II. The Features of Seabuckthorn

Name and Taxonomical Position

Seabuckthorn is a general term given to the shrub-tree *Hippophae Linn.* This genus belongs to the family *Elaeagnaceae* which consists of several species and sub-species among which the most important is *Hippophae rhamnoides Linn*, commonly known as seabuckthorn. Because it is mainly this species that has been used for economic and ecological purposes, the term 'seabuckthorn' usually means *Hippophae rhamnoides*. This species is widely distributed in many places throughout Eurasia. It has evolved over a long period of time and has varied so much that it has to be classified into different units.

In 1971, Finnish taxonomist Arne Rousi divided this species into 9 sub-species that he found growing from Norway in Scandinavia to the Northeast of China. Of these sub-species, *Hippophae rhamnoides L.*, sub-species *sinensis Rousi*, is commonly used in China. In this paper, seabuckthorn stands for this sub-species or Chinese seabuckthorn. However, the other species and sub-species will also be mentioned because they have many characteristics and can be used in different ways. Arne Rousi recognised three species of *Hippophae*: *Hippophae rhamnoides L., Hippophae salicifolia D. Don., and Hippophae tibetana Schlecht.*

Hippophae rhamnoides L. has been further divided into nine sub-species:

H. Rhamnoides L., Subsp. *carpatica Rousi*
H. Rhamnoides L., Subsp. *caucasica Rousi*
H. Rhamnoides L., Subsp. *gyantsensis Rousi*
H. Rhamnoides L., Subsp. *mongolica Rousi*
H. Rhamnoides L., Subsp. *sinensis Rousi*
H. Rhamnoides L., Subsp. *turkestanica Rousi*
H. Rhamnoides L., Subsp. *yunnanensis Rousi*
H. Rhamnoides L., Subsp. *rhamnoides*
H. Rhamnoides L., Subsp. *fluviatilis Rousi*

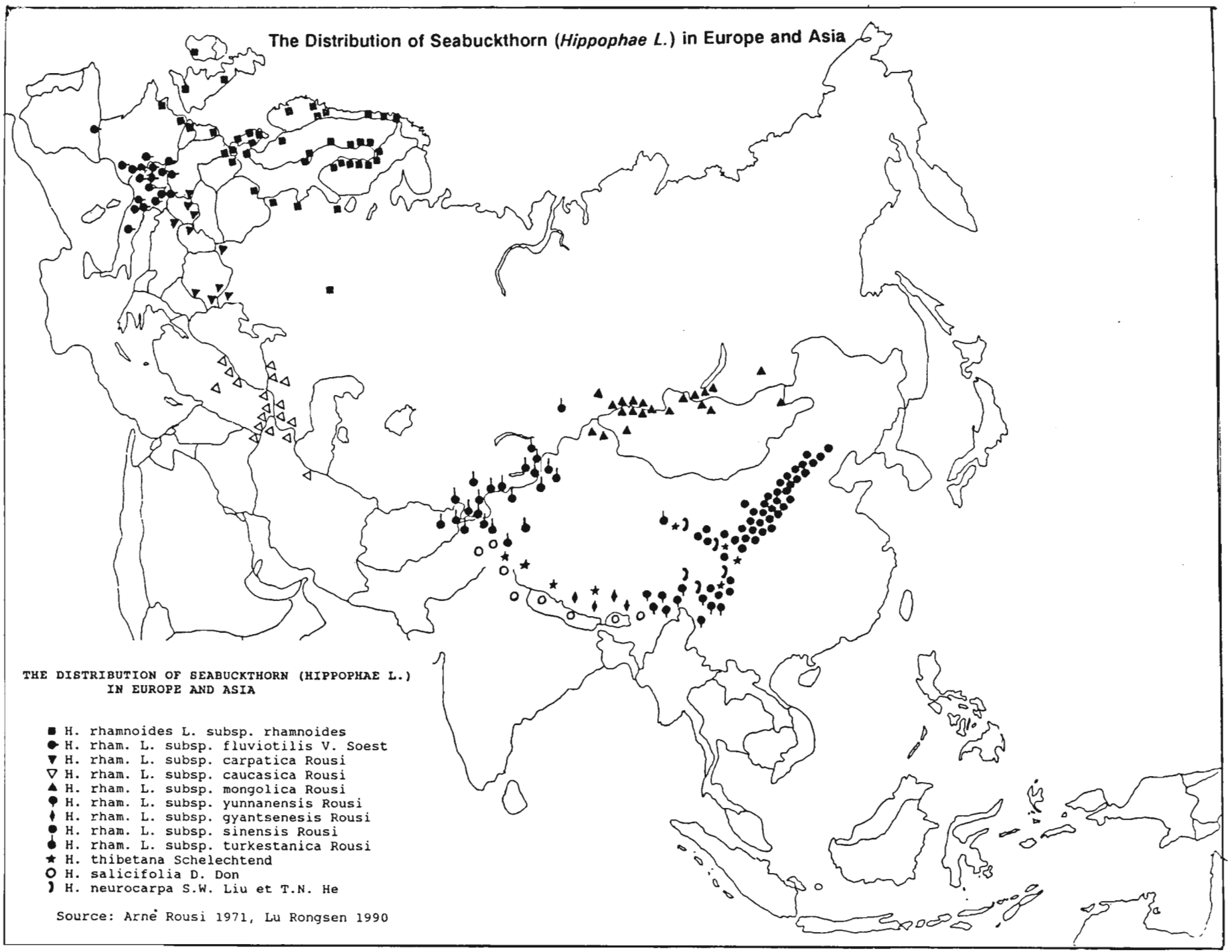
In 1978, Chinese taxonomists, Liu Shangwu and He Tinnong, reported the existence of a new species, *H. neurocarpa S.W. Liu et. T.N. He*, from the Qinghai-Xizang Plateau. Since then four species of *Hippophae L.*, viz., *H. rhamnoides* (including nine sub-species), *H. salicifolia, H. tibetana*, and *H. neurocarpa*, have been recognised by Chinese scientists. In 1988, another Chinese taxonomist, Lian Yongshan, introduced a new classification system for the genus. He upgraded *H. rhamnoides*, subsp. *gyantsensis*, to an independent species, viz., *H. gyantsensis (Rousi) Lian* of the *Hippophae* and introduced two groups, the coat and coatless groups. So, according to Lian's classification system there are 5 species and 8 sub-species. Lian's classification is, however, yet to gain wide recognition.

The distribution of these seabuckthorn species throughout Europe and Asia is shown in Map 1. A general glance at the global distribution pattern of *Hippophae spp.* indicates that it is concentrated in the Hindu Kush-Himalayan Region, adjoining areas of China, and parts of Europe and the former USSR as well as the Scandinavian Region. All of these areas are climatically cold-temperate.

Plant Morphology

Seabuckthorn is a deciduous, usually spinescent, shrub. In exceptional locations, e.g., in the northern or north-western mountain areas of China, it is a small tree growing up to a height of 1 to 5m. However, it can grow up to more than 15 to 18m in forest areas with abundance of water, e.g., on river banks. With brown or black rough bark and a thick grayish green crown, it often forms a massive grove on the river banks or dry river beds. Its natural lifespan appears to be at least 60 to 70 years.

In recent years, many large seabuckthorn trees have been found. In Muli County, Sichuan, there is a tree with a height of 16m, a trunk girth of 5.3m, and a crown diameter of 16.1m. It is estimated that its age is more than 320 years and it is still bearing fruit. Another tree found in Zhongdian County of Yunnan Province recorded a height of 17.5m, a trunk girth of 3.8m, and a crown diameter of 15.5m. It is estimated that its age is more than 300 years.


The Distribution of Seabuckthorn (*Hippophae L.*) in Europe and Asia
THE DISTRIBUTION OF SEABUCKTHORN (HIPPOPHAE L.)
IN EUROPE AND ASIA
H. rhamnoides L. subsp. rhamnoides
H. rham. L. subsp. fluviotilis V. Soest
H. rham. L. subsp. carpatica Rousi
H. rham. L. subsp. caucasica Rousi
H. rham. L. subsp. mongolica Rousi
H. rham. L. subsp. yunnanensis Rousi
H. rham. L. subsp. gyantsenesis Rousi
H. rham. L. subsp. sinensis Rousi
H. rham. L. subsp. turkestanica Rousi
H. thibetana Schelechtend
H. salicifolia D. Don
H. neurocarpa S.W. Liu et T.N. He
Source: Arne Rousi 1971, Lu Rongsen 1990

The leaves are small (usually 3 to 8 cm long and 0.4 to 1.0 cm wide), linear, lanceolate, and covered on the back side with silvery stellate scales that reflect sunshine and reduce moisture loss.

Separate Male and Female Plants

Seabuckthorn bushes are either male or female. The males produce pollen and have flowers without petals. Each flower contains four stamens. When the atmospheric temperature ranges from 6°C-10°C, the anthers split and the pollen is blown out by the wind in large quantities. The females produce fruit and seeds and have flowers, also without petals. Each flower contains one ovary and one ovule. The female flower depends almost entirely on the wind for pollination.

Neither the male nor the female flowers have nectaries, so they cannot attract bees or other insects to collect nectar. Honeybees and a variety of other insects often visit the male flower only to forage pollen for protein, but they rarely visit the female flowers.

Seabuckthorn floral buds are mostly mixed with vegetative buds and are rarely pure. Floral buds appear on the current season's growth, mainly in the summer or the autumn. They usually open in the following spring.

Generally, the male floral bud consists of four to six flowers, the female floral bud consists of one flower and rarely two or three. The sex of a young seabuckthorn plant cannot be judged until the first flower buds appear. In precocious plants this may be in the third year, whereas in slow plants it may happen in the fifth or the sixth year. This makes it difficult to identify and give the right position to the male plant in a plantation, or to root out the unwanted male and inferior females when they are at the nursery stage.

Fruit

Seabuckthorn bears a special fruit, that is different from other common fruits or berries. Morphologically it develops from an ovary and a calyx tube which is closely connected to the ovary. Actually the fruit is a combination of an unsplit, fleshy, expanded calyx tube and an ovary. In other words, the expanded, juicy calyx tube is the important part with economic value.

The seed is surrounded by a parchment-like ovarian wall. Usually, the seed is ovate-oblong with a length of 4 to 7 mm, a breadth of 2.5 to 3.5mm, and a thickness of 1.6 to 2.2 mm. The skin of the seed is greyish-brown or dark brown, leathery, and lustrous.

The time taken from flowering to fruit maturation is 12 to 15 weeks. Young fruits are hard and greenish, but turn soft and orange or orange-red as they mature.

Seabuckthorn bushes or trees hold the mature fruit for several months, this gives ample time to harvest them. In a natural seabuckthorn forest, fruits can remain on the branches until the following spring. During this period (usually cold winter), the fruits gradually shrink but do not fall. Therefore they become the favourite food of animals, especially birds.

Roots

Seabuckthorn has a very strong root system that taps the underground moisture. Bushes that are a mere 5 years old have been found with taproots of up to 1.10m deep and horizontal roots of up to 2.58m wide in the Loess Plateau. Some mature shrubs have been found with roots extending as far as 10m in a horizontal direction. Some 80 per cent of its feeding roots are in the topsoil (0.2 to 0.8m). Often young plants have taproots twice the height of the plant and root widths three times wider than the crown of the plant above the ground. With its strong root system, seabuckthorn can suck up more water and fertiliser than other plants.

The seabuckthorn root system is so extensive that its roots can branch many times in a growing season and form a complex network of roots. A lot of root turion seedlings grow upwards from the horizontal roots and form new bushes. When plants are buried with sand and mud sediments, massive adventitious roots grow from root collars. Some of the adventitious roots extend to form a new horizontal root system. From this, new turion seedlings grow again. In other words, one plant will propagate massive bushes or a small forest in several years. This is the reason why seabuckthorn bushes play an important role in protecting river banks, preventing floods, and clogging mud which would otherwise be washed away in flood waters. In fact these bushes are more effective than any construction work.

A symbiotic mycorrhizal fungus, which is identified as *Flankia*, has been found on seabuckthorn roots. This

symbiosis between the fungus and seabuckthorn results in root nodule formation that can fix the maximum amount of atmospheric nitrogen. It is estimated that the capacity of seabuckthorn roots to fix nitrogen is twice that of soyabean.

A land covered with six year old seabuckthorn bushes contains organic matter of up to 2.2 per cent and nitrogen of up to 0.12 per cent; i.e., 12.2 times and 1.9 times higher respectively than land located on river banks in the same area.

Besides fixing nitrogen, the perennial root nodule has the function of transforming difficult to dissolve organic and mineral matter into an absorbable state.

Environmental Requirements

Temperature

Seabuckthorn belongs to the group of thermophilic plants. This can be proved by examining its germination temperature. Usually, the seeds of apple and cherry germinate at 1 to 3°C, having passed through their physiologically dormant period. But seabuckthorn needs a higher temperature than these plants. For example, at 10-12°C, only 13.2 per cent of seabuckthorn seeds germinate over a period of 47 days. But if the temperature goes up to 24-26°C, 95 per cent of the seeds will germinate within six days.

Notwithstanding, an adult seabuckthorn plant can withstand extremely low temperatures; during the winter season air temperatures of -10 to -13°C are common in its natural habitat. It has been reported that seabuckthorn can endure an extreme minimum temperature of -40.4°C (in Northern China) and -43°C (in the Gorky State of the former USSR) without sustaining long-term damage.

It would appear, therefore, that low temperatures during winter are not an important limitation to seabuckthorn cultivation. On the other hand, the high temperature during summer (maximum air temperature >30°C, maximum ground surface temperature >55°C) often causes burning on seedlings, sometimes killing them. This is the reason why efforts to introduce seabuckthorn from mountain areas to the plains have often failed.

It has been mentioned that *Hippophae* contains several species and sub-species that are widely distributed throughout various physical environments of Eurasia, therefore it is understood that they survive in different climatic conditions. The Chinese seabuckthorn (*H. rhamnoides L.*, subsp. *sinensis*) spreads throughout vast mountain areas with annual mean temperatures of 3.6 to 10.7°C. The Central Asian seabuckthorn (*H. rhamnoides L.*, subsp. *turkestanica*) is distributed throughout the arid desert area where the annual mean temperature is from 2.7-7.5°C. The Tibetan seabuckthorn (*H. tibetana*) is scattered throughout the cold plateau where the annual mean temperature is from -4.7 to 1.1°C.

Moisture

Generally, seabuckthorn is a hydrophilous plant. Its natural habitat, where it thrives well, includes river banks, valleys, and shady slopes of mountains where air temperatures and soil conditions do not suit many agricultural crops. Most natural populations grow in areas receiving 400 to 600mm of annual precipitation. Seabuckthorn should not be planted on sites where the rainfall is less than 400mm, the underground water below 2m, and where there are no irrigation facilities.

In some places, although precipitation is from 400 to 500mm, soil moisture could be critical during the spring season, the period during which flowering and young fruit development occur. Owing to the spring drought, the young fruits could wither or fall.

For economic reasons, 600 to 700mm of annual moisture appears to be most suitable for establishing plantations, and, in most areas, it is probably needed to ensure commercial success. However, where drainage is good, extra water may not be detrimental; seabuckthorn has been observed to grow satisfactorily along river banks where flooding often takes place, especially in summer.

Natural seabuckthorn populations are widely distributed throughout the temperate zones of Asia and Europe and in the subtropical zone of Asia at higher altitudes. In the mountain areas, the most suitable altitudes are between 1,500 to 2,500m, where precipitation is about 600mm and the annual mean temperature about 4° to 8°C, as a result of which plants grow well and produce large, good quality fruit.

Altitudes between 1,000 to 1,500m, where precipitation is about 500mm and the annual mean temperature is 8 to 10°C,

are also suitable and plants grow and bear normally. But altitudes below 1,000m and above 2,500m are not so suitable, and, although plants do grow, they produce small and poor quality fruit.

Although seabuckthorn is a hydrophyte, as described above, it has developed some xerophytic features over its long evolutionary course. For example, its leaves are small and narrow, covered with thick cuticles and dense stellate hairs on the back, and there are lots of thorns on the stems. All these features help seabuckthorn to reduce water drainage; thus seabuckthorn can withstand atmospheric drought. Massive seabuckthorn bushes with good flowers and fruit exist in the arid river valleys of Central Asia, Kazakhstan, Azerbaijan, and Xinjiang, China, where precipitation is less than 400mm, the weather windy and dry, and where there are many hours of sunshine. This demonstrates the above-mentioned characteristics of seabuckthorn.

Wherever the plant is grown, good drainage is vital; seabuckthorn cannot survive water logging. Marshy wasteland should never be planted with seabuckthorn, because the root system would be destroyed because of the lack of oxygen.

Soil

In the natural environment, thriving seabuckthorn plants are found on sloping, well-drained soil with silt and on the banks of rivers, lakes, and seashores. This is the reason why many researchers considered these soils to be most suitable to the biological characteristics of seabuckthorn. Indeed, these soils provide seabuckthorn with enough water, air, and fertiliser, thus making it grow well and producing fine fruit. Some plants have proved successful even on sandy soils and stony soils. Heavy clays may be suitable in some areas but only if internal drainage is good. The plant cannot withstand soils with poor porosity. Excess water and lack of air would kill the plant.

Extensive measurements taken for wild seabuckthorn populations in north and northwestern China have shown that the plants thrive in soils ranging from pH 6 to 7, but in other places, they have been found in soils ranging from pH 5.5 to 8.3. This indicates that soil acidity and alkalinity are probably not limiting factors. For a long time, there has been a wrong notion that seabuckthorn as a plant does not need more soil nutrients. This is not true. The experiences on plantations have shown that the productivity of seabuckthorn can be increased greatly by providing enough water and fertiliser. For example, in Lisavenko Institute of Horticulture, Siberia, the yield of cultivated seabuckthorn increased up to 13,000 kg/ha (the yield of natural bushes is only 300-700 kg/ha).

In fact, seabuckthorn needs more nutrients during the period of growth and fruit development. Seabuckthorn can obtain nitrogen through root nodules from the atmosphere. On the Loess Plateau, China, where seabuckthorn populations dominate, the soil has been reported to be phosphorus deficient, but further studies revealed that seabuckthorn rhizosphere soil contains 2 to 5 times more rapidly available phosphorus than soil without roots. This means that the secretion of the root can transform the insoluble phospho-calcium compound ($[Ca_2\ (PO_4)_2]_3\ CaCo_3$) into soluble phosphorus, which is then absorbed by the roots.

Salinity

Seabuckthorn is also a salt-tolerant plant as has been demonstrated in many places, e.g., Siberia, Central Asia, Azerbaijan, and Xinjiang, China, where seabuckthorn populations grow well on the soils of wastelands, deserts, and dunes of the seashore that have highly concentrated salt contents.

When tested in the laboratory, some varieties of seabuckthorn showed increasing growth of seedlings when about 0.15 per cent of sodium chloride (NaCl) solution was added. Furthermore, before sowing, soaking seabuckthorn seeds in 0.15 per cent of NaCl solution for 24 hours not only produced healthy seedlings but also increased the output of standard seedlings in nurseries.

An experiment carried out in Shaanxi, China, showed that seabuckthorn bushes can be used to reduce salinity: a plot was planted with willow and it contained 0.32 per cent of salt, but, when the plot was planted with willow and seabuckthorn, the salinity decreased to 0.1 per cent. Long-time tolerance of salinity on plantations has not been demonstrated, especially in irrigated conditions. The build-up of salinity in the root zone could be a future problem for plantations with restricted drainage and which contain salt water.