig. 1.7 Sea beet (likely) in the hands of the farmer. Painting at Beni Hassan, Egypt (Woenig 1866)

Fig. 1.8 The word meaning "beet" written in old Egyptian alphabet (Veyssiere de la Croze 1755)

and Hopf 2000). The lack of morphological differentiation often does not allow the establishment of whether remains are from wild or cultivated beets. In general, if the beet plant remains are found far from the sea and after the spread of agriculture in the area, it may be assumed that they are derived from cultivated beets. This is the case of beet seeds found in central Germany in sites dating to the Roman Empire (Zohary and Hopf 2000). A very original hypothesis was proposed by Stokes (1812).

He restored the old name *Beta sylvestris* and the likewise old name *Pyrola major,* establishing that it is "native of North America and Europe".

The cultivated beets have been adapted in response to selective pressures imposed by growers, who instinctively selected for reproduction the plants with the best expression of the traits of interest. The domestication process was hastened by utilizing plants showing mutations as well, but only if the new trait enhanced the qualities required by the farmers (Fehr 1987). This early selection, according to Ford-Lloyd et al. (1975), gave rise to a taxon classified as *Beta vulgaris* subsp. *provulgaris*, an ancestral form selected both for root and leaf production. The inherited offspring of this plant is believed still existent in Turkey (Ford-Lloyd et al. 1975).

Some traits necessary for survival in the wild became superfluous in cultivated field (Zohary 2004). For example, cultivation by the farmer reduced the beet's already poor competitive ability against weeds, a trait which is not necessary or of reduced in artificial monoculture. The annual cycle, necessary for increasing seed production and thus essential for the survival in the wild (Biancardi et al. 2005, 2010), slowly became biennial. In this way, as with other vegetables, was increased the duration over which leaves and roots remained edible (Harlan 1992). As a consequence of the selection process, genetic diversity decreased rapidly (Bartsch et al. 1999). Santoni and Bervillè (1995) observed in cultivated beets the lack of the rDNA unit V-10.4-3.3, common vice versa in wild beets. Because *Beta maritima* has been used in the last century as a source of resistances, the authors suspected the elimination of this DNA unit occurred through the selection processes. Recently, Li et al. (2010) confirmed the key role of genetic variation for the traits of interest in the first phase of sugar beet breeding (Ober and Luterbacher 2002).

The first written mention of beet farming goes back to an Assyrian text of the eighth century BC, which described the hanging gardens of Babylon (Meissner 1926; Ulbrich 1934; Körber-Grohne 1987; Mabberley 1997; Zohary and Hopf 2000). As has happened with the most important crops, the cultivated beet left its first domestication sites (Kleiner and Hacker 2010). Whereas Cheng et al. (2011) speculated that *Beta* has been domesticated in the Mediterranean area. Some centuries BC, the leaf beet was called "selga" or "silga", words that, according to Winner (1993), would have the same origin as the Latin adjective "*sicula*" (Sicilian). Around 400 BC, the cultivated leaf beet returned to Asia Minor (whence the sea beet had spread some millennia earlier) from Sicily, whose population of Greek origin had extensive trade relations with Mycenae and the eastern Mediterranean harbors (Becker-Dillingen 1928; Ulbrich 1934). Older European peoples, such as the Arians, did not cultivate beet (de Candolle 1885; Geschwind and Sellier 1902).

1.3 Athens and Rome

The first unambiguous written reference to beet cultivation dates back to Aristophanes, who mentions beet, at the time called τευτλον (*seutlon* or *teutlon*), in the plays "The Acharners", "The Frogs", and "Friends" (Winner 1993). According to von Lippmann (1925), in an old edition of "*War between frogs and mice*", a comedy written by Homer, there are some words resembling τευτλον, but their meaning is still uncertain. Again, according to von Lippmann (1925), the first written reference positively alluding to beet dates back to Diocles from Carystos (end of fourth century BC), who included its dried leaves in a medicinal mixture with other herbs. Diocles stated that the wild beet (τευτλον άγςια or άγριον) was very common along the coasts of Greece and its islands. The wild plant was rather different when compared to the cropped *Beta* (Jaeger 1952). The cultivated beet is of two types: white (λενχόυ) and black (μελαν). For sea beet, Diocles used also the terms "βλιτος (*blitos*)" and "λειμωνιον (*leimonium*)", which certainly can be attributed to the plant. Diocles is believed to be the author of the first illustrated herbal considered the prototype of several later authors (Collins 2000).

In "*Historia plantarum*" (295 BC?), the philosopher Theophrastus confirmed the existence of two varieties of cultivated beets: the black "τευτλον μελαν (*nigra*)" and the white "τευτλον λενχόυ (*candida*)" also called "*cicla*". Both display a long and narrow root similar to horseradish and have a sweet and satisfying taste. This description coincides with the shape of the plants painted at Beni Hassan. Both Diocles and Theophrastus described a beet, like the black one, and grown at the time for its roots. According to Sturtevant (1919), Aristotle himself cited the existence of a third cultivated type: the red beet. Theophrastus also listed the medicinal properties of sea beet. Since that time, the plant has taken on the dual nature of food and of medicinal herb against some diseases.

As for other types of beet, with rare exceptions, the therapeutic use was the most prevalent in books written until the end of the twelfth century (Jackson 1881; Lamarck 1810). The medicinal properties of sea beet were best described by the physician Hippocrates, who is recognized as the founder of medicine based on proto-scientific basis (Dalby 2003). von Lippmann (1925) argued that the dark-leaved variety (*nigra*) was cultivated extensively in the Grecian world also for the root.

In "*De Re Rustica*" (274 BC), the Roman writer Cato used the word "*Beta*" for the first time without giving indication of its source (Schneider 1794). The term appeared in the following phrase regarding the composition of a laxative mixture:

"*Si ungulam non habebis, adde betae coliculos cum radice sua*"

(If the nail of jam is not available, use the beet stalk and its root).

According to Columella and several later writers, the name seems to derive from the second letter of the Grecian alphabet, that is, the letter whose form looks like the embryo of the seed in the early stages of germination (Berti-Pichat 1866). de Lobel (1576) confirmed:

"*Betam etenim a litera graeca β sic dictam vocant*"

(It is believed that *Beta* is so-called from the Greek letter β).

Whitering, cited by Baxter (1837), approved that the name is derived from the form of its seed vessel, which, when swollen with seed, resembles the letter "β". The hypothesis that "*Beta*" was derived from the Celtic "bett" (red), or from the Irish "biatas" (red beet) (Kirby 1906; Baxter 1837) does not seem to be supported due to the infrequent contacts that Rome had at the time with the British Islands (Poiret 1827; von Lippmann 1925). Moreover, according to Geschwind and Sellier (1902), people of Celtic origin began to grow beets in Central Europe only around the fourth century AD. According to Strabo (cited by von Lippmann 1925), the use in North Sea area of "wildwachsene Gemüse" (wild vegetables) including beet, was dated earlier. An original hypothesis was given by Pabst (1887): in his opinion the word "*beta*" derived from the Latin "*meta*", which means, among other things, "conic heap of stones", similar to the spindle form of the beet root. Because the germinating seed resembles α (alpha) more than to β (Fig. 1.9), the assonance of the Greek word "βλιτος" cannot be missed. The etymological evolution of the word may be as follows: βλιτος → *Blitos* → *Blitum* → *Bleta* → *Beta* (Becker-Dillingen 1928).

The beet crop was mentioned several times by Latin writers including Plautus, Cicero, Catullus, Virgil and Varro. Martial (80 AD?) listed the beet "among the abundance of the rich countries", and defines it as "unserviceable to a sluggish stomach" (Feemster-Jashemsky and Meyer 2002). Beet was cited in two epigrams:

"*Pigroque ventris non inutiles betas*" (Beet is useful for lazy bowel).

"*Ut sapiant fatua fabrorum prandia betae, o quam saepe petet vina, piperque cocuus*"

(Insipid beet may bid a tradesman dine, but asks abundant pepper and wine)

Suetonius wrote that the emperor Caesar Augustus invented the verb "*betizare*" to indicate man showing effeminate behavior (Tanara 1674). Pliny the Elder (75 AD?) provided important information on the crop in "*Historia Naturalis*", mentioning both agricultural methods of cultivation and medicinal properties. Like Hippocrates and Theophrastus, Pliny mentioned the existence of varieties with white roots (*candida*) and dark green leaves (*nigra*). The plant could be sown either in spring or autumn; the seed took 6 days to germinate in summer and 10 days in winter. Germination of some seeds also occurred after two or more years. Among the uses of beet as food, Pliny also mentioned the root. This seems to confirm the hypothesis that in Roman times some new varieties (*Beta rubra*) appeared whose root, tender and sweet, was eaten after cooking. The use of the root, perhaps only of sea beet, was already common for medicinal uses in Greece, as reported by Hippocrates. For Pliny, the wild beet, named "*Beta silvestris*" (see footnote 4) corresponded to the plant called "*limonium*" or "*neuroides*", words dating back to Hippocrates:

"*Est et Beta silvestris quam limonium vocant, alii neuroidem, multo minor tenuoribusque ac densioribus*"

(Sea beet is called "*limonium*" by some and "*neuroidem*" by others, it has smaller and shallower leaves than the cultivated one)

Fig. 1.9 Painting of *Beta vulgaris* showing some particulars of flower and seed (www.bodley.ox.ac.uk)

Pliny also mentioned the existence of illustrated herbaria drawn up by a physician of the Aristotelian school (likely Diocles by Carystos), which described the medicinal properties of plant, mineral, and animal substances (Collins 2000).

The word "*Beta*" was written in some mural graffiti found at Pompeii. The wall inscription in Fig. 1.10, dating before 79 AD, is abbreviated or partially removed and is probably, together with the following, the oldest original writing of the name *Beta*. In another graffiti (Fig. 1.11) was written:

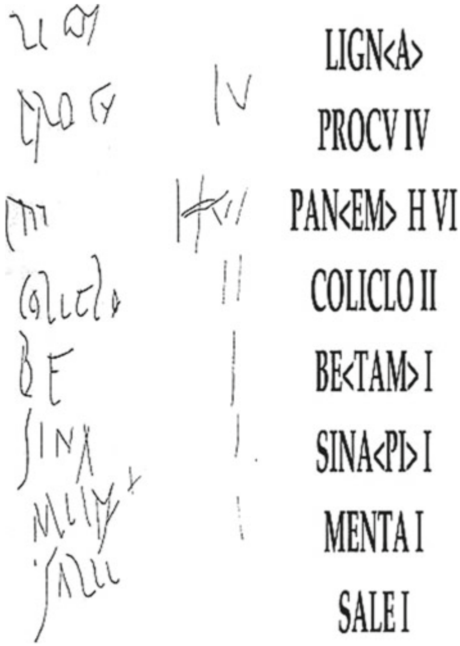

Fig. 1.10 List of prices written near a food shop at Pompeii: *procu* (pig) 4; *panem* (bread) 6; *coliclo* (small cabbage) 2; *betam* (beet) 1; *sinapi* (mustard) 1; *menta* (mint) 1; *sale* (salt) 1. Prices are in *axa* (around half dollar at the time) pro *libra* (around 350 g) (Ciarallo 2004)

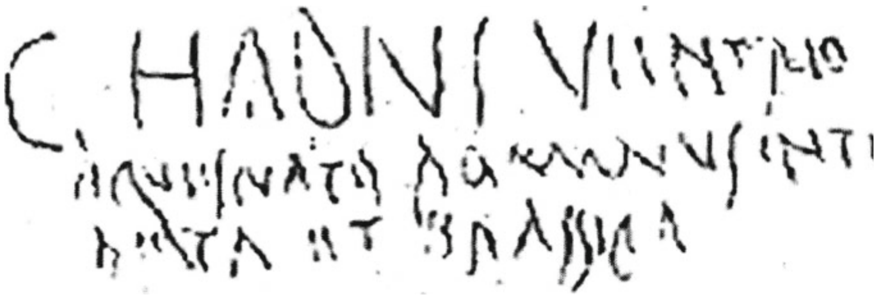

Fig. 1.11 Wall inscription at Pompeii (Ciarallo 2004)

"*C. Hadius Ventrio equus natus romanus intra beta et brassica*"

(*C. Hadius Ventrio*, knight, born Roman citizen among beets and cabbages)[3]

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[3] The graffiti refers to the vulgar origin of the man, likely "nouveau riche", alluding to the digestive consequences of consuming the mentioned vegetables Funari (1998).

After Pliny, beet was referred to by the name "*Beta*", at least in books written in Latin, but an incredible amount of synonyms of "*silvestris*"[4] was created (Appendix D). Dioscorides, a contemporary of Pliny and physician of the emperor Claudius Nero, described in "*De materia medica*" (89 AD?) the various medicinal properties of *Beta silvestris*. About *limonium*, mentioned by Pliny (also called *lonchitis*, *sinapi aselli, etc*.), Dioscorides stated that the leaves were similar to beets, but were more slender, long, and numerous. In other words, *limonium* was a different species with other uses. Attached to the important treatise, which was widespread and influential during the Middle Ages was believed to be a herbarium probably dating back to Crateuas, which included a color drawing certainly referring to beet (Fig. 1.12). According to Collins (2000), the herbarium seems to be attributed to Diocles by Carystos. The caption written in old Greek indicated that the illustration represents the "wild beet" called "*sylbatica*" (synonymous of "*silvestris*") by the Romans" (Biancardi et al. 2002). But the plant resembles a cultivated beet more than wild because of the regular shape of the root.

As used by astrologers, 18 chapters of "*De materia medica*" described the influence of stars and planets over the herbs and their medicinal effects. Indeed, it was believed that successful therapy always was linked with the astral influence (Riva 2010). Magical properties, such as keeping away the devil, curing the plague, and stimulating sexual attraction, often were attributed to some herbs until a couple of centuries ago. As regards, the herbarium sample attributed to Crateuas, it seems quite unlikely that it was appended to the original "*De Materia Medica*", because the text makes no references to enclosed drawings (Ventura 1998).

Galen opened a sort of pharmacy in downtown Rome. In "*De alimentorum facultatibus*" he (190 AD?) claimed to be unaware of the wild form of beet, which he called "*agrestis*", unless this plant could be identified as "*lapathum*", which had uses other than those described by Pliny and Dioscorides. For the cultivated species, he used the old Greek name "τευτλον" (*teuthlus*).

According to Aristotle, Galen distinguished four elements: fire, water, earth, and air. Fire is characterized by heat and dryness; air by heat and moisture; water by cold and moisture; and earth by cold and dryness. Human health depends on the right balance of these conflicting tendencies (Anderson 1977; Arber 1912). For therapeutic use, Galen argued that the plants have four degrees of "dryness or moisture, heat and coldness" (Gray 1821). Galen believed that beet possesses a cold and wet nature and must be used accordingly. As a Christian, Galen believed in a unique divinity, for this reason his theory was well accepted also by Jews and Arabs (Jackson 1881; Pezzella 2007).

[4]The correct Latin adjective first used by Pliny is "*silvestris*", and not "*sylvestris*" as was written by later authors.

Fig. 1.12 Painting of *Beta maritima* attributed to Crateuas (Courtesy: Biblioteca Marciana, Venice. Reproduction is prohibited)

1.4 Middle Age

For at least eight centuries after the fall of the Roman Empire, there was an almost complete cessation of study and publication in all disciplines. von Lippman (1925) listed and precisely described the references regarding the beet crop during the so-called "Dark ages". Despite the conservation and copying of manuscripts carried out in monasteries and abbeys, many invaluable books were lost. By the end of the millennium, the Arabs had begun to pursue the study of botany, based mainly on translations of Aristotle, Theophrastus, Dioscorides, and Galen (Arber 1912; Collins 2000). Many currently used botanical products, such as camphor, lavender, rhubarb, opium, cane sugar, tamarinds, hops, and so on, were introduced by Arab physicians (Gray 1821). The books of many Arabian authors remained confined to libraries because of the difficulty of writing and reading (Jackson 1881), but some found widespread dissemination in Europe through the Caliphate of Cordoba, Spain and translations, particularly those made in the Benedictine monastery of Monte Cassino, Italy. Some Arabian books mentioned wild and cultivated beets together with their medical applications. Ibn Sina (Avicenna) recommended the use of sea beet leaves, agreeing on their wet and cold nature (as stated by Galen), in different therapeutic applications. Aven Roshdi (Averroes), physician and philosopher, used sea beet named "decka" in some drug mixtures (Bruhnfels 1534). Ibn Beith mentioned the existence of wild beets (likely weed beets) alongside the cultivated fields, which were characterized by a different shape and color. Avicenna, on the other hand, called "selq" the more isolated beets likely *Beta maritima* (Sontheimer 1845). Other Arabic names such as "selg" and "silg" resemble the old Greek name, "sevkle" (de Candolle 1884, 1904).

According to Krasochkin (1960), the beet crop likely spread from Byzantium to Kiev, Russia, in the tenth century. Hildegard von Bingen (Throop 1998) reported this diffusion throughout Germany in the same time frame, but surely the crop had already reached the region during the Roman Empire (Geschwind and Sellier 1902). Shun et al. (2000) contended that the beet was known in China around 500 BC.

In the early 800s, "*Blitum*" was quoted as a synonym of sea beet in the anonymous treatise "Compendium der Naturwissenschaften" Fellner (1879), whose botanical and medicinal information was derived from Isidor of Seville, who took the information from Pliny and Theophrastus (Arber 1912) around AD 1000 (de Divitiis et al. 2004). Cultivated beets, referred to as "*bleta*", were also mentioned for several medicinal uses in the "*Codex*", likely written by Arnaldus de Villanova. The manuscript, which had a significant role in the spread of Arabic medicine, did not mention the sea beet.

Albertus Magnus, Bishop of Ratisbona (Regensburg, Germany), reported some recipes based on *blitum* and parsley (*Petroselinum* spp.) (Kennedy 1913). He held the theory that species are mutable, in fact, cultivated plants might run wild and degenerate, and the wild plants could be domesticated. Matteo Silvatico cited *Bleta silvestris* for some therapeutic applications taken from the Arabic literature (Silvatico 1523).

As stated by von Lippmann (1925), identification of *sea beet* in *herbaria*[5], books, descriptions, and indexes of botanical gardens, all written with increasing share after the invention of the printing press, is often difficult. Moreover, confusion exists, not only among the various synonyms and varieties obtained by selection, but also in the identification problem (which still exists) between beets and turnip (*Brassica* spp.) in the case of roots, and between beets and spinach (*Spinacia oleracea*) in the case of leaves (Fischer-Benzon 1894). One must also remember the multitude of local names given to various types of cultivated beet. Because the wild and cultivated beets easily cross with one another, one also must take into account wild populations derived from spontaneous crosses.

Among the herbals of Greek origin recalled previously, we also must mention the "*Herbarium Apuleii Platonici*" and translated into several European languages around 1480. The manuscript "*Tractatus de virtutibus herbarum*" written by Arnoldus de Villanova is illustrated with very simple drawings of various plants, including the beet, here called "*bleta*" (Fig. 1.13). The drawing is accompanied by a short description of the medicinal properties taken mainly from Theophrastus. As regards the sea beet, the hypothesis of Pliny, that identified the *Beta silvestris*

[5]The books describing the medicinal applications of plants are named "*herbaria*" or "*dynamidia*" whether they include or not drawings of the plants (Piccoli 2000). The use of *dynamidia* seems to date back to the Chinese, Assyrian-Babylonian, and Egyptian medicine. The "Pents'ao" was written in China around sixteenth century BC (Pezzella 1993). The "Papyrus of Luxor" dated 1550 BC was essentially a list of medical properties of plants (Pezzella 2007). Further examples are given by the *Herbaria* attributed to Crateuas and Apuleius: at least one copy of the latter was employed in the abbeys. In the Middle Age, the herbaria become banal reproductions of ancient manuscripts (Lazzarini et al. 2004). Many transcriptions made by copyists not involved in botany lead to a considerable increase of mistakes in texts and illustrations (Weitzmann 1979). The drawings became very formal and simple, sometimes with complete bilateral symmetry and often included only for embellish the manuscript (Arber 1912). Therefore, the identification of the represented or described plants became quite impossible. The language was a mixture of Latin, vulgar, common, and foreign terms frequently difficult to translate, as the names given to the plants. In the manuscripts, the name of the author was often omitted as the references regarding the hand written book (Gasparrini-Leporace et al. 1952). Only toward the end of the thirteenth century, when it was necessary to print the most important manuscripts, they began to check the names and the correspondence with the reality of descriptions and illustrations. The first printed herbaria were also named "Book of Nature" from the "Půch der Natur" written likely by Konrad von Megenberg (1348?) and published around 1470.

XXVII

BLETA

¶Bleta eſt frigi.& humide complexionis. & ſunt due ſpe-
ties alba & nigra. Alba habet uirtutez abſtergendi & leniẽ
di & humectandi & infrigidandi. Sed nigra habet aliquaiẽ
ſtipticitatem: ideo nigra ſtringit uentrem. ſed alba ſua hu-
miditate laxat uentrem: ideo cõſtipatur ualet decoctio ble
te in carnibus. Valet etiam expurgando ſuperfluitates ca-
pitis fiat inde ſternutatorium cum ſucco blete & melle &
parum zinciberis imponendo naribus. Et ſuccus eius cuz
ſemperuiua prohibet generationem apoſtematis. Idem ua
let ad ignem ſacrum & ad eriſipilam cum aceto mixtum.

Fig. 1.13 *Beta maritima* here named "*Bleta*" (Courtesy: Orto Botanico, Padua. Reproduction is prohibited) with *limonium*, was partially confirmed in the "*Liber simplicibus*"[6] written by Roccabonella (1457) (de Toni 1925; Pitacco 2002; Teza 1898). The manuscript,[7] providing the illustration of sea beet (Fig. 1.14), is accompanied by its names in Greek, Latin, Italian, German, French, and so on (Fig. 1.15). Roccabonella explained that the drawing of Andrea Amodio represents the *bleta silvestris*, corresponding to *limolion* or *limonion*, the Greek names of wild beet according to Pliny. The small and fangy root seems confirm that it could be a sea beet, likely widespread in the lagoon around Venice at the time. The realism of the hand drawing can be noted, especially when compared with other contemporary illustrations (Fig. 1.16). Signs of the changing times also can be seen in the work by Hermolao Barbaro (1494). In his treatise "*Castigationes Plinianae*", the author erased from the text of Pliny's "*Historia Naturalis*" the mistakes collected during the frequent recopying that took during the Middle Age.

The thinking of Aristotle, who was, among other things, the author of two lost treatises on botany, dominated all scientific disciplines for a long time, delaying and, in many cases, preventing the development of modern science. The books of Aristotle, Theophrastus, and Hippocrates were transcribed by hand many times, losing in part, as it has been said, their relationship with the originals. Only around the fourteenth

[6]"*Simplices*" were called medical substances extracted from various sources and used without any further processing. Those mixed or treated were called "*compositae*". The first category of drugs is currently called "Galenic" as well; the second "Hippocratic" in agreement on the respective authors. A very useful list of the *simplices* at the time available in the pharmacies of Ferrara, Italy, is given by Musa Brassavola (1537). The medical substances are divided into herbs (including *Beta nigra* and *alba*), seeds, fruits, roots, barks, gums, metals, soils, salts, oils from flowers, oils from mine, and so on. The last ones are named "*petroleum et asphaltum*" as well. At the end of the treatise, as for the modern drugs, are written the applications and the warnings which can be paid before using. The "*Hortus simpliciorum*" or "*Hortus sanitatis*", *and so on* (Garden of simple drugs or Garden of health) were the ancestors of the current "*Hortus botanicus*" (Botanical garden), where a number of plants are grown and studied. According to Schulters (1817), the first *Hortus* arose in Padua, Italy (1533)

[7]The manuscripts are books written by hand on different substrates (papyrus, animal skin, parchment, handmade paper, etc.). Given the reproduction system and the very high costs, the spread was limited to the libraries of monasteries, universities, royal courts, etc. *Incunabula* are called the books produced by the invention of printing (1455) until around the middle fourteenth century. These printed books distinguished by preserving the setting of the old manuscripts, which were often loose-pages, with any title, page number, index, and with any indication about the author or subsequently of the printer. Thanks to the increased share and the lowering costs, the printed books took gradually a set-up similar to the modern publications. The first *incunabulum* was the Latin version of the Holy Bible printed around 1455 by Gutenberg. The Pliny's "*Historia Naturalis*" was printed in 1478, whereas the Dioscorides "*Materia medica*" was the first printed book regarding medicine and botany (Gray 1821). *Tacuina sanitatis* were illustrated books containing popular therapeutic remedies, taken in part from the Arabic literature, at the time considered most effective and innovative than the traditional Greek-Roman medicine. The term "*tacuinum*" derives from the Arabic "Taqwin al sihha" (Tables of health). Reworked and translated into Latin around 1200, these booklets began to spread in Tuscany and Lombardy, Italy. Because this sort of manuals was intended mainly to the aristocracy, the manuscripts were embellished with precious decorations and miniatures. In addition to plant drawings, scenes from daily life were illustrated with great richness of details. Unlike *herbaria*, descriptions of the plants were summarized in few lines each illustration (Fig. 5.2).

Fig. 1.14 Painting of *Beta sylvestris* attributed to Andrea Amodio (Courtesy: Biblioteca Marciana, Venice. Reproduction is prohibited)

Century, did scientific thinking begin struggling to rid itself of the ancient classical approach. Schultes (1817) in "Grundniss einer Geschichte und Literatur der Botanik", terminates with Lorenzo de' Medici (1449–1492) the first period of the history of botany, which began with Theophrastus. In this case, the Florentine is seen as the initiator of the new course, firstly in the arts (Renaissance) and then in the sciences. Jackson (1881) agrees with Schultes, but he finishes the first period with Bruhnfels (1488–1534) (Figs. 1.17 and 1.18). A new era of botanical illustration also began, clearly anticipated by Roccabonella. Incidentally, should be remembered the relative independence that Venice had in the relations with the Roman Catholic Church that had supported the thinking of Aristotle until recent times (1492).

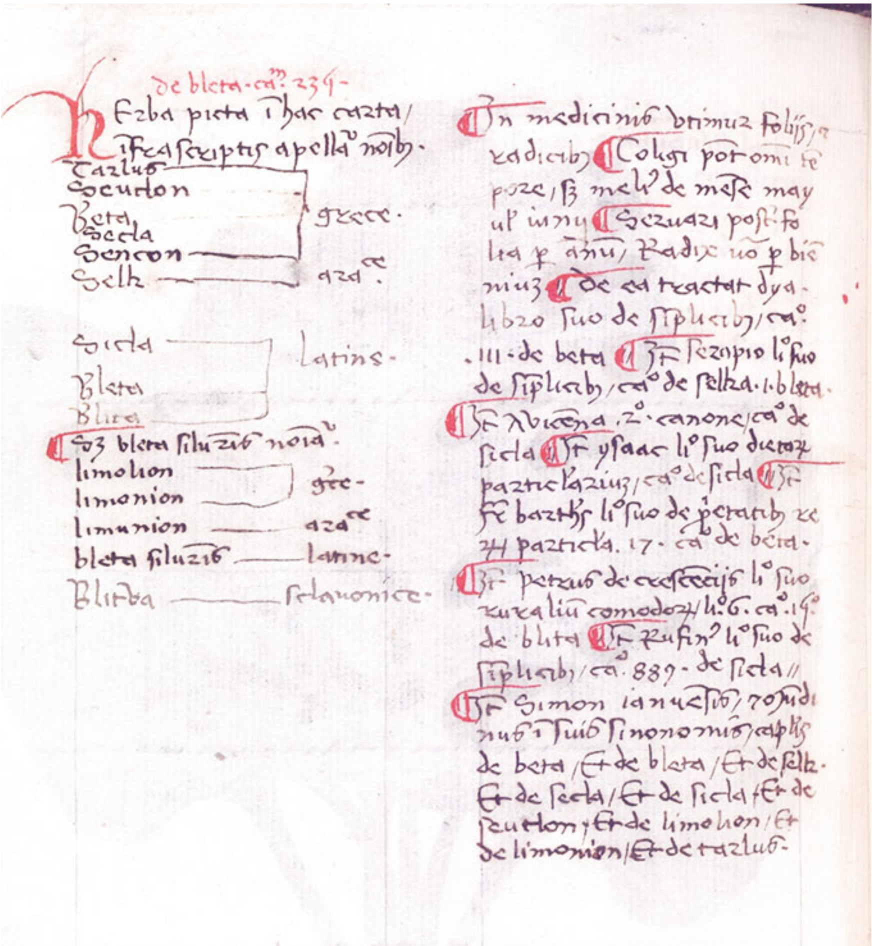

Fig. 1.15 The verso of the former page with translations of *Beta sylvestris* in some languages (Courtesy: Biblioteca Marciana, Venice. Reproduction is prohibited)

1.5 Renaissance

The study of plant physiology and pathology began to develop during this time, though not without difficulties. New plants and herbal drugs coming from the Americas became commonplace in European pharmacies, with applications taken mainly from the native people (Ximenez 1615). Otto Bruhnfels published the treatise “*Herbarium vivae iconae etc*.” in 1534 which contained illustrations that clearly were free from the old tradition (Bruhnfels 1534). Previously, often the differences between the actual observation of the plants (Fig. 1.14) and the description given by ancient authors are very evident (Fig. 1.16). The *Herbarium* of Bruhnfels (Fig. 1.18)

Fig. 1.16 Sea beet (right), here named "herba ferella", in Erbario cod. 4936 (Courtesy: Biblioteca Marciana, Venice. Reproduction is prohibited)

cited the *Beta silvestris* as a plant collected for food in many places in Germany, and the species, confirmed Bruhnfels, is native of Dalmatia.

In "*Herbarium siccum*", Aldrovandi catalogued the dried sample on Fig. 1.19 as "*Beta carota*" (carrot beet)*, Rapum sativum etc.* (Soldano 2003). But in the explanations reported in the manuscripts, written by Aldrovandi himself, the plant is named "*Beta silvestris marina*" (Fig. 1.20). Here the word "*marina*" appears for the first time related to the sea beet. A third manuscript reported that "*Beta silvestris marina nascit in Lio prope mare*" (sea beet grows on the seashore near the Lido of Venice) (Soldano 2003). In another page of *Herbarium,* the stalk, surely of *Beta maritima,* is classified as *Spinacium silvestre* (wild spinach), which is described as "growing between Ancona and Senigallia" on the Italian coast of Adriatic Sea, where *Beta maritima* is still very common on the undisturbed seashores.[8]

The drawings of plants began to become very accurate in "*De historia stirpium commentarii insignes*" edited by Fuchs (1551) who catalogued *Beta sylvestris* as *limonium* and cited other names given to the plant: *tintinabulum terrae* (Latin), pyrola (vulgar Italian), Wintergrün, Holtzmangold or Waldmangold (German), and so on.

[8]In Fig. 1.19, it is still possible to see salt crystals on every part of the plant.

Fig. 1.17 Mengelwurtz (fodder beet) in a drawing of Bruhnfels (1534)

The illustration of *limonium* (Fig. 1.21) does not correspond to the characteristics of *Beta maritima*. Other mistakes arise through the author's willingness to apply the names taken from Dioscorides to the plant from Northern Europe. The majority of these mistakes were made because the real functions of the different parts of the plants were not understood yet. It was not until 1682 that the sexual and reproductive functions of flowers were explained by Grew (Arber 1912). Another source of errors was the absence of a common terminology. According to Arber (1912), Fuchs and later Dodoens, were the first botanists who attempted to introduce common botanical terms. Fuchs wrote that the *limonium* grew in shady places and flowered in June. The white and red beets (*Beta candida* and *Beta nigra*) were described and illustrated (Fig. 1.22) in a section of the book, where the heading is the ancient Greek word "teutlo".

Fig. 1.18 Front page of "Kreuterbuch etc." written by Bruhnfels (1534)

Fig. 1.19 In "*Herbarium siccum*" (Soldano 2003), Aldrovandi collected a plant classified wrongly *Spinachium sylvestre* (spinat). In reality, the plant is surely a sea beet, named *Beta marina* by Aldrovandi (Courtesy: Museo Aldrovandi, Bologna. Reproduction is prohibited)

The book "*De plantis*" written by the physician Cesalpino was published in 1583. According to Geschwind and Sellier (1902), he was among the first to describe the plants using a rather scientific approach that took into account the flower and the seed traits and, therefore, was the first attempt at plant classification using modern standards. He might be considered as the last representative of Aristotelian botany (Gray 1821). Dodoens (1553) described a drawing representing the *blitum* (Fig. 1.23) as "*Beta sylvestris ac terrae tintinabulum*, also named Wintergruen, Holtzmanngoldt in German, and Wintergruen, Officinis Pyrola in Brabantis". In the 1554 edition, Dodoens changed completely the illustrations representing the *Beta nigra* and *Beta candida* (Fig. 1.24) with drawings taken from Fuchs (1551).

A few years later, Luigi Squalermo (named also Anguillara) wrote in the work "*De simplicibus*" (1561) to be aware that *limonium* is sea beet, then known in Italy as "piantaggine acquatica" or "giegola silvestre" or "helleboro bianco". This opinion was not confirmed by later writers. Squalermo, mentioning the books of Pliny and Dioscorides, stated that the cultivated beets are black or white. Moreover, there exists

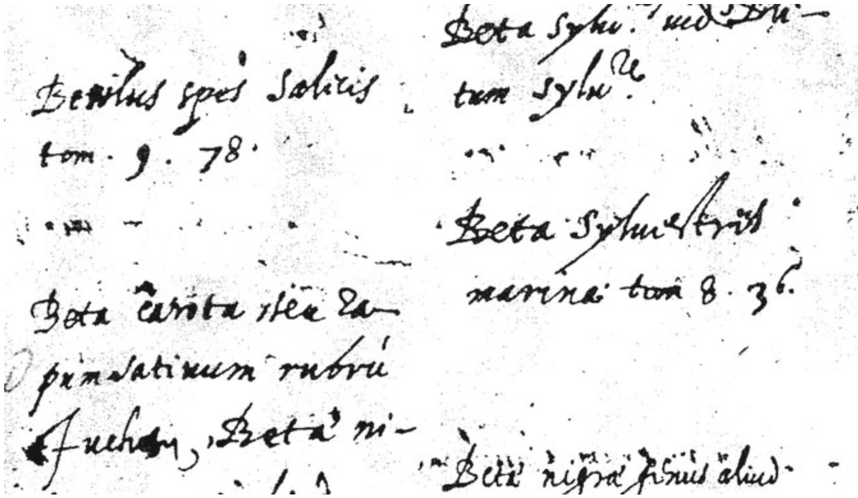

Fig. 1.20 In the explanations of the former page, Aldrovandi used for the first time the term "*marina*" (marine) (Courtesy: Museo Aldrovandi, Bologna. Reproduction is prohibited)

a third variety in Greece called "cochinoguglia", whose roots are bright red and round like the turnip (*Brassica rapa* L.).

Mattioli (1557) cited the opinion of Galen, who claimed not to know of any kind of wild beets, unless it was the plant named "*rombice*" or "*lapatio*". The same observation appeared in the treatise "Il Dioscoride" (Mattioli 1565), a translation and commentary on the work of the ancient physician. The book was among the most popular until the time of *Linnaeus*, and was printed in 60 editions and more than 32,000 copies (Gray 1821). In Fig. 1.24, it is possible to see the limitation imposed on drawings by the small size of the carved wooden blocks used in the first printed books. *Beta sylvestris* also is called "*pyrola*" by Mattioli (1586). Antonio Michiel (1510), who, after quoting several names in various languages, wrote that *Beta sylvestris* probably corresponded to the *limonium* mentioned by Dioscorides. The plant grows "in forests and shady places, along the river Reno, Italy, and around the Castle of Sambuca, Italy".

Hieronymus Bock in "Krauter Buch" described the characteristics of the cultivated *Beta nigra* and *Beta agrestis* (Fig. 1.25) (Bock 1560). The name "*agrestis*", was commonly used as synonymous to "*silvestris* or *sylvestris*". Sea beet here is called "Wald Mangold", "Winter grün", "Winter grün Pyrola", "*Betula Theophrasti*", and so on (Bock 1552). Bock confirmed the correspondence of the name, "*Beta agrestis*", with the "*limonium*" mentioned by Pliny (75 AD). The name "Winter grün" (winter green) derives from the ability of the sea beet leaves to remain green and alive throughout the winter. Anonymous (1852) better explained: "How dark and rich is the green tint of those leaves, which, on their long stalks, lie about the root of sea beet, and how well does the deep green hue contrast with the pale sea-green tint of the perfoliate yellow wort, and of many other plants of the rock".

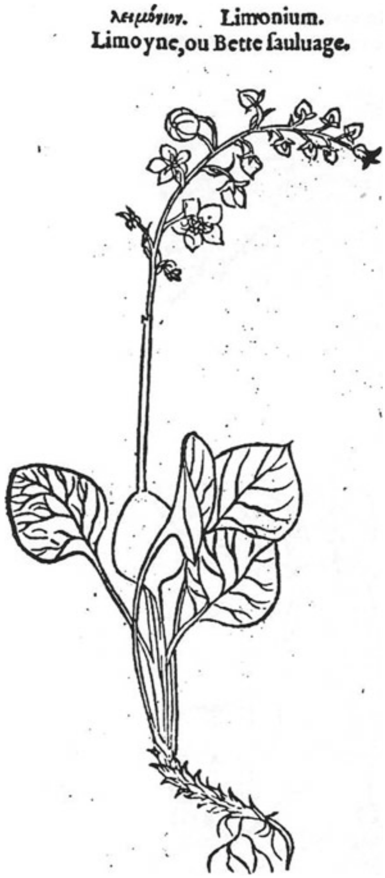

Fig. 1.21 Drawing of limonium or Bette saulvage (Fuchs 1551)

The invention of microscope introduced another revolution in the seventeenth century. This instrument enhanced exponentially the knowledge of anatomy, histology, and physiology of living organisms (Malpighi 1688), exactly as the telescope had in astronomy. The new discovery, developed at least in part thanks to progress in glass processing in the Netherlands and at Murano, Venice (Italy), revealed the real structure of plant and animals. Malpighi published the results of the first observations on plants in his "*Anatome plantarum*" printed by the London Royal Society Malpighi (1675). Five drawings of germinating seed of *Beta* are included (Fig. 1.26).

Johann Günther von Andernach, when commenting on the work of Paulus Aegineta, used the ancient Greek name "*teutlon*" as did Fuchs. The wild beet was described by Castore Durante in "Herbario Nuovo" (1635) with the name "piombagine" (*plumbago*) and "bietola salvatica". The author reported that leaves and stalk are similar to *limonium*, and consequently, it is called "false *limonium*". The plant grows "along streets and hedges, and also in wild places" The medical properties and

Fig. 1.22 White and red beets (*Beta candida* and *Beta nigra*) represented by Fuchs (1551)

some synonyms are listed in the book, together with drawings of *Beta alba*, *nigra*, *rubra*, and *plumbago.*

In "*Historia generalis plantarum*", Dalechamps (1587) included drawings and descriptions of the known types of beets (*alba*, *nigra*, *rubra vulgatior*, *rubra Matthioli*), and those of *Beta erythrorhiza* (with red root) and *Beta platicaulis* (with flattened seed stalk). The first name was taken from Dodoens (1553), the second was given by Dalechamps himself. In describing *Beta platicaulis*, he considered it as a different species, although we know today that the plants were suffering from a rather common anomaly known in Italy as "fasciazione" (Munerati and Zapparoli 1915).

A very accurate description of growing and harvesting techniques was given in the "*Ruralium commodorum*", written by Pietro de Crescenzi (1605), which also described an important feature of the beet crop, the bienniality (namely, that beets had been selected for flowering in the second year, i.e. after overwintering), which made the crop more nutritional and suitable for cultivation. The "herbalist" William Coles (1657) included in the list of all sorts of beets both "sea beet" and "prickly beet of Candy; the former is surely *Beta maritima* and the latter is the species named *Beta agrestis or Beta cretica semine spinoso* (Fig. 1.24) by some later authors. Coles

Fig. 1.23 *Blitum* represented by Dodoens (1553)

seems to be the first who used the English term "sea beet". Tanara (1674) reported that when the leaves of beets were cut in the fall of the moon, they grow back with greater vigor and speed. He also reported some interesting observations on contamination of varieties caused by foreign pollen. Indeed, for the red beets, it was necessary to use seed coming yearly from France to get uniform color in the roots. The seed produced in Italy likely was contaminated often by pollen spread from other types of beets, which gave rise to hybrids with different color and shape.

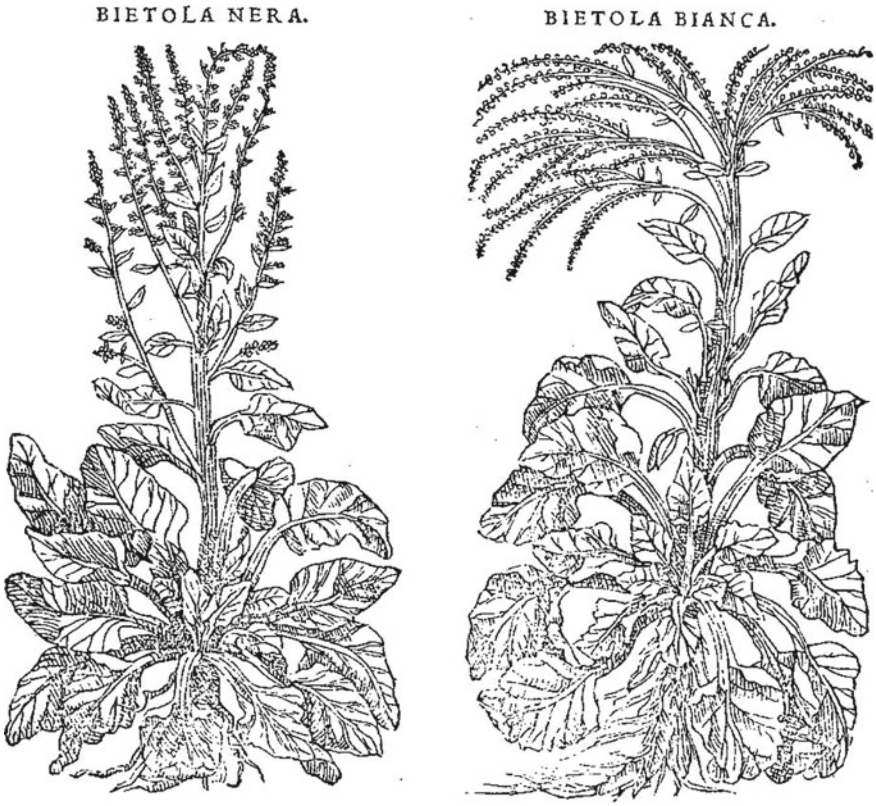

Fig. 1.24 *Beta sylvestris* black (left) and white (Mattioli 1557)

Chabray (1666), in "*Stirpium sciagraphia et icones, etc*.", together with the drawings, described various types of cultivated and wild beets. In the appendix of the book, he cited several synonyms of *Beta sylvestris* (*limonium*, *trifolium palustre*, *lampsana*, *pyrola*, *mysotis*, *potamogaton*, *carduus pratense*, *plantago aquatica*, *lapathum*) mostly of unknown origin. Chabray reported that the name "*blitum*", while in use, was attributed to a plant different from the *Beta sylvestris* described by Theophrastus; an example of this confusion is seen by Dorsten (1540), who confused *Beta* with *Brassica* spp. Among the wild beets, only the drawing of *Beta cretica* is reported by Chabray.

Pena and de Lobel (1576) began grouping the plants by their characteristics (grass, grass-like plants etc.) in "*Adversaria nova*" (1576). In "*Plantarum seu stirpium historia etc.*," de Lobel (1576) mentioned the sea beet under the name "*Beta sylvestris spontanea marina*" surely derived from the adjective used by Aldrovandi some decades before. In the second letter of the word *silvestris*, de Lobel used the letter "Y" not existing in the Latin alphabet.

Fig. 1.25 *Beta cretica* (Chabray 1666)

Gaspard Bauhin, in "*Pinax theatri botanici*" (1623), assembled a number of synonyms for *Beta* partly adopted by Linnaeus. Bauhin began grouping species according to their botanical affinities, thus pioneering the binomial classification. The book reported a complete reference of the authors involved in botany and medicine. Bauhin is thought to be the author of the name "*maritima*" given to the sea beet. In "*Paradisi in sole, etc.*", Parkinson (1629) sought to clarify the uncertainties about the correct identification of the ancient term "*Beta nigra*". Sea beet was called "common green beete" found in "salt marshes near Rochester". Parkinson also hinted at a "great red bete" recently imported to London "by Master Lete and given unto Master Gerard for his herbal". The plant is similar to the Italian beet (*Beta romana*), but larger and with red petioles. The latter, also called *Beta raposa* for its resemblance to the turnip could be used for both the leaves and roots. *Beta maritim*a was called "*blitum*," and eaten cooked together with other herbs. In the revised edition of de Lobel's (1591) "*Stirpium illustrationes etc.,*" Parkinson (1655) described two types of sea beets, *Beta maritima syl(vestris) spontanea* and *Beta maritima syl(vestris) minor*, the roots of the former were much more developed. Both were grouped with *Beta maxima* i.e. the cultivated type.

Gerard and Poggi (1636) wrote in "The herball or general histoire of plants" "… the ordinary white beet (*Beta alba*) growes wilde upon the sea-coast of Tenet and diners others places by the sea." In reference to the confusion caused by the different names given to *Beta sylvestris*, he added: "For the barbarous names we can say nothing: now it is said to be called *limonium* because it growes in wet or overflown meadows: it is called *neuroides* because the leaf is composed of divers strings or fibers running from one end thereof to the other, as in plantaine (*Plantago* spp.) … In addition, it may be das fitly termed *lonchtis* for the similitude that the leafe hath

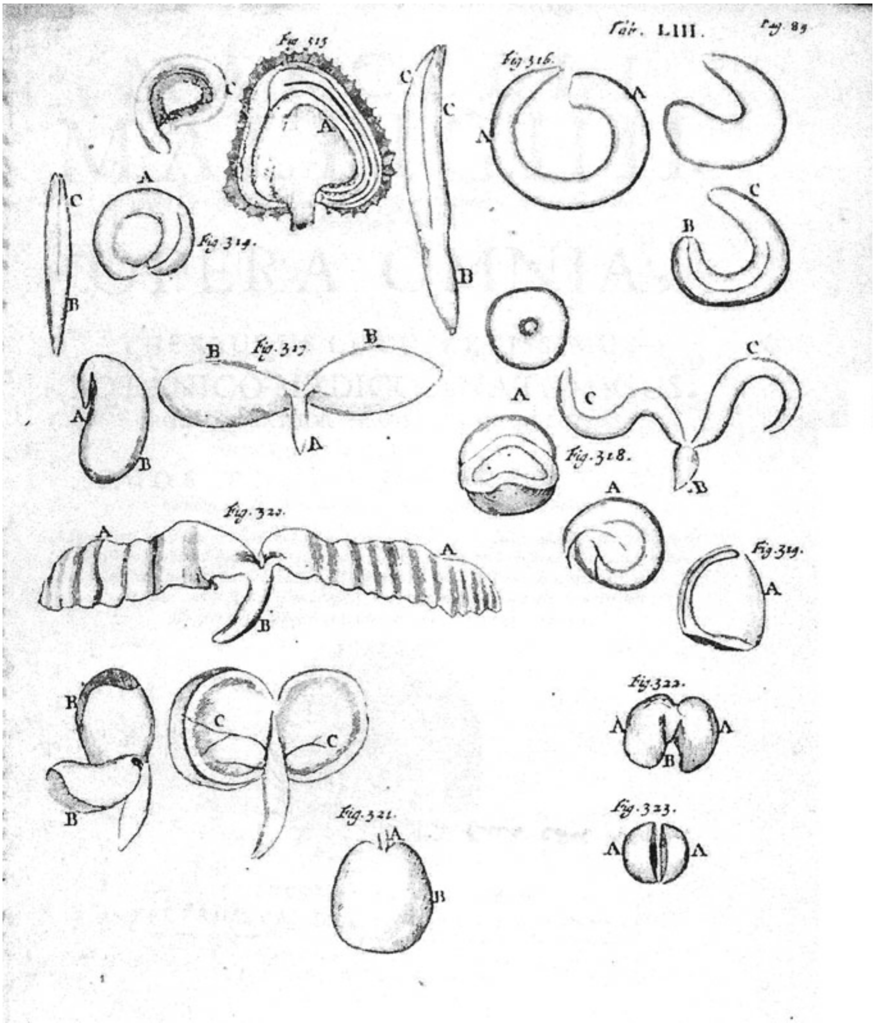

Fig. 1.26 Above left are the germination phases of beet seed: "… the flattened seed cavity contains the embryo (**a**); the rootlet is pushed by the elongated plantula (**b**), which bears two thick and equal cotyledons (**c**) (Malpighi 1675)

to the top of head of a lance … And for *potamogaton*, which signifies a neighbor to the riner or water, I thinke it loves the water as well, and is as neere a neighbour to it as that which takes its name from thence and is described by Dioscorides. Now to come to Pliny, he calls it *Beta sylvestris*, *limonium* and *neuroides*. The two later names are out of Dioscorides, and I shall shew you where also you shall finde the former in him. Thus much I thinke might serve for vindication of my assertion, for I dare boldly affirm, that no late writer can fit all these names to any other plant; and that makes me more to wonder that all our late herbarilists, as Mattioli, Dodoens, Fuchs, Cesalpino, Dalechamps, but above all Pena and de Lobel, should not allow this plant to be *limonium*, especially seeing that Anguillara had before or in their time asserted it so to be: but whether he gave any reason or no for his assertion, I cannot tell because I could never by any means get his opinion, but onely find by Bauhin *Pinax*, that such was his opinion hereof".

John Ray extended and corrected the intuitions of Cesalpino (Gray 1821). In "*Historia plantarum*" (Ray 1693, 1724), he described *Beta sylvestris maritima*, named that by Bauhin and Parkinson. Parkinson also named it *Beta sylvestre spontanea maritima* and *Beta commune viridis* (Parkinson 1655). The species, as suggested by Johnson (1636), resembled *Beta alba*, but it grew in marshy places and, more frequently, along beaches. Ray wrote that the *Beta sylvestris maritima* differed from all other beets because it was perennial, a statement sustained also by Coakley (1787) and Koch (1858). According to Ray, *Beta sylvestris maritima* was similar to *Beta communis viridis*, however, in disagreement with Gerard and Poggi (1636), he found it rather different from *Beta alba*. In "*Methodus plantarum*", Ray (1703) pointed out that the single beet flowers developed seeds with a single embryo (monogerm), whereas multiple flowers developed glomerules containing the same number of embryos as there were flowers (multigerm). Johnson (1636), author of "*The Herbal etc*.", identified *Beta maritima* in the coastal area of Tenet and other locations near the sea, as had been reported by Gerard and Poggi (1636).

The images of *Beta alba*, *nigra,* and *rubra* appeared in the book (Bauhin 1731) with the title "Kräuter Buch" but here the figures were accompanied by a more precise explanation. *Beta sylvestris* was drawn under the heading "Wintergrün" (also called "Holz Mangold", "Wald Mangold", and "Waldkohl"). The book cited several synonyms in various languages (Appendix C): "*Pyrola*", "*Beta sylvestris*", "*Pyrola rotundifolia mayor,*" "*Limonium*" (Latin), "Wintergreen" (English); Pyrol (French), and Pirola (Italian). Under the heading "Wald Mangold", there were the drawings of Gross Limonium, Wald Mangold (*Limonium*, pyrola), and Klein Limonium mit Olivenblätter (little *Limonium* with leaves as olive tree). The figures referred to Wintergrün and Wald Mangold bore no resemblance to *Beta maritima* or *sylvestris*. The same is true for *limonium*, which was repeatedly mentioned in the text.

Beta sylvestri maritima was mentioned briefly by Blackwell (1765), in "Sammlung der Gewächse", the German edition of "*Herbarium Blackwellianum"*. The author clearly distinguished *Beta maritima* from *Pyrola* (Fig. 1.27), instead of treating them the same, as was done by Bock and Fuchs. The names *Beta sylvestris maritima* and *Beta sylvestris spontanea marina* are attributed to Bauhin and de Lobel, respectively. In the treatise were included color illustrations and the description of the characteristics of *Beta rubra vel nigra* (Fig. 1.28).

Zanichelli (1735) reported the "presence of *Beta maritima* in various parts of the lagoon around Venice and in particular around the harbor of Malamocco". This location is near the Lido cited by Soldano (2003). The similarity between the cultivated and wild forms was confirmed, excluding the shape and smaller size of the *Beta maritima* root and its annual life cycle. The observations of Zanichelli were shared by Naccari (1826), who defined the plant as "biennial and bearing sessile flowers,

Fig. 1.27 Pyrola (Blackwell 1765)

Fig. 1.28 *Beta rubra vel nigra* (red or black beet) according to Blackwell (1765)

often lonely". Note that "lonely" could be synonym of "monogerm" in the Savitsky meaning.

The species were ranked under a new grouping called "*genus*" (pl. *genera*) in "*Institutiones rei herbariae*" written by de Tournefort (1700). About 10,000 names of *genera*, including *Beta*, have survived, not only in the Linnaean system (Schultes 1817), but also in the current taxonomy. He cited two species of sea beet: *Beta sylvestris maritima* (also named *sylvestris*, *spontanea*, and *marina*) and *Beta* *sylvestris* (also named *cretica*, *maritima*, and *foliis crispis*). Seed and flower of beets were shown in the third volume of the cited book.

Smith (1803), after an accurate description on some quite original illustrations of *Beta alba* and *Beta rubra* represented without the root (Figs. 1.29 and 1.30), included *Beta sylvestris* under the heading *bistorta*, which "Andere nennen sie *Lappam minorem*, andere *Bardanam minorem*, andere *Limonium*, andere *Britannicam*. Bei dem Plinis heisst sie *Beta sylvestris* (by some called *lappam*, by others *bardanam* or *limonium*. By Pliny, it was named *Beta sylvestris*").

The first published work of Linnaeus (1735) was *Systema naturae*. Every plant was identified by the name of the species preceded by the corresponding genus as was done by Cesalpino and Bauhin. The main part of botanists and zoologists rapidly adopted this system. Linnaeus (1735) observed that beet, if returned to the wild environment, never took the original form of sea beet. Therefore, the two types were

Fig. 1.29 *Beta rubra* (Weinmann 1737)

Fig. 1.30 Drawing of sea beet showing the development of seed on the stalk, the shiny leaf blades of different shape/dimension and some red-veined parts

classified as distinct species: *Beta vulgaris* and *Beta maritima* (Figs. 1.31 and 1.32). The first included all cultivated varieties, the second derived directly from "the native original unknown species, probably extinct in the prehistory" (Ford-Lloyd et al. 1975; Greene 1909a, b).

The Gardner's Dictionary (Miller 1768) declared that sea beet "is probably the parent of all garden beets". Hill (1775) described the drawings of three types of beet: "common", "ciclane", and "sea beet". The first had the leaves more or less colored in red, it is biennial, and native of the coasts of Italy. The second one had light green leaves and corresponded to *Beta cicla*. The third one also was biennial and native to the English coasts. Hill reported, "It has been said that the first two species were produced by culture from this. Tis soon said, but will not bear enquiry; at least, experience here at Bayswater, perfectly contradicts it". Hill's posthumous edition of

Fig. 1.31 Stalk and seed of *Beta maritima* (Linnaeus 1735)

Fig. 1.32 Close up of the former figure (Linnaeus 1735)

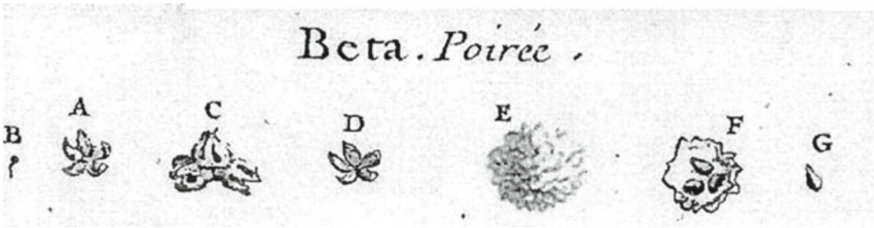

Fig. 1.33 Flowers and germinating seeds of *Beta maritima* on the "Encyclopedie" (Lamarck 1810)

the book "*Synopsis plantarum*" (written by Ray) was among the first to adopt the new taxonomic system of Linnaeus.

Smith (1803) gave us, along with a colored drawing of *Beta maritima*, a precise description of its morphology and physiology. The stem "bears in the axils clusters of small leaves and flowers solitary or in pairs". Smith argued that sea beet is certainly distinct from *Beta vulgaris*, as described by Linnaeus, since it flowered during the first year. He stated that "With us it appears to be perennial, flowering in August and September. The stigmas are very frequently three in number". Also Hardwicke (1887) confirmed never having seen beet flowers with more or less than three stigmas.

Lamarck (1810) briefly described *Beta maritima* in the Encyclopèdie edited by Diderot and D'Alambert (1751). The drawing (Fig. 1.33) illustrates the characteristics of the seed stalk and flowers. He cited Oliver de Serres, who, describing some red beets "just arrived from Italy", referred to the sugar syrup extracted from the roots. This observation likely addressed Margraaf's (1907) research in obtaining crystals of sucrose from beet juice. The adventure of sugar beet crop began at the end of the same century (Achard 1907; von Lippmann 1929).

A very original description of *Beta maritima* was given by Gray (1821) "Stem prostrate at bottom; lower leaves triangular, petiolate; flowers solitary or in pairs, lobes of the perigonium quite entire. Root: black, internally white, stems many, much branched at the top; flowers racemose". By the end of 1700, countless reports on the local flora had been published. These sorts of surveys, which gradually ceased in the subsequent century, are still useful for locating the ranges of wild species and detecting any changes in their geographical distribution and botanical characteristics (Jackson 1881).

1.6 Age of Science

After the rediscovery of the experiments of Gregor Mendel (Tschermak-Seysenegg 1951), botany gradually evolved from the mere description, localization, collection, and classification of plants, primarily toward studies aimed at physiology and scientific improvement of the production traits. Mendel (1865) established the fundamental "laws of inheritance", which became the basic rules of the modern plant breeding (Allard 1960; Fehr 1987; Poehlman 1987). Initially plants were evaluated by investigating their behavior in homogeneous environments, and then they were selected, crossed, and reproduced using appropriate systems (Bateson 1902).

By the beginning of the 1800s, beet varieties adapted to sugar production were being selected in Germany. In the course of only a few years, sugar production quickly became the most important use of cultivated beet. In France and Germany, private seed companies began breeding programs that were very successful in improvement of sugar production, mainly through mass selection. Genetics, breeding, plant pathology, and other disciplines took advantage of the advances in analytical instrumentation (i.e. the polarimeter), primarily developed for rapid analyses in sugar factory (de Vilmorin 1850, 1856). de Vilmorin (1923) successfully developed the first methods of family selection.

Brotero (1804) identified populations of sea beet "*ad Tagi ripas, et alibi in maritimis*" (along the Tagus River, Portugal, and in other marine sites). The plants exhibited the following traits: "*caulis ex decumbenti erectus; flores saepius gemini, axillares, sessiles, in spicam foliaceam tenuem digesti*" (the stalks are prostrate or erect; flowers are often twin sessile flowers located in the bract axils). They are not distributed closely on the leafy inflorescence. Another detailed description of some sea beet traits was given by Baxter (1837): "Roots: large, thick, and fleshy, blackish on the outside, white within. Stems: procumbent at the base, from 6 inches to 2 feet long, angular and furrowed, alternatively branched, leafy, often reddish. Root-leaves: large, spreading, slightly succulent, stalked, egg-shaped, veiny, and more or less wavy at the edges. Stem-leaves: nearly sessile, alternate, and, in consequence of the position of the stem, oblique or vertical. Flowers: greenish, usually in pairs, rarely solitary, sessile, in the axils of the leaves, of which the uppermost are diminished almost to bracteas". A similar description was given by Hooker (1835).

Reichenbach and Reichenbach (1909) confirmed that:

> "*Est planta silvestris a qua omnes betarum stirpes culti originem trahunt*"
>
> (There is a wild plant from which all the cultivated beets originated)

The plant also may be annual, and it grows "*in omnibus terris mediterranei*". Another brief description of *Beta maritima* was given by Bois (1927):

> "*C'est une plante vivace ou bisannuelle, à racine dure et grêle, à feuilles un peau charnues, les radicales ovales ou rhomboïdales, les caulinaires ovales ou lancéolées*"
>
> (Sea beet is a vivace or biennial plant, with hard and skinny roots, the leaves a little fleshy, oval and rhombic if developed from the root, oval and pointed if attached to the stem)

With the theory of inheritance allowing the basis for plant breeding, statistics provided a tool to maximize the gain that plant breeders could make with their selections. Much of this work was begun on crops such as maize, wheat, barley, and so on (East 1912; East and Jones 1919). Statistics and field plot design were valuable tools in the improvement of sugar beet as well (Harris 1917); it was immediately recognized as a powerful mean for reducing error when evaluating the results of replicated field trials. Rimpau, Schindler, and Munerati were among the first researchers who focused their research primarily on sugar beet. But von Proskowetz was certainly the first to understand the importance of *Beta maritima* not only as a donor of useful traits but also to perform the first crosses with the commercial varieties (Kajanus 1910).

The book written by von Lippmann (1925) provided an excellent summary of these early researches. But the basic contribution by Mendel was at all ignored by the book. At this time *Beta maritima* began to be regarded as a potential source of useful traits for beet crop. The same was tried for other species in the genus *Beta*, but there were problems still existing in obtaining viable hybrids (Rimpau 1891; Campbell and Russell 1964).

Publications concerning medicine and botany were written or printed primarily as books until the end of seventeenth century. These books rarely included sea beet. Since then, journals, reviews, and proceedings of scientific societies have become prevalent. Although the number of papers reporting on sea beet has increased almost exponential over the last decades (www.newcrops.uq.edu.au), only a few book chapters and dissertations on sea beet have been edited. No book has been published until the first edition of this book.

Historically, publications have been written in the dominant scientific language of the time: Greek and Latin until the Imperial Period of Rome, Latin until Linnaeus and beyond, and German until World War II. Since then, English has gradually become the dominant language of sciences. Unlike other sciences, botany retained the traditional use of Latin until the early eighteenth century. Also for this reason, it was customary for botanists to adopt Latin names (pseudonym or pen name) until around the end of sixteenth century. The German language dominance lasted longer in botany than in other sciences, especially in studies related to sugar beet, in part because the crop and its technology were born and developed in Germany. Many of the fundamental books on botany were written in German in the seventeenth century. As medical plant, sea beet was mentioned primarily in books printed in Latin and German; the species was almost ignored in the English literature until the beginning of the last century. The literature on botany and medicine written in Arabic from the ninth to twelfth century was also important. From fourteenth century onward, important works were published in many other languages (English, Italian, French, Spanish, etc.). In the last few decades, English has become dominant because, among other things, the important journals are published in USA and UK. Almost all papers on sea beet published by international journals, certainly in the last three decades, have been edited in English.

1.7 State-of-the-Art and Prospects

For the presence in the same environment of different types of beets perfectly interfertile (*Beta maritima*, *Beta vulgaris* crops, seed production fields, ruderal, weed, and feral beets), condition rarely possible for other crops, *Beta maritima* is becoming a reference plant for other species and disciplines (Auer 2003). This is proved by the growing number of publications dealing with the plant. This is true especially for the research regarding molecular biology.

The major risk for survival of sea beet germplasm in natural condition is represented by the climatic changes, which, at least in Europe, seems reducing significantly the amount and the frequencies of summer rains. Taking the Fig. 1.1 as an example, it is easily foreseen that the life of the represented plant is closely linked with the rain water supply. In slightly better situation, lives the great part of *Beta maritima*, that is on sandy or stony soils, without water capacity and not or rarely provided by water table. In these conditions, the minimum shortage or delay of rain can represent the death of the plants. This is the situation observed recently in some sites of West Adriatic Sea, once composed by hundreds of individuals, where the plants are completely disappeared.

The in situ organization and conservation of sea beet populations worldwide will be an important mean to follow and at due time utilize the reactions induced by the new climatic conditions. As regards, the tolerance to abiotic stresses, until now without significant results, the in situ selection of *Beta maritima* in environments, where selection pressures modified the population originating adaptive ecotypes, will enable to identify potential hotspot of genetic diversity in order to enhance the tolerances to abiotic stresses (Monteiro et al. 2018).

Thanks to the expected development of molecular analyses and the still quite unexplored germplasm of garden and leaf beet (Cheng et al. 2011), many progresses are still possible against diseases and stress.

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