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Domestication and morphological variation in wild and cultivated populations of Cornelian cherry (*Cornus mas* L.) in the area of the Drvar Valley, Bosnia and Herzegovina

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Abstract

Cornelian cherry has a profound cultural and traditional meaning to the people of the Drvar Valley. It is utilized by the people for its edible fruit from both the wild and cultivated populations originating from the area. The management practices involve basic extensive cultivation methods as clearing space around the selected trees, thus enhancing the growing conditions and propagation by seedlings and layering of the desired individuals with better yield and bigger fruit. Cherries are utilized by processing it for food and drinks for purposes of consumption and commercialization. Cultivated and wild populations are compared here in order to assess the level of changes, directions and the degree of domestication. Cornelian cherry fruits from the cultivated populations are significantly larger and heavier than those from the wild populations. Trees are better yielding and generally, the fruit related characteristics significantly differ between the cultivated and the wild populations. It appears that the people of the Drvar Valley have influenced such improvement by means of long term selection and cultivation thus creating distinguished domesticated populations i.e. landrace of Cornelian cherry in the Drvar Valley. The ongoing domestication process of this plant species is documented by collecting and comparing the biological characteristics of the populations, as well as the ethno-botanical information vital for understanding the domestication and cultivation processes.

Keywords: Cornelian cherry, *Cornus mas*, domestication process, landraces, Drvar Valley, ethno-botany

Contents

Introduction

"Among the forest trees, the first that blossoms in the course of nature is the elder, which has the most pith of any, and the male cornel, which has none at all."

Pliny the Elder (2nd century AD)

Many authors have defined domestication as an evolutionary process determined by human intention to model the living organisms according to human needs (Darwin 1859; Casas et al. 2003; Hancock 2004). Therefore, domestication as such is an evolutionary process in which human selection is the crucial force in causing the changes in populations. The principal result of the process is that domesticated populations diverge from their parental wild populations in morphological, physiological and behavioural features that are favoured by the domesticators. Brown et al. (2009) define it as "domestication is the outcome of a selection process that leads to plants adapted to cultivation and utilisation by humans" in their comprehensive and novel approach. In the recent years there has been gradually raising interest in Cornelian cherry and there are ongoing processes of further domestication of the species (Klimenko 2004).

Taxonomy and ecology of Cornelian cherry

This fruit producing wild tree species, indigenous to South and Central Europe and South-West Asia, can nowadays be found in many other areas where it has been naturalized (Wiersma and Leon 1999; Mabberley 2008). Indeed as shown by Xiang et al. (2005) the entire genus originates in Europe from where it has spread throughout the world. Wiersma and Leon (1999) describe the genus *Cornus*, part of the family Cornaceae, order Cornales, is represented worldwide with about 60 species that are perennial, semi-woody herbs, shrubs and small trees, mostly in temperate climate zones. Mostly deciduous, but some are also evergreen, leafs opposite, simple, entire, with prominent venation. Flowers are generally small, white, green-white or yellow, gathered in inflorescence and the fruit is a two-seeded drupe (Griffiths 1994).

C. mas (synonym *Cornus mascula*) or Cornelian cherry, Cornel (Engl.), Körsbärskornell (Sw.), cornullier mâle (Fr.), cornejo macho (Sp.), corniolo maschio (It.), Kornelkirsche (Ger.), dren, drijen, drenic, drenjina, drenjak (Serb.) is a prominent member of this genus. It is deciduous plant with a growth habit that varies from bushy shrub with a spreading canopy to a small tree that can be about 5 meters high. According to Griffiths (1994) leaves are 4 to 10 centimetres long, ovate, apex acute, base tapered or rounded and dark green. Cornelian cherry flowers are small, bright yellow in flat topped cymes

that are about 2 centimetres wide and blossom before the leaves develop in spring. Fruits are bright to dark red or even yellow and oblong cherries with astringent taste (Griebel 1917; Klimenko 2004).

Cornelian cherry is easily grown plant that succeeds in moderate soil, but also grows well in clay soils (PFAF 2000). The soil acidity can vary from slightly acid to chalk. Plants are hardy and resistant. It naturally propagates by seed. According to PFPF Species database (2000), the seeds are sown when ripe and without fruit flesh since it inhibits the germination. Stratification is recommended and the germination can take as much as 18 months. Vegetative propagation can be done by cuttings of half-ripe shoots that are sown in frame in July/August, or mature wood from the current year's growth that is put in frame in autumn, or by the layering of the new growth in spring (PFPF 2000). According to the same source, seedlings can take even 20 years until the full production but live much longer than the cuttings, which come in the production much earlier.

Chemical properties

Astringency is one of the characteristics of the fruit, as well as high percentage of vitamin C that amounts up to 145 milligrams per 100 grams of fruits and it is used in the traditional medicine, with effects acknowledged by the modern medicine (Jacimovic & Bozovic 2007). The fruit contains tannins, sugars, pectin, organic acids, etc. (Bijelic et al. 2007). Moreover, the content of various anthocyanins (Du & Frederic 1973) and antioxidants is high, with bioactive functions (Seeram et al. 2002) and with anti-oxidant, anti-inflammatory, anticancer and anti-diabetic activities (Turyanitsa et al. 2006).

Utilization and cultivation history

The Cornelian cherry has been utilized by the people in the Balkans for many thousands years and it has been documented in human settlements since the Neolith (Kroll 2000; Jeraj et al. 2009). Written records can be found throughout the antique as it has been mentioned in the contemporary literature of the time. One of the oldest documents on the use of Cornelian cherry for food is the Homer's Odyssey (800 BC). The Iliad's Wooden Horse of Troy itself was mentioned according to Pausinias' History of Greece to be built from Cornelian cherry wood.

Due to hardiness of the wood, the tree was used for items that required tough material. One of the first testimonies of this kind is from the Xenophon (5th century BC) describing the weapons made of the Cornelian cherry wood in his book Hellenica and On Horsemanship.

In the Natural History of the Fruit Trees and other places in the History of Nature, by Pliny the Elder (1st century AD) Cornelian cherry is described in a number of places. Though he mostly writes about the Cornelian cherry amongst the forest trees, there is mentioning of the cultivated Cornelian cherries in his Book on Fruit Trees and in the Book on Remedies Derived from the Cultivated Trees, both part of the History of Nature (Pliny the Elder, 1st century AD). All early documented uses of Cornelian cherry is best summarized by Pliny the Elder who describes the species as being used for edible fruit, medicine, wood and pesticide.

Many of those areas of use have been lost over the years, hence at present the Cornelian cherry is used mainly for decorative purposes and to some extent for gathering fruit from the wild (Ercysly 2004; Jacimovic & Bozovic 2007; PFPF 2000). There are also present selection efforts with the aim of creating new high yielding cultivars in Ukraine (Klimenko 2004) and in Serbia (Bijelic et al. 2007).

Tradition and use of Cornelian cherry by people of the Drvar Valley

As noted in the book on people's believes and customs of Serbs the Cornelian cherry is equivalent of "the health" itself (Rajic 2002), hence the traditional saying "Zdrav kao dren" (eng. Healthy as Cornel) is deeply rooted in Serbian culture and as such represents the general motto of the Cornelian cherry growers in Drvar Valley, which is written on their products and expressed at gatherings and festivals. Many traditions involving the Cornelian cherry, such as personal names and surnames, as well as names of places, mountains, towns and villages named after the plant point to the long tradition of use and profound cultural meaning of the Cornelian cherry among the Serbian people (Milojevic 1871; Djokic 2002; Rajic 2002). The relationship of the people to the Cornelian cherry tree goes so far that Rajic (2002) writes the Serbs "believe that Cornelian cherry is the healthiest thing in the world". It plays part in the national medieval Serbian epic poetry (Low 1922), Christmas, Easter, Pentecost and other holiday traditions to that extent that people sometimes "take the holy communion" of Cornelian cherry buds (Djokic 2002; Jokic 2008).

There are many old customs related to Cornelian cherry, especially as the symbol of health among the people of Drvar Valley. Even nowadays, some mothers take newborn baby under the Cornelian cherry, 'for the health' of the baby. Bundle of a newborn's hair is dug under the tree for the same reason. In the surrounding of the traditional household in the Drvar Valley you often find several Cornelian cherry trees.

Cornelian cherries are collected for many purposes, for example: to be consumed fresh, processed in jams, juices and compotes. The cherries are also used to produce the characteristic brandy "Drvarska drenja", known as sui generis trademark of the area. During the late summer and early autumn general practice for the majority of the rural households is to harvest the cherries and prepare food from it for the winter.

Domestication and cultivation practices as the aims of the study

The fruit is obtained from both wild and cultivated trees. Although there is a long history of use of the cherries, it is not known exactly when the people in Drvar Valley started to cultivate it. There are practices of extensive cultivation at several levels, such as silvicultural practices of clearing the vegetation around wild grown trees that leads to increase in both the quality and the quantity of the fruit. People have also brought the superior seeds and plants from the wild to their properties and even into their home backyards.

Having in mind the age of the trees on a number of the properties in the Drvar Valley, some of those cultivation practices might have started many centuries ago. Several researches have lately shown that there is definite change in morphological characteristics patterns due to such extensive cultivation practices and a human selection as part of it (Arellano & Casas 2003; Casas et al. 2007). They demonstrated that changes in morphological variation patterns are visible at the level of silvicultural management and cultivated populations in comparison to the wild populations.

Baring in mind all the positive characteristics of the Cornelian cherry and contemporary efforts in creating new cultivars, as well as the reputation of the Drvar Valley for its traditional production of the Cornelian cherries, it was interesting to study the level of domestication of the species in the perceived cultivated Cornelian cherries of the Drvar Valley.

During the recent war all of the households in the Drvar Valley were abandoned. Several years thereafter, people started to return to their devastated homes and farms where the orchards due to the long time without cultivation were in bad condition, but Cornelian cherry trees bear fruit normally. Many growers said that this "saved them" at the time they returned to their homes. The fruits were used as a fresh food, winter food and they also contributed to the house budget by cherries and products from it being sold. This influenced people to return to the old practices of using Cornelian cherries and at the same time revive the traditional knowledge of utilization, selection and cultivation. These circumstances created situation where it was possible to study processes of domestication which are currently ongoing, but also to

reveal how the domestication could have operated in the past. This would help to discover valuable practices, reveal domesticated populations and landraces..

Hypothesis

It is my hypothesis that people of the Drvar Valley are practicing selection work on Cornelian cherry and by doing so they are increasing the number of individuals with favourable characteristics. As a consequence of this practice a certain level of domestication of Cornelian cherry would follow. The purpose of this work was to test the hypothesis by identifying the plants and cultivated populations and comparing their morphological variation with wild populations in the same area.

Materials and methods

"The Sauromatae have no iron, neither mined by them selves nor yet imported. They have, in fact, no dealings at all with the foreigners around them. To meet this deficiency they have contrived inventions. In place of iron they use bone for their spear-blades, and Cornelian cherry wood for their bows and arrows."

Pausanias (2nd century AD)

Study area

The study has been conducted in the Drvar Valley, located south-west of Banja Luka. The valley is dominated by the town of Drvar and the River Unac drains the basin. It covers about 100 square kilometres. The valley is located within the limestone and dolomite area of the inner Dinaric Alps. The edges of the valley are bordered by the mountains Sator and Vijenac on the south and south-west, the mountains Lunjevaca and Osjecnica in the north and north-east and the mountain Vucjak in the west. According to Hydrometeorological Institute FBH, the region has an alpine mountainous continental climate with influences of Mediterranean climate. Precipitation is about 1250-1500 mm per year and annual temperature averages at about 11° C. Huseljic et al. (2007) indicate that soil is the red soil rich in carbonates and that area lacks surface water.

However, the region constitutes a reservoir of high biodiversity (Huseljic et al. 2006). One of the best indicators of the biodiversity richness is the presence of protected areas – the proposed National Park Una located partly within the Drvar Valley downstream of Unac River and the Forest reserve Lom in the mountains of Osjecnica and Klekovaca on the North. Huseljic et al. (2007) indicate that there are many rare species such as bear, wolf and lynx can be found in the dense fir, spruce and beech forests. The flora in these ecosystems includes the Lilium martagon, Vicia oroboides, Dentaria enneaphyllos, Gentiana asclepiadea, Saxifraga roundifolia, Listera cordata, Goodyaera repens, Platanthera bifolia, Polygonatum latifolium and over 50 kinds of macro-mycetes.

The area has been inhabited at least since the times of the Roman Empire. The diversity of ethnic groups is not high since historically almost 100% of population belongs to Orthodox Serb community.

Cornelian cherry populations studied

As by Arellano and Casas (2003) three wild and three cultivated populations were studied (Fig. 1). The populations of Cornelian cherry are identified as two different types. The first type are the wild populations which are not utilized, or at least not significantly influenced or managed by people.

Figure 1. Illustration of the positions of wild and cultivated Cornelian cherry populations studied in the Drvar Valley (image from Google Earth)

The second type are the cultivated populations which are exploited and used. Wild and cultivated populations were randomly selected on the bases of available information of key informants from the local community. All populations have wild origin, but the utilized ones are to certain extent influenced by people.

Samples were taken from similar locations, but from different populations. The locations should be similar in order to minimize the environmental influences in the comparison between the different populations (Arellano & Casas 2003). Maximum similarity of the location was achieved by choosing populations close to each other. However, the distinction between all the individual populations was ensured through natural separation of the populations, by a dense forest, human settlements, or other natural obstacles. The second item that assured a separation of populations was the distance of at least four kilometres between the different populations, according to Wissemann at al. (2007). The distance between the populations varied from a minimum of four to a maximum of twelve kilometres.

Cultivated population I was located west of the town of Drvar in Bastasi, N 44°23'57" and E 016°19'21". There are around 90 trees, which are generally in good condition. The trees are lined around meadows, which are used as pasture for cattle. Other vegetation is cleared around the trunks. The property and the trees have been in the Puzić family for generations. Mr. Puzic inherited

it from his ancestors, but he cannot say when or by which ancestor the Cornelian cherry trees were established there. Based on his statement that 'most probably his grand-grandfather' established the trees 'probably by clearing other vegetation around the wild growing trees' and on the bases of the growth habit of the trees it can be concluded that the oldest trees are about 150 years old. Mr. Puzić regularly cuts grass and other vegetation under and between the trees and sometimes removes older branches. Annually he puts domestic animal manure under the trees.

Cultivated population II (Fig. 2) is located south of Drvar, N 44°22'06" and E 016°22'17", about 5.5 kilometres from cultivated population I. It consists of about 50 trees managed by the family. The trees are generally in good condition, lined in quite regular rows with about three to five meters distance between the trees and about six to seven meters between the rows. The trees have been in the family for generations and it is unknown to the present generation how it was established. Based on tree growth habit and statements of the owners it is probable that the oldest trees are about 150 years old. Sabljic's put cattle manure under the trees, cut low branches as well as the old, rotten ones. The trees are also pruned, though irregularly, so that the crown becomes less dense and other vegetation under the tree is cleared on a regular basis.

Figure 2. Photo of the cultivated population II. Under the trees visible are the sheets used for picking the cherries. (Photo: Borut Bosancic)

Cultivated population III is located east of Drvar, in Zupa, N 44°17'01" and E 016°31'26". It consists of about 70 trees, densely lined along the edge of meadows. The Cornelian cherries are in good condition. Surrounding vegetation is cleared, though the forest leans on the Cornelian cherries on the other side of the meadow. Mr. Vjestica inherited the trees from his ancestors. He says that the orchard is at least 200 years old, but he is not able to say how it was established. On the basis of observed tree growth habit and owner's statement it is probable that the oldest trees are of about that age. Mr. Vjestica puts cattle manure under the trees, cuts off old and rotten branches and clears other vegetation around the Cornelian cherry trees. This was done 'not so often lately' because he still had not managed to fully return since his family house was devastated during the war, which puts him in a similar situation to all other interviewed persons whose destiny is the same as the rest of the community in the Drvar area.

The wild populations are generally located further away from the settlements. Cornelian cherries are found in patches with scarce vegetation, mostly on the edges of forests. The locations for the wild populations were selected due to more dense abundance of the Cornelian cherries on the specific site, which was found out through observations and information from the local community. The wild vegetation at the localities beside abundant Cornelian cherries consists of Wild roses (*Rosa canina* L.), Blackberry (*Rubus idaeus* L.), Hawthorn (*Crataegus monogyna* Jacq.), Common dogwood (*Cornus sanguinea* L.), Oriental hornbeam (*Carpinus orientalis* Mill.), European hornbeam (*Carpinus betulus* L.), Beech (*Fagus sylvatica* L.) and Silver fir (*Abies alba* Mill.), European oak (*Quercus robur* L.), as well as many herbaceous species like Thyme (*Thymus vulgaris* L.), Meadow saffron (*Colchicum autumnale* L.), Sage (*Salvia sp.* L.) and Cornflower (*Centaurea sp.* L.).

Wild population I is located north-east of Drvar, N 44°23'53" and E 016°25'49". It consists of about 60 trees on the locality in the patch of meadows along the edges of the forest. Trees are generally in good condition. Vegetation around the trees is mostly quite dense, but there are also trees standing alone or in pairs in the meadows.

Wild population II is located west of Drvar, N 44°24'54" and E 016°18'11", about 9 kilometres from wild population I. It consists of about 70 trees located on the edge of the forest and meadows used as a pasture, as well as along the forest pathways. Vegetation around individual trees is dense, but also here there are some individual trees growing in the more open area.

Wild population III (Fig. 3) is located south-east from Drvar, N 44°20'55" and E 016°23'18", some 10 kilometres from wild population II. It consists of about 50 trees located along a pathway of the forest and on the edge of the forest

towards meadow pastures. The trees are generally in very good condition, although growing among other forest edge vegetation.

Ethno-botanical studies on different kinds of use and management (Arellano & Casas 2003) of Cornelian cherry were conducted among people of the Drvar Valley who grow and manage the Cornelian cherries. A survey of structured interviews was conducted among ten households. According to available information collected from informants on the field, that number represents roughly about ten percent of families cultivating and managing the Cornelian cherries to larger extent.

Figure 3. Photo of the part of wild population III, located along the forest pathway. Cornelian cherry trees are easily distinguished from other vegetation by the characteristic colour of the leaves. (Photo: Borut Bosancic)

Ethno-botanical studies

The interviews included questions about management of the trees and its products, in order to find a pattern and to document processes (Have 2004; Thomas 2006) of plant selection and use of the plant. The questions can be found in Appendix 1.

Direct observations

The direct observation was applied to get better understanding and description of the applied selection and cultivation practices used by the interviewed families (Guimaraes & Mourao 2006). Farmers showed their orchards and properties, as well as the methodology they apply and they demonstrated the maintenance of the trees.

Ways of utilisation of Cornelian cherry were presented, as there were also presented ways of medicinal use of the Cornelian cherry and its products. The harvesting and quality criterions have been shown. Direct observation was also used during the survey to get deeper perception of the answers and to validate it (Sunwar et al. 2006).

Morphological studies

Sampling procedure

The specific trees to be sampled from, were selected in the way that all the trees in the population, i.e. on the selected location, were counted in order to collect samples from 15 trees. After counting the complete population the number of counted trees (n) was divided by 15. After that each (n/15)th tree was sampled. Therefore, if population consisted of 90 trees, the number 90 was divided with 15. The result six said that every sixth tree was to be sampled.

Descriptors were observed and described for each sampled tree. Ten samples of leaves with petioles were taken from different parts of a tree and ten samples of ripe fruit with stalks were taken from different parts of a tree. The different parts of a tree were defined by dividing the tree horizontally in 5 sections and vertically into two halves, upper and lower. One leaf and fruit with petiole and stalks were sampled from the five lower sections and from five upper sections of the tree. This way it was assured that all parts of the tree were are represented in the sample. When some trees did not have enough ripe fruit all the ripe fruits found with stalks on the tree were collected to represent the tree.

All the collected samples were than packed in the separate bags and put into portable refrigerators. When the whole population had been sampled all the samples were brought to the measuring location. The measuring methodology was undertaken in the specific pre-programmed way.

Descriptors

Although it was possible to find some standard descriptors used for Cornelian cherry (Demir & Kalyoncu 2003; Klimenko 2004; Ercizly 2004; Bijelic et al. 2007) descriptors for many generative and vegetative parts could not be found. It was therefore necessary to use descriptors of similar species. The best

similarity in descriptors (Rodrigues et al. 2008) was found for sweet cherry (*Prunus avium* L.) and sour cherry (*Prunus cerasus* L.). As shown in Table 1 and Appendix 2, 36 different morphological descriptors were measured. It was an important issue to measure both the generative and vegetative descriptors.

The measurements were performed as follows. First the trees were described and each tree was measured before samples of leaves and fruits were taken from it. The growth habit of the tree was described. The same was done for the tree vigour and general damage. The yield was estimated in relation to the number of fruit on the tree. Up to 300 fruit per tree was considered to be 'very poor', 300 to 800 was considered to be 'poor', 800 to 1300 was considered to be 'low', 1300 to 2000 was considered as 'good' and more than 2000 was considered as 'very good'. The branching of the tree represents the number of branches which comes from the base of the tree. A Cornelian cherry individual is regularly bushy in appearance and number of branches that form the bush was counted.

The first of the fruit related measurements concerne d the degree of cracking. It was measured as follows: no cracking, for fully healthy fruits; small cracks for several dots cracked on the fruit; healed, for those which were cracked, but healed and cracked, for fruit which had major cracks. Fruit shape was measured using a standard model, so it easily could be described as oval, elliptic, round and drop shaped. Fruit length and diameter were measured with the vernier calliper to precision of 1/50 of the millimetre. Weight was determined with precision of one hundredth of the gram. Fruit skin colour was described with help of the ribbon with printed colour scale. Discoloration of the fruit was described as having none, few dots, small and few, big and few and last major discoloration. The descriptor cluster describes how many cherries that grow together, since the fruit grows in groups, like domestic cherries. Fruit volume was expressed as volume of ten fruits, measured in container with precision of tenth part of cubic centimetre. Each fruit has a certain number of leaves near it, which sometimes differ. This number was recorded. Length and width of the fruit stalk was measured with the vernier calliper.

Table 1. Measured morphological descriptors of *Cornus mas*

Descriptor	Units of measure
Tree habit	nominal
Tree vigour	number
Yield per tree	number
General damage on the tree	number
Number of stems	number
Fruit cracking	number
Fruit shape	nominal
Fruit length	mm
Fruit diameter	mm
Fruit weight	g
Ripe fruit skin colour	nominal
Discoloration on the fruit	nominal
Cluster (no. of fruit together)	number
Fruit volume	ml
Number of leaves at fruit/cluster	number
Stalk length	mm
Stalk width	mm
Weight of fruit flesh	g
Flesh firmness	number
Ripe fruit flesh colour	nominal
Flesh taste	nominal
Flesh quality	number
Flesh thickness	mm
Flesh volume	ml
Pit length	mm
Pit diameter	mm
Pit weight	g
Pit volume	ml
Leaf colour	nominal
Leaf blade length	mm
Leaf blade width	mm
Leaf blade length/width	number
Petiole length	mm
Petiole width	mm
Discoloration/damage of the leaf	number
Weight of 10 leaves	g

Fruit flesh was cleaned from the seed before determining the seed weight. Than it was weighted on the scale to determine the weight. The firmness of fruit flesh was determined as soft, intermediate and firm in accordance with the appearance of the flesh. The colour of the fruit flesh was systematized as pale, yellow, light red, red and dark red using separate printed ribbon. Taste was categorized as categories sour, sour-sweet and sweet. The taste of each individual fruit was determined. Eating quality was given as numerical mark from 1 to 5 where 5 is the best with the following factors determined: fruit flesh firmness, taste and sensation. Thickness of fruit flesh was calculated as the difference in fruit diameter and seed diameter. Fruit flesh volume was calculated as the difference in volume of fruit and seed.

Seed was cleaned from flesh and its weight, length, diameter was measured. The volume of 10 seeds was measured together.

The leaf was also measured as follows: leaf colour was described as light green, green, dark green and red using a prepared ribbon. The length and width were measured. The ratio between length and width was calculated. Petiole length and width was measured. Discoloration on the leaf was described as none, few dots, small and few, big and few, major discoloration. The weight of ten leaves was measured.

Statistical data analysis

Studies of collected data comprised of the multivariate statistical methods and the analysis, i.e. Cluster Analysis, Principal Component statistical analysis and Discriminant Function Analysis (Arellano and Casas 2003; Potapova and Hamilton 2007). The number of analysis was conducted to establish whether there are morphological differences between the studied types of individuals and populations, hence to corroborate and verify the findings by identifying which characteristics determine such differences. With Cluster Analysis obtained was a dendrogram of individuals in order to observe general grouping and relation patterns. Principal Component Analysis was conducted in order to classify studied populations and individuals according to their morphologic similarity or difference with aim to establish whether there are significant differences among wild and cultivated populations and individuals, but also which characteristics determine such differences as per Arellano & Casas (2003). As the Principal Component Analysis does not assume any pre-classification of the individuals the groups obtained following it conducted was the Discriminant Function Analysis with goal to investigate the morphological separation between the observed groups and test the significance of such separation. All the statistical analysis were conducted in the computer software SPSS (Farshadfar and Farshadfar 2008; Chun-Xia et al. 2008).

The descriptors were generally measured in total of 10 measures per character, per individual, except for the tree characteristics. For the statistical tests the average value of the descriptor per individual was used. Only ordinal and scale measured descriptors were used for the statistical tests. The nominally measured descriptors of shape, colour and tree habit were not used in statistical tests. Consequently, the data matrix consisted of 30 variables per 90 individuals and in case where the variables were analysed per populations the individuals in the matrix were divided into 6 populations of 15 individuals each, as it was sampled.

Correlation analysis was performed to identify individual and general correlations between the measured characteristics and to observe correlations between the parts that were direct target of the selection and those that were not. Pearsson's correlation was used (Arellano & Casas 2003).

Cluster Analysis was performed by analysing the standardized variables for each individual, without any grouping pre-classification, through the Euclidean distance coefficient (Arellano & Casas 2003).

For the Principal Component Analysis the eigen-vectors were computed, projected and plotted for the first two principal components. Thereafter, the Discriminant Function Analysis was performed from the grouped wild individuals and grouped cultivated individuals, based on its morphological characteristics as variables.

In addition to that, SPSS statistical software package was used also for ANOVA to test descriptors measures significance among studied populations (with 95% confidence). Populations are compared and grouped by characteristics in accordance with the post-hoc multiple range test by Tukey's method (with 95% of confidence).

Results

"Let bring the dry Cornel wood,
That has been nine years seasoning,
That I may see what I can bring out of it."

Medieval Epic Ballad (Low 1922)

Cornelian cherry and the people of the Drvar Valley

It can be noticed by going through the Drvar Valley that many houses, especially the older ones, have one or more Cornelian cherry trees in the garden. Some of those trees are 300 years old. Many households were visited, which resulted in a lot of information and interesting observations. The origin of the very old Cornelian cherry trees is unknown to most of the current owners, since it has been in the family for many generations and the information has been lost over the years. According to the conducted interviews (Appendix 3) information about the origin of the trees were for example: a grand-ancestors left the best tree out of many existing ones on the property; they brought good seeds or seedlings from another good tree on the property; they brought it from the wild; or got it from a good tree of their neighbour's. It was observed that younger trees that were of unknown origin were mostly located on the edges of the garden and in the fences, while the old trees, as well as the younger trees of known origin, i.e. planted ones, were located just nearby the houses or within the garden or orchard area. In all cases the cherries grew together with other fruit trees in the garden, and were appreciated more than other fruit species for its special taste, toughness and resistance to diseases, as well as the presumed medical properties and traditional values. The latter sometimes even reaches to the limits of folk believes, like the tradition to put a newborn child, or bundle of its hair, under a Cornelian cherry tree for good health and toughness of the newborn.

3.1.1. Utilization of Cornelian cherry

As a result from the questionnaire conducted it was evident that the growers of Cornelian cherry trees utilize the tree only for the fruit. Both the fruit flesh and the pits are used. The kernels are dried, pulverized and used only for herbal tea mixtures allegedly helpful for problems with high sugar level in blood, as indicated by one of the growers. The fruit is eaten fresh in the autumn when it ripens, but also it is consumed as various jams and marmalades, mixed with sugar, as well pickled and as juice. Another way that families use to preserve the fruit is by drying it. Dried cherries are used for compote and herbal teas. However, the most famous product from the area is "Drvarska Drenja" the

traditional Cornelian cherry brandy from Drvar Valley (Fig. 4), made by fermentation and distillation of Cornelian cherries. From Drenja is also produced "Liker od drenjina" which is liqueur prepared by soaking fresh cherries in the brandy and aging it for a year.

Figure 4. Grower presents his "Drvarska drenja" in the hand-painted bottle. (Photo: Borut Bosancic)

Generally, the cherries are obtained from both the cultivated and wild populations. Families that have plenty of their own trees do not use the wild trees and sometimes even have problems to harvest their own yield. However, many households utilize both the trees from their own properties and the wild ones.

Selection and origin of cultivated populations

Interviews with growers provided information about cultivation and selection practices, as well as indications about origin of the cultivated Cornelian cherry populations. The survey indicated that besides cultivation two interviewed persons also made selections of Cornelian cherry, while two other persons spoke in detail about selection but were not practicing the selection work at the moment. All four said that the selection was done by choosing the biggest fruits from the best yielding trees and sowing it. Two of the growers, have propagated the trees, both by seeds and one of them also uses the layering (Fig. 5). One of them sells Cornelian cherries plants to other growers.

Figure 5. Interviewed grower shows how Cornelian cherry is propagated. Picture on the left shows his seedlings and on the right one he demonstrates layering.

When it comes to origin of Cornelian cherries in the area, four persons said that they do not know exactly the origin of their trees since the orchards were established by previous generations and the information has been forgotten. In all those cases, the assumption is that the ancestor cut bushes around already established wild Cornelian cherry trees and thereafter continued to maintain it, leaving the best of it and removing the bad ones. Four of the growers were aware of origin of the Cornelian cherry trees in their family's property and they also indicate that their ancestors used the biggest fruit from the best yielding trees and sowed it at the desired positions. However, when talking about the distant origin of the older trees that were used as a mother trees for further selection, all of them indicated that those most probably came from the wild. All of the interviewed families said that they always save Cornelian cherries when cutting wood for fuel or other needs. Several described cutting Cornelian cherry as a "sin".

Harvesting and quality criterions

Although there is no strong criterion for good or bad for the majority of the current growers the size and sweetness of the fruit determines the use of it for various products. The sweeter ones are used for juice and 'slatko', while the other ones are used for the distillation of the fruit brandy 'drenja'. There are many criterions separating the various types of Cornelian cherries. They are divided into the "rane" and "kasne", or the ones that get ripe early and late in the season respectively. In addition, there are also "slatke" and "ljute", or sweet and astringent tasting respectively. By the colour of the ripe fruit it is divided to "bijele" or white, "crvene" or red and "crne" or black, actually coloured with light red to dark red respectively.

Way of harvesting is similar for all the growers. The cherries are generally picked from the ground and not from the tree itself. All of the growers prefer

to do this in the way that they do not disturb the trees by vigorous shaking, but rather wait until the cherries naturally fall off. That delays the harvesting by sometimes more than 30 days, since Cornelian cherry ripens slowly. Therefore, all of the cultivated populations have very shortly cut grass beneath the trees and in several cases it was observed that sheets of tough artificial material were spread and left under the trees for the ease of harvesting.

Maintenance of the trees

When asked how the trees are maintained, all of the growers described the use of similar methods to cultivate their trees. They clean other vegetation around and especially beneath the trees. Old rotten branches were regularly removed by everybody who grows the Cornelian cherries. They all said that manure is occasionally spread around the trees and one grower explained that it had been common to let the sheep occasionally graze under the trees. Although all but one of the interviewed growers does not prune the trees for the canopy thinning, many used to train the trees into the tree growth habit. It cannot be concluded which is the preferred growth habit since some growers prefer not to cut any of the healthy branches and to have natural habit, which is mostly bushy. One explanation was that Cornelian cherry 'does not like to be cut'. None of the growers ever used any kind of pesticides for the Cornelian cherry.

Medical properties

Every interviewed grower considered Cornelian cherries and its product to have medical properties. All of them indicated it as beneficial for stomach problems, especially those related to diarrhoea. When asked to assess the impact on the scale of one to ten, the assessment ranged from seven to ten, with the average mark of 9.5 among the interviewed families. The most effective products are compote made of dried fruits, as indicated by six of interviewed persons and unsweetened juice, as indicated by five of them. There are also other properties attributed to Cornelian cherry and its products. The most interesting one is that it is 'good in general'. The brandy is considered beneficial to improve blood circulation 'if taken one small glass in the morning'. Cooked bark is said to be beneficial if put at the wound. One family indicated that they are never ill of the flue or other similar illnesses when it is a season of ripe Cornelian cherries, i.e. when the cherries are picked and eaten fresh on a daily basis. The bottom line is that Cornelian cherries are widely considered as very beneficial for the health in general and as a remedy for stomach problems.

Correlation between the measured characteristics

The correlations calculated between the characteristics on the Pearsson's correlation has shown very high correlation among the fruit characters which were part of the analysis of the research, such as length, weight, diameter and

volume of the fruit. Fruit pit characteristics are also highly correlated to the other fruit measures, although on the somewhat lower level.

On the other hand, concerning the vegetative parts of the Cornelian cherry populations studied, such as fruit stalk, petiole and leaf characteristics there is low correlation, like the low level of correlation between the fruit stalk width and the leaf width, or the leaf length and the petiole length. There is to some extant higher correlation between the petiole width and the leaf width, and also the stalk width and the leaf weight. There is generally low correlation between the vegetative and generative characteristics. The most prominent correlations are shown in Table 2.

Table 2. The most prominent correlations among the analyzed characteristics of Cornelian cherry

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1,00													
2	0,85	1,00												
3	0,90	0,97	1,00											
4	0,18	0,05	0,06	1,00										
5	0,39	0,43	0,42	0,19	1,00									
6	0,89	0,98	1,00	0,04	0,41	1,00								
7	0,63	0,34	0,42	0,21	0,31	0,39	1,00							
8	0,61	0,73	0,72	0,15	0,34	0,69	0,25	1,00						
9	0,83	0,75	0,80	0,26	0,39	0,76	0,52	0,87	1,00					
10	0,37	0,39	0,39	0,30	0,50	0,37	0,35	0,38	0,43	1,00				
11	0,43	0,55	0,50	0,22	0,66	0,50	0,28	0,41	0,41	0,69	1,00			
12	0,42	0,45	0,46	0,21	0,56	0,46	0,31	0,41	0,42	0,73	0,73	1,00		
13	0,47	0,48	0,46	0,27	0,39	0,44	0,36	0,51	0,54	0,64	0,57	0,51	1,00	
14	0,27	0,35	0,31	0,08	0,35	0,30	0,12	0,31	0,28	0,47	0,56	0,52	0,38	1,00

1 = Fruit length; 2 = Fruit diameter; 3 = Fruit weight; 4 = Stalk length; 5 = Stalk width; 6 = Flesh weight; 7 = Pit Length; 8 = Pit diameter; 9 = Pit weight; 10 = Leaf length; 11 = Leaf weight; 12 = Leaf width; 13= Petiole length; 14 = Petiole width

Individuals clustered by measured morphological characteristics

The dendrogram shown in Figure 6, demonstrates cultivated populations grouped in the lower part of the graph, while the wild populations are grouped together in the upper part. There are only two exceptions where the individuals from wild populations were clustered among the cultivated ones. There is however, not a single individual from the cultivated populations clustered among the wild ones. This indicates morphological difference between the cultivated and wild populations and grouping of those individuals within the same cluster respectively.

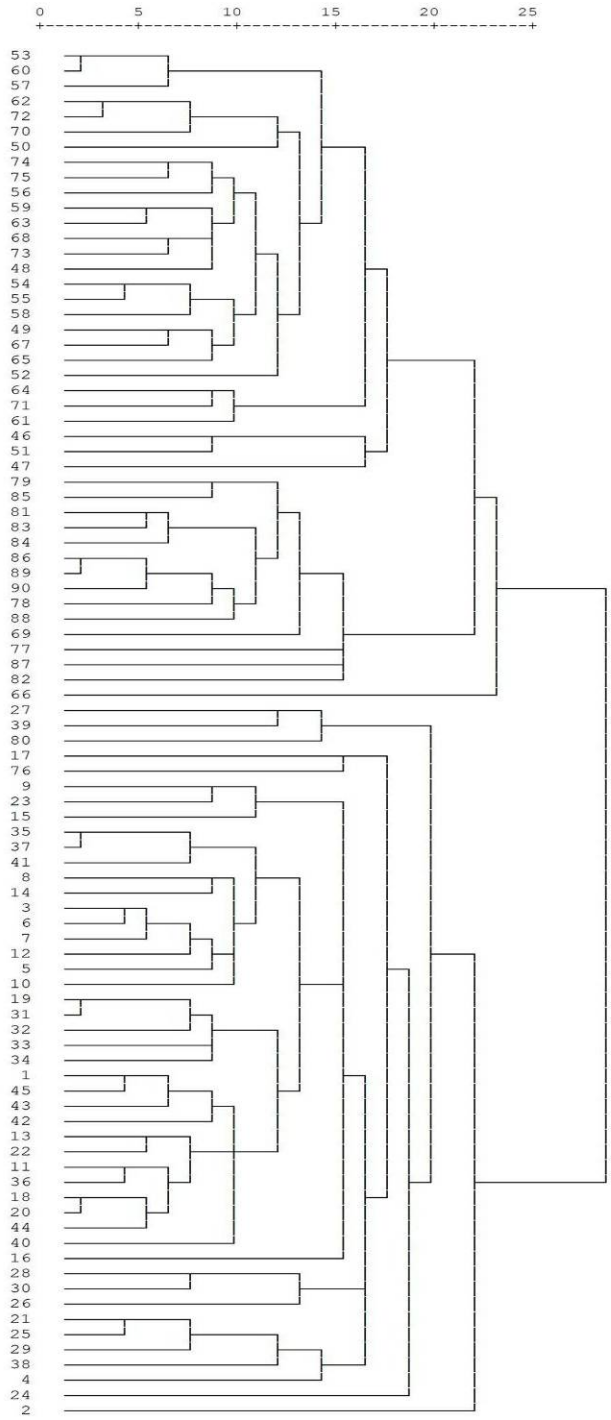

Figure 6. Cluster analysis of the morphological variation among the studied Cornelian cherry individuals: 45 cultivated (1-45) in the lower cluster and 45 wild (46-90) in the upper cluster.

Grouping patterns

Figure 7 shows projection of Cornelian cherry individuals in the coordinate system of the first two principal components, which are accounting for 55,95% of variance. It can be observed the individuals of the wild and cultivated populations are grouped within the continuous gradient, but it is easily observed that cultivated individuals are in the right part of the plot, while the wild ones are in the left one.

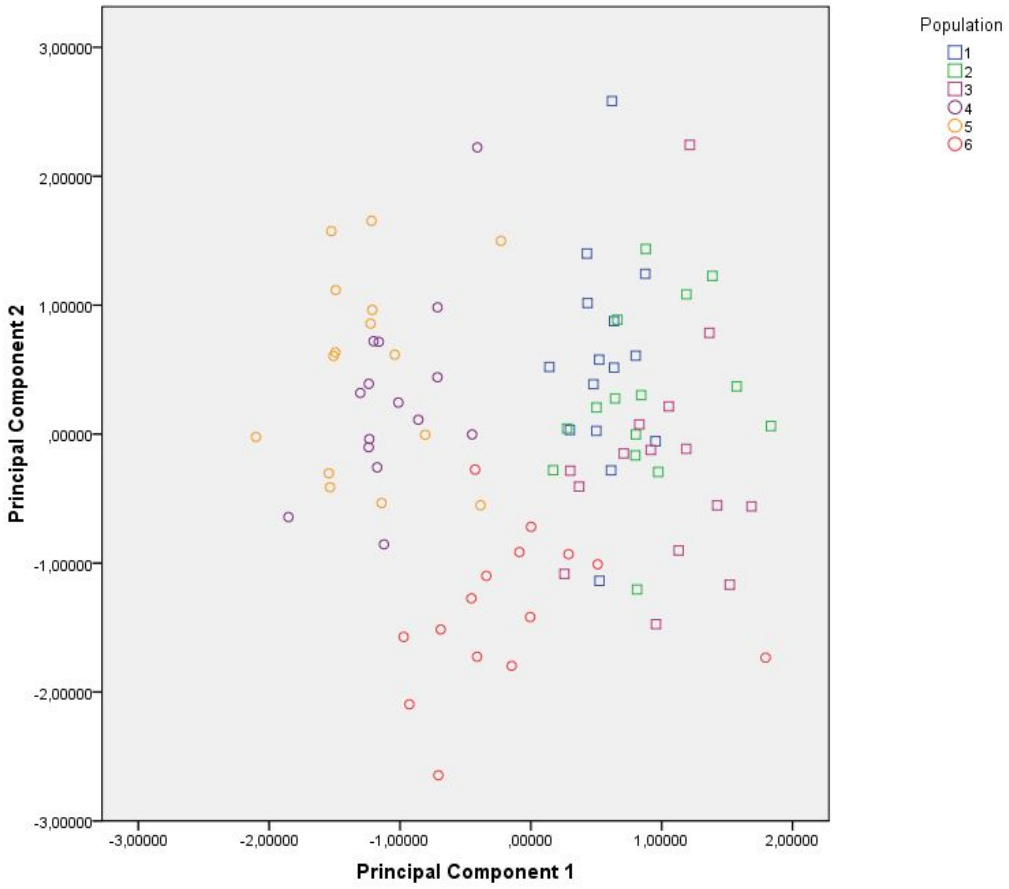

Figure 7. Principal Component Analysis of wild (circles) and cultivated (squares) individuals of Cornelian cherry. 1 – Cultivated population I; 2 – Cultivated population II; 3 – Cultivated population III; 4 – Wild population I; 5 – Wild population II; 6 – Wild population III.

Table 3. Extracted vector values from the Principal Component Analysis of morphological variation among the individuals from the wild and cultivated populations of Cornelian cherry

Character	Principal Component 1	Principal Component 2
Fruit cracking	-0,747	0,217
Fruit length	0,884	-0,081
Fruit diameter	0,961	-0,195
Fruit weight	0,959	-0,194
Fruit discoloration	-0,709	0,360
No. of fruit together	0,532	0,327
Fruit volume	0,950	-0,196
Number of leaves near fruit	-0,114	0,215
Stalk length	0,128	0,520
Stalk width	0,534	0,420
Flesh weight	0,950	-0,226
Flesh firmness	-0,381	0,361
Flesh taste	0,331	-0,290
Flesh quality	0,763	-0,425
Flesh thickness	0,927	-0,262
Flesh volume	0,943	-0,222
Pit length	0,467	0,237
Pit diameter	0,758	0,113
Pit weight	0,825	0,130
Pit volume	0,782	0,151
Leaf length	0,553	0,590
Leaf width	0,589	0,488
Petiole length	0,602	0,433
Petiole width	0,439	0,345
Leaf discoloration	-0,372	0,123
Leaf weight	0,642	0,511
Tree vigour	0,763	0,019
Yield of the tree	0,867	0,094
Tree damage	-0,162	0,181
Number of branching	-0,339	-0,109

These groups of individuals are clearly classified by the principal component 1, which accounts for the 46,63% of variation. The contributing characters, with highest contribution, are the fruit characteristics, most prominent being fruit weight, fruit diameter, fruit length, flesh volume, flesh thickness, pit weight and yield of the tree. Eigen values are presented in the Table 3. In the second principal component, the highest contributing characters are the vegetative characteristics of the Cornelian cherry, most prominent being leaf length, stalk length, leaf weight, leaf width, petiole length and stalk width respectively.

Difference between wild and cultivated Cornelian cherries

Table 4 shows that the differences between the wild and cultivated individuals are highly significant. As presented in Table 5 in the Discriminant Function Analysis all of the wild and cultivated individuals are 100% within its predicted group.

Table 4. Scores of the Discriminant Function Analysis of the morphological descriptors of individuals belonging to the wild and cultivated types of Cornelian cherry populations

Discriminant Function			Test of Function			
Eigenvalue	% of Variance	Canonical Correlation	Wilks' Lambda	χ^2	df	Sig.
16,674	100,0	0,971	0,057	215,408	26	0,000

The groups are predicted by the software based on the morphological characters, independently on original grouping. Subsequently, the predicted groups are compared with the actual groups. The finding indicates significant morphological difference between the wild and cultivated Cornelian cherry.

Table 5. Classification according to Discriminant Function Analysis of the wild and cultivated individuals on the basis of their morphological characteristics. Actual grouping in Cultivated and Wild is confirmed by predicted numbers in the analysis. All actual 45 cultivated and 45 wild individuals fit the predicted category.

	Predicted Group					
Actual group	Cultivated Num.	Wild Num.	Total Num.	Cultivated %	Wild %	Total %
Cultivated	45	0	45	100,0	0,0	100,0
Wild	0	45	45	0,0	100,0	100,0

Comparison of populations using morphological descriptors

As it is shown in the Appendix 4 the populations differ significantly for the majority of the descriptors used. However, it can be noticed that grouping of the populations is different for various characteristics. It shows that most dimensions of fruit, fruit flesh and pit, such as fruit length, fruit diameter, cluster, flesh weight, flesh thickness, pit weight and pit volume are significantly higher in cultivated populations than in the wild ones. Conversely, there are descriptors that do not follow this pattern and are distributed more evenly among wild and cultivated populations, such as the stalk length, number of leaves near fruit, leaf length and petiole width.

Discussion

"The domestication syndrome is the set of characters that distinguishes the crop plant from its wild ancestors. The characters arise at least in part from human selection and hence relate to ways in which the plants are cultivated and harvested."

Brown et al. (2009)

Domestication of Cornelian cherry in the Drvar Valley

Cornelian cherry is a plant that has been widely utilized for food by people of the West Balkans since at least the Neolithic age (Kroll 2000; Jeraj et al. 2009) and it continues being utilised by the modern people in Drvar Valley, who use the cherries and its products in various ways and also commercialize it. People do use both cultivated and wild populations to gather fruit. Cornelian cherry has also deeply enrooted symbolism within the local community of the Drvar Valley, which can be understood when fitted within the wider community of the Serbian ethnical background. Those are the important interactions between the human community and Cornelian cherry in the Drvar Valley.

Cherries are the main part of the tree that is used by the local community and consequently represent the main target of the human selection work. Several characteristics are distinguished: better yielding, larger and better quality Cornelian cherries are particularly favoured by the interviewed growers for cultivation, consumption and processing. The identified selection efforts are focused on those characteristics. This is also supported by data analysis of morphological descriptors where the Principal Component Analysis pointed to those characteristics as the most important differentiating between the wild and cultivated individuals.

It is shown that people do propagate the Cornelian cherry by sowing the biggest and sweetest cherries and this practice has been traced in this study through the live testimony of one interviewed person to at least about 100 years in the past. However, based on the age of some trees and row-like distribution of those trees in the cultivated populations there is strong indication that artificial propagation practice goes much further back in the past.

Differences between wild and cultivated populations

Statistical analyses consistently demonstrate clear morphological differences between the wild and cultivated populations of the Cornelian cherry.

Phenotypic assessment depends on the environment, genotype and interaction between them. The differences are the largest in the fruit-related characteristics. Cultivated populations have significantly larger and sweeter fruit. All the individual cultivated trees yield more and are generally in better condition. Those differences may be explained by human influence. This human influence consists of the two major parts: selection and propagation of the favourable material and management of the environmental conditions. Both has been practiced historically during a long time at an extensive scale. Propagation material was selected from the best yielding plants with the biggest fruit. The ethno-botanical research indicates that most of the propagation was done by seed and to the lesser extent by vegetative propagation using the method of layering. This kind of practice noticeably involves human selection. Additional to this is the observed row-like position and distribution of trees in the managed orchards, as well as the observed density of the trees that is not found among wild populations. There was no grafting practices found during the research, but this is possibly not practiced due to bushy habit of the species, which is preferred by some of the growers. Management of the environmental conditions implicates implementation of certain practices, which according the conducted survey typically involve occasional addition of animal manure and cutting or trimming of other vegetation around the trees. Cornelian cherry is very resistant to pest end diseases so the growers do not apply any pesticide or chemicals whatsoever.

In order to explain differences between the cultivated and the wild population both the selection process and management of environmental conditions have to be taken into consideration. However, in that perspective the changes of the environmental conditions of the kind that it is practiced by the growers in the Drvar Valley are on very basic extensive level. Therefore, it is not very probable that such extensive cultivation that has been practiced by the growers was the only factor that has had such major influence on the characteristics of fruits and the yield. According to the results of the morphological analysis and the ethno-botanical survey, it is most probably the influence of the long-term selection that has significantly contributed to the differences between the cultivated populations and the wild ones. Furthermore, indicative is the major difference between the morphological characteristics of the individuals belonging to the cultivated and wild populations, meaning that the analyses of morphological characteristics shows that not even a single tree from cultivated populations is similar to other trees in wild population, i.e. that there are almost no individuals with intermediate characteristics. According to the study on domestication of plants, conducted by Casas et al. (2007), such results of the multivariate statistics in relation to the morphological characteristics between the populations clearly demonstrates the kind of difference that typically occurs between the wild and the cultivated populations.

To explain the transition of the wild to cultivated populations further clarification will be needed, as there are no intermediate populations, or even individuals with morphological characteristics that would represent transition between wild and cultivated types of population. The conducted ethnobotanical research provides valuable information that could explain this, as the survey clearly shows that Cornelian cherry trees are spared in any process of woodcutting. There is also practice of gathering fruit from the wild. Both gathering and sparing the trees from being cut clearly indicate, according to Casas et. al. (2007), that there are also populations on some level of silvicultural management. Namely, Casas provides evidence that domestication process already starts with gathering, letting stand and similar types of low-level extensive cultivation in the wild. Those populations could fill with its morphological characteristics the gap in between the phenotype of the cultivated and the wild populations.

Studied cultivated populations of Cornelian cherry in Drvar Valley are the outcome of a long selection process that led to plants adapted to cultivation and utilization by humans. In the course of this long process, the human community of the area created a morphologically distinct, but also diverse, population of the Cornelian cherry, which is associated with traditional farming system of the local community in the Drvar Valley. This kind of process is clearly described by Brown et al. (2009) as 'domestication' and morphologically distinct cultivated populations of the Cornelian cherry are described as 'landrace' in the full meaning of Brown's definition "Landrace: locally adapted and distinct population of a crop, often genetically diverse, associated with traditional farming systems." (pg. 103).

Domestication is a real biological and protracted process, which leads to plants that are adapted to cultivation and utilization by humans (Brown et al. 2009). It requires according to Casas et al. (2003) human selection pressure on the favourable characteristics that are inherited by the following generations. In case that phenotype is not supported by changes in genotype, the favourable characteristics would be lost. However, determining genetic basis of morphological variations requires intensive studies in quantitative genetics and long lasting experiments, thus this information remains uncertain. Though results of such research possibly could still not trace the fine genetic background of some phenotypic change, as Ercisly et al. (2008) indicated in research on the genetic differentiation of the Cornelian cherry, even some point mutation that is difficult to trace could easily affect such characteristics as fruit colour or shape. Moreover, phenotypes with large fruit and those with small fruit, as well as large pit and small pit were found within the same population. Individuals that belong to same cultivated population are exposed to the same environmental conditions and same changes in the environmental conditions. Therefore, such differences within the populations according to

Arrelano and Casas (2003) are additional factor that leads to conclusion that analysed variation is not determined by only the environmental conditions. Since the size of fruit is one of the main targets of the selection practiced by the people of the Drvar Valley, such differences are additional indicator that human selection is also one of the main factors that explains the difference between wild and cultivated populations.

Biodiversity implications

Cultivation of Cornelian cherry in the agroecosystems in the household farms of the Drvar Valley diversifies the production and enriches the diversity of species on the farm. Most valuable characteristic of the Cornelian cherry is its resistance to pests and diseases. This research established that cultivated populations did not lose this property, as they are all in very good shape without visible signs of damage caused by pest or disease, even though the growers do not use anything to protect the trees. This practice has very low impact on the natural surrounding and allows other species to coexist.

Ecosystem services in this case deem a plausible perspective that forest ecosystem can be used in different ways, as a source of fruit and beneficial genetic traits for further selection work on the Cornelian cherry. The more of the forest products are used for the services other than cutting, the bigger is the value of the forests. Therefore using the Cornelian cherry to obtain fruits from the wild will deem much more sustainable to preserve the surrounding ecosystem. Economical, cultural, recreational and traditional values are combined in this process since Cornelian cherry provides, as part of its ecosystem services described in the Millennium Ecosystem Assessment (2005), food, biochemicals, natural medicine, pharmaceuticals and ornamental resource. All of those aspects are generally in decline. The knowledge on use of the Cornelian cherry has resurrected and revived among the people of Drvar Valley due to misfortunes of the war which made people turn to nature and find and relay again to its resources. This is now again in decline due to better priced mass agricultural products. Therefore it is necessary to act towards the benefits of this plant in order to save it and continue the use of this valuable resource.

One of the important parts of the biodiversity is the biodiversity in the agricultural landscape. There is a great potential to integrate Cornelian cherry production into the agricultural systems in order to diversify and by doing so improve its biodiversity value. In this process resistant nature of Cornelian cherry is of essential significance, since no pest protection, hence no chemical pollution by pesticides is needed. Agricultural systems diversified in such way in Drvar Valley had been the major part of income in case of the crisis situation.

Conservation

Due to uniqueness of the cultivated Cornelian cherry populations in Drvar Valley it is necessary to incorporate consideration of biodiversity into management practices in sectors of agriculture so that cultivated populations of the Cornelian cherry are better protected. It is reasonable to expect that next step in the domestication is the creation and general use of cloned cultivars. As the specific Cornalian cherry landrace of Drvar Valley has been created mostly by seed propagation, a loss of diversity is a real threat. That would mean a loss of centuries long human selection and breeding efforts. Special care should be taken to preserve all aspects of the traditional use of the Cornelian cherry in the cultivated and semi-cultivated agricultural landscapes.

As the species is in practice treated as the most fundamental element of biodiversity (Gaston and Spicer 2004), it is also limited with it, though put in practice when compared with FAO's (2003) recommendations for preservation of genetic resources of wild crop relatives and wild plants for food production in protected areas and on other lands not explicitly listed as protected areas. This is also in line with Convention on Biological Diversity (1993) definition, which says that conservation means "maintenance and recovery" of viable populations of species which should take place "in the case of domesticated or cultivated species, in the surrounding where they have developed their distinctive properties". Conservation would be achieved in the process of utilization of the Cornelian cherry since the use does not negatively affect the population; even more, it has positive effects. There is a definite compatibility between the present use and conservation. The study has shown that Cornelian cherry represents an important biological resource for the local people and that traditional management of the cultivated populations does not involve use of chemicals or significant disturbance of the soil and surrounding landscape. Therefore a special attention is to be paid to protection of the traditional use. In case that this is not done and conservation situation deteriorates, it would be necessary to do the recovery of the populations, or as the last solution to save it in the gene bank. In that case, use of live grafts or cuttings would preserve the domesticated material. Seeds could be also preserved, but this way the genetic structure of the material would be changed in comparison to the mother plant.

Habitats typical for wild Cornelian cherry populations are constantly threatened and endangered with exploitation, such as a forest cutting. Alternatively, Cornelian cherry as a part of the natural forest ecosystems is the component which very much contributes to value of those ecosystems to the local community which uses the resource. Original ways and recipes are to be preserved, together with cultural and traditional connotations, which can enhance the use and utilization and also enrich the awareness of the species and its habitat.

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Appendix 1 - Questionnaire

General

1. Name
2. Location / address
3. Year of birth
4. Occupation
5. Family status
6. Cultural background

Agro – technology and propagation

7. How many trees do you have on the property?
8. Do you cultivate them it in some way?
9. Do you know the origin of the trees?
10. Did you or your ancestors ever bring seedlings from outside of the Drvar Valley, i.e. other another country, or heard that someone did so?
11. Any agro-technological measures used?
12. If you propagate the trees, how do you select the trees for following generations?
13. Do you use any pesticides and/or other chemicals?
14. When you cut vegetation for various needs, or clear a field for agricultural use, or cut a forest, do you spare Cornelian cherry trees?

Products

15. What products of Cornelian cherry are utilized in your household?
16. Where do the cherries come from?
17. Is some specific type of the fruit better than the other or used for some specific product, i.e. yellow for jam, or red for brandy, etc.?

Medical properties

18. Do you consider Cornel to have medical properties?
19. What products have medical properties?
20. What does it affect and how?
21. How do you assess health impact of the Cornelian cherry on the scale from 1 to 10?
22. How do you assess impact of effective products product having medical properties?

Appendix 2 - Descriptors

1. Tree habit

Tree habit, is the descriptor taken from the cherry (Rodrigues et al. 2008) and adopted to describe better the Cornelian cherries on the field as 'bushy', 'tree like' and 'intermediate'. In this context, the bushy habit describes individual with many stems, i.e. more than three stems and plenty of lateral branching. Tree like individual has a solid trunk. Individuals that have two or three solid stems are described as intermediate (Fig. 2.1.).

Figure 2.1. Cornelian cherry habit from left to right: bushy, intermediate and tree like. (Photos: Borut Bosancic)

2. Tree vigour

This descriptor was taken from the cherry (Rodrigues et al. 2008) and adopted to describe the vigour of Cornelian cherries on the field as 'poor', 'good' and 'very good'. It was determined based on the general outlook of the individual, taking into consideration its age and habit.

3. Yield per tree

This characteristic is used in other works on Cornelian cherry (Klimenko 2004) and is adapted for this study. Up to 300 fruit per tree was considered to be 'very poor', 300 to 800 was considered to be 'poor', 800 to 1300 was considered to be 'low', 1300 to 2000 was considered as 'good' and more than 2000 was considered as 'very good'. The number of the fruit was established by counting the fruit on the tree.

4. General damage on the tree

This characteristic was divided as 'none' for no visible damage on the tree, 'low' for the minor damages where up to ten percent of the individual is damaged and 'damaged' for major damages on the tree. All kinds of damages were taken into consideration, i.e. drought, fire, pests, diseases, etc.

5. Number of stems

This is the number of stems that grows from the root of the plant forming the bush, or the tree if it is one stem.

6. Fruit cracking

This characteristic is taken from the cherry (Rodrigues et al. 2008) and adjusted for the Cornelian cherry where each sampled fruit was assessed as 'not cracked', 'minor cracks' and 'major cracks'. Cracks affecting less than ten percent of the fruit were described as minor, while the other ones were described as major.

7. Fruit shape

This descriptor is used for Cornelian cherry by Klimenko (2004) and also taken from the cherry (Rodrigues et al. 2008) and adopted for the shapes of the Cornelian cherries in the Drvar Valley to three categories of 'elliptic', 'round' and 'drop shaped' in accordance to the corresponding shapes (Fig. 2.2.).

Figure 2.2. Cornelian cherry fruit shapes from left to right: elliptic, round and drop shaped. (Photos: Borut Bosancic)

8. Fruit length

This descriptor is used for Cornelian cherry by Bijelic et al. (2007), also mentioned for the cherry (Rodrigues et al. 2008) and indicates the length of the fruit measured in millimetres, to the precision of 1/50 of the millimetre.

9. Fruit diameter

This descriptor is used for Cornelian cherry by Bijelic et al. (2007) and in this study represents the width of the fruit on the middle measured in millimetres, to the precision of 1/50 of the millimetre.

10. Fruit weight

This descriptor used for Cornelian cherry by Bijelic et al. (2007) but also mentioned for the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry and represents the weight of the fruit measured in grams, to the precision of one hundredth part of the gram.

11. Ripe fruit skin colour

This descriptor is similar to those used by Klimenko (2004) and the cherry (Rodrigues et al. 2008). It is adopted for the Cornelian cherry in the Drvar Valley to describe the colour of the fruit in categories of 'light red', 'red', 'dark red' and 'black' (Fig. 2.3.). It is compared with set of colours and described to the closest match.

Figure 2.3. Cornelian cherry fruit colours from left to right: two light red fruits, two reds, two dark reds and two blacks. (Photo: Borut Bosancic)

12. Discoloration on the fruit

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the discoloration occurring on the fruit beside the dominating colour in the four categories: 'no discoloration', 'dots', 'minor discoloration' and 'major discoloration'. Described as 'no discolorations' were the fruits that have no interruptions in the main colour, as 'dots' the fruits with small black dots type of discolorations, as 'minor discolorations' were described those that had less than ten percent of the other colour and more than that 'major discolorations'.

13. Cluster – number of fruit together

This descriptor is taken to measure the number of fruit in one cluster, i.e. fruits originating from one generative bud (Fig. 2.4.).

Figure 2.4. From left to right: Cornelian cherry fruit cluster of five and four fruits. (Photos: Borut Bosancic)

14. Fruit volume

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry and measured in cubic centimetres to the precision of 1/10 cubic centimetres by sinking the fruits in the water and measuring the volume of the water above the initial level in the gauge glass.

15. Number of leaves at fruit/cluster

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry in order to record the number of leaves at the fruit cluster.

16. Stalk length

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to measure each fruit's stalk length in millimetres, to the precision of 1/50 of the millimetre.

17. Stalk width

This descriptor is taken to measure the width of the fruit stalk in the middle, which is measured in millimetres, to the precision of 1/50 of the millimetre.

18. Weight of fruit flesh

This descriptor is used in study of Bijelic et al. (2007) and represents the weight of the fruit flesh measured in grams, to the precision of one hundredth part of the gram. It is calculated from the weight of the whole fruit from which is subtracted the weight of the pit.

19. Flesh firmness

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry and divided into three categories of 'soft', 'intermediate' and 'firm', each describing the palpation sensation of touching the fruit.

20. Ripe fruit flesh colour

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry and described as 'pale/yellow', 'light red', 'red' and 'dark red' (Fig. 2.5.) by comparing the colours with the printed ribbon.

Figure 2.5. Cornelian cherry fruit flesh colour from left to right: two pale/yellow, two light red, two red and two dark red fruits. (Photo: Borut Bosancic)

21. Flesh taste

This descriptor is used for Cornelian cherry by Klimenko (2004) and Demir & Kalyoncu (2003) and is also taken from the cherry (Rodrigues et al. 2008), adopted for the local Cornelian cherry to describe the organoleptic properties in categories of 'sour', 'intermediate' and 'sweet'.

22. Flesh quality

This descriptor is used for Cornelian cherry by Klimenko (2004) and Demir & Kalyoncu (2003) and is also taken from the cherry (Rodrigues et al. 2008), adopted for the local Cornelian cherry to describe the organoleptic properties in terms of sweetness and sourness balance, taste, juiciness, sensation and structure on the scale from one to five.

23. Flesh thickness

Is developed to measure the thickness of the fruit flesh in millimetres with precision of 1/50 millimetres and is calculated by subtracting the width of the pit from width of the whole fruit.

24. Flesh volume

Is developed to measure the volume of the flesh in cubic centimetres, with precision of one tenth of the cubic centimetre, which is calculated by subtracting the volume of the pit from the volume of the whole fruit.

25. Pit length

Is developed to measure the length of the pit in the fruit in millimetres, with precision of the 1/50 millimetre.

26. Pit diameter

Is developed to measure the width of the pit in the fruit in millimetres, with precision of the 1/50 of millimetre. It is measured on the middle of the pit.

27. Pit weight

From Bijelic et al. (2007) the descriptor measures the weight of the pit of the fruit in grams, with precision of 1/100 gram.

28. Pit volume

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the volume of the pit. It is measured in cubic centimetres, with precision of one tenth of cubic centimetre.

29. Leaf colour

Is developed to describe the variation of the colour of the leaves and is categorized as 'light green', 'green', 'dark green' and 'red' (Fig. 2.6.) in accordance with the colour scheme that it was compared with.

Figure 2.6. Leaf colours from left to right: light green, green, dark green and red. (photo: Borut Bosancic)

30. Leaf blade length

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the length of the leaf blade measured in millimetres, with precision of 1/50 millimetres.

31. Leaf blade width

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the width of the leaf blade measured in millimetres, with precision of 1/50 millimetres.

32. Leaf length/width

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the length of the leaf blade in comparison with the width measured in millimetres, with precision of 1/50 millimetres and calculated by dividing the length with the width of the leaf blade.

33. Petiole length

This descriptor is taken from the cherry (Rodrigues et al. 2008), adopted for the Cornelian cherry to describe the length of the leaf petiole measured in millimetres, with precision of 1/50 millimetres.

34. Petiole width

This descriptor is taken to describe the width of the leaf petiole measured in millimetres, with precision of 1/50 millimetres. It is measured on the half of the petiole.

35. Discoloration/damage of the leaf

This descriptor is to describe the discoloration occurring on the leaf similarly to those in the fruit. Beside the dominating colour the discoloration occurrences are put in the four categories(Fig. 2.7.): 'no damage/discoloration', 'dots', 'minor damage/discoloration' and 'major damage/discoloration'. Described as 'no discolorations' were the leafs that have no interruptions in the main colour, as 'dots' the leafs with small black dots type discolorations, as 'minor discolorations' those that had less than ten percent of the other colour and more than that 'major discolorations'.

Figure 2.7. Leaf damages/discoloration from left to right: no discolorations, dots, minor discolorations and major discolorations. (Photos: Borut Bosancic)

36. Weight of 10 leaves

This descriptor is taken to measure the weight of the leafs, which is done by measuring the weight of ten leaves from the same plant in grams, with precision of 1/100 gram.

Appendix 3 – Interviews

Interview 1

Vaso, 75 years old

Mr. Vaso is a retired worker who was born in the Drvar Valley and lives in the village of Bastasi. He lives on his pension and incomes from the agricultural activities. 'It is an ancient tradition that Cornelian cherry is never cut in the forest and is always spared' says Mr. Vaso who has about 100 trees on the family property. The older ones are about 150 years old. The orchard looks well maintained and the oldest trees look very old. He maintains the orchard by cutting grass and other vegetation under the trees. Older branches are removed 'from time to time' says Mr. Vaso. He uses manure from his stable and puts it around the trees. There was never any need to apply pesticides or any other chemicals.

The orchard was established by cutting the trees and other vegetation around the Cornelian cherries by his grand-grandfather. He is very certain that there were no plants or seeds brought from outside to the Drvar Valley.
Products of the Cornelian cherry used in the household are the brandy, jam, juice, slatko, liqueur, marmalade and dried cherries. All the cherries are picked from the property of Puzics's.

It is considered that the Cornelian cherry has also medical properties. The product that has most effect are dried cherries. It is effective as Mr. Puzic says for the pain in the stomach. On a scale from one to ten the health impact of the Cornelian cherry is assessed with a clear ten.

Interview 2

Draginja, 76 years old

Ms. Draginja is born and has lived all her life in the Drvar Valley. A good part of the income of the household comes from growing the Cornelian cherries. There are about 100 trees in the orchard, the oldest ones being more than 150 years old. The orchard was established by previous generations. Ms. Draginja says that the ancestors cut the vegetation around the existing wild trees and developed an orchard from it. Those trees are well maintained and properly lined up. She is sure that no trees or seeds came from outside of the Drvar Valley.

Manure from the stable is put around the trees and old rotten branches are cut off. Ms. Draginja's family also practice pruning at the level to 'enable more

light in the canopy'. No pesticides or other chemicals are used. Cornel cherry is always spared when cutting the vegetation on the property or in the forest. Products of the Cornelian cherry in Ms. Draginja's household are juice, slatko, marmalade, jam, brandy, liqueur and dried cherries. All the cherries are picked from the family property. Early red (crvene rane) cherries are the best for all the products, while the sugar has to be added to the black (crne) ones for improvement. She says that Cornelian cherry 'saved' the family when they returned to their home after the war. Cornel cherries were one of the first and most important incomes for the family upon the return.
According to Ms. Draginja the Cornelian cherry has medical properties and all the products are considered to be 'healthy', with assessment of the health impact with the mark ten. As Ms. Draginja says, it is generally 'good for the stomach'.

Interview 3

Djuro, 58 years old

Mr. Djuro is one of the most well-known breeders and growers of the Cornelian cherry in the Drvar Valley. He is retired and he spends a lot of time growing and breeding the Cornelian cherries. The orchard was established a long time ago and not even his mother, born in 1926, does remember how old the orchard is. He is sure that all the Cornelian cherries originate from the area of Drvar Valley and that no trees have been brought here from somewhere else.

The maintenance of the trees consists of putting sheep manure around the trees and clearing the vegetation under it. Rotten branches are also removed. Selection of trees for propagation is done by sowing the cherries from the 'best' trees to produce seedlings. The seedlings are replanted after a year or two when it is time to give or sell them to the neighbours and other growers in the valley. He also propagates by layering. The best trees according to Mr. Djuro are those with highest yield and biggest fruit.

'No, no, God forbid putting it on the Cornel cherries' was the answer on the question about using the pesticides or chemicals. People cutting and thereby destroying the Cornel trees in the wild were described by Mr. Djuro as 'the worse men of all'.

Products used in Mr. Djuro's family are many, most prominent of all being slatko, jam, marmalade, pickled cherries with other fruit, liqueur, vine, juice, dry cherries and dry pits. The cherries come mostly from the family property but some are purchased from others who collect it from their orchards or from the wild. Especially, when the year is bad for the Cornelian cherries as this year.

Cornel cherry is generally considered to have good medical properties and is given the mark ten on a scale from one to ten. Mr. Djuro said that dry grinded pits are good for lowering the high level of the blood sugar and dry cherries and juice for the stomach problems. The impact was scaled as eight for the dry pits, and ten for the juice and dry fruit. Herbal tea made of dry fruit is 'good when you have cold' and was assessed with mark eight.

Interview 4

Radojka, 74 years old

Ms. Radojka who is now retired says that the Cornelian cherries on the family property are maintained by clearing other vegetation around the trees and cutting the cherries to avoid the bushy growth habit and train it as a tree. Trees around the house and in the garden are properly lined up on equal distances along the fence and the paths in the garden. The selection of the trees was done by previous generations and Ms. Radojka does not know the criteria for this, but she is sure that all the trees originate from the area. No pesticides or other chemicals are needed or used for the Cornelian cherries. Cornel cherries are always spared when cutting the woods.

Products made of the Cornelian cherry in Ms. Radojka's household are the fruit brandy, jam, juice, dried cherries and liqueur. Both the cherries from the wild and from the property are collected and used in the household.

Cornelian cherry is considered to have medical properties and the product most attributed are the dried cherries, i.e. the compote made of the dried cherries. Ms. Radojka also mentions the old household remedy of applying the cooked bark of the Cornel on the wound. Medical effectiveness of the Cornelian cherry is assessed with mark ten on the scale between one and ten. In the same way, Cornelian cherry is considered healthy in general as told by Ms. Radojka to be 'beneficial for everything', having in mind all the above mentioned products have generally good impact to the health.

Interview 5

Veselin, 94 years old

Mr. Veselin is a retired worker and has a property with Cornelian cherries. He maintains the trees by putting manure under the trees and removes regularly the rotten branches. He is also practicing the painting of the trunks with white limestone paint in the winter. Most of the Cornelian cherries on his property have sprouted naturally and the best were taken care of. He says that all the cherries in the area are originating from the wild or the local growers and there has never been brought any Cornelian cherry into the Drvar Valley from outside the valley. No pesticides or other chemicals have been needed for the

Cornelian cherry. All Cornelian cherry trees are spared when cutting the woods.

Products produced in Mr. Veselin's family are the juice, dried cherries and compote made of it. The cherries are picked only from the garden. Mr. Veselin prefers the fresh cherries, which are described as 'both sweet and sour' therefore tasty and eaten 'like a bonbon'. Before the wars, meaning the World War 2 and the recent civil war, the Cornelian cherries were forgotten to some level, but after the wars people used it to a much larger extent. Over the years, several people have preserved the tradition of cultivating the Cornelian cherry. He says that throughout the history of the Drvar Valley there have always been several people and families who grew the Cornelian cherries to the larger extent.

He considers Cornel cherry to have medical properties. The best products with best impact to health are the juice made of cherries and the dried cherries. It is considered beneficial for stomach problems. General effect to the health is assessed with the mark of ten.

Interview 6

Branko, 54 years old

Mr. Branko is a local deputy police commander in the Police Station of Drvar. He has an orchard of Cornelian cherries in his own family property. The orchard was established at the property by the previous generations of his family. He considers that all the Cornelian cherries on the property originate from the area. Trees are maintained. Grass is cut around the trees and branches are cut in order to establish a tree and avoid the bushy growth habit. Manure is put under the trees. No pesticides or other chemicals are ever needed or used. When cutting the woods all Cornelian cherry trees are spared.

Products of the Cornelian cherry in Mr. Branko's family are numerous: fruit brandy, juice, syrup, liqueur, jam, marmalade, dry cherries and slatko. All the products are made of the cherries originating from the family property. The big and sweeter cherries are used for syrup, jam and slatko, while the rest are used for distillation of the drenja.

Cornelian cherry is generally considered to have medical properties. The juice made without sugar and the dry cherries are the best for the stomach problems. A small amount of brandy in the morning helps to improve the blood circulation. The general impact of cornel cherry to the health is assessed with ten. In that respect, all the products are beneficial for health, but some more than the others are. The best is the juice. Jam and marmalade are

considered good, but not so beneficial for the health as the other products since Mr. Branko assessed them with seven on the scale of one to ten

Interview 7

Radmila, 44 years old

The Cornelian cherry orchard of Ms. Radmila consists of about 500 trees covering a whole hillside. The orchard was established in this way. Her grandfather planted several trees he handpicked from the wild and thereafter he made a selection as he left the best of those. A criterion for a good Cornelian cherry was the size of the fruit and the yield. No trees or seeds were brought from place other than the Drvar Valley.

Until recently, the orchard was maintained in the 'traditional way' meaning that the sheep were kept under the trees. The trees provided protection for the sheep, while the sheep cleared the vegetation around the Cornelian cherries and provided manure. Ms. Radmila said that Cornelian cherries 'do not like to be cut'. Therefore, there is no pruning or thinning practices in the family's orchard and they do not apply pesticides or other chemicals.

Products of the Cornelian cherry made in Radmila's family are the fruit brandy, jam, dried cherries, juice, liqueur and slatko. All the cherries come from the family orchard and there is also enough for sale. For juice and jam the dark red and sweet cherries are preferable, while the other ones are used for distillation of brandy.

Cornelian cherry is considered to have medical properties. The best products according to Ms. Radmila are the dried cherries and the fresh fruit, but juice and liqueur are also very good. All the products are beneficial for stomach problems. 'I or nobody else of the family is ill during the season of picking and eating the fresh cherries' said Ms. Radmila. Health impact of the Cornelian cherry was assessed with the mark ten.

She also provided an explanation for the generally bad year of Cornelian cherry, where all the other growers agree that it was indeed a very bad year in terms of both yield and size of the fruit. Ms. Radmila said that this was because of the rain during the season of flowering followed by a long drought during the summer. She also mentioned interesting tradition of putting newborn child, or put in the ground a bundle of its hair, under the Cornelian cherry tree for good health.

Interview 8

Sofija, 74 years old

Ms. Sofija has maintained the Cornelian cherry trees by putting manure under the trees, hoeing the earth around and clearing vegetation. The manure was from the stable and the wood sawdust. There were also practices of pruning some of the branches in order to allow more light and space into the canopy. New trees were established by sowing seeds selected from larger fruit from better yielding trees. All the trees originated from the area of the Drvar Valley. No pesticides had ever been used for the Cornelian cherry.

Products which are prepared from the cherries in the household are various: drenja, juice, slatko, jam, liqueur and dry fruit. Fruit were collected both from the garden and from the wild. The bigger fruits are used more for jams and drying.

Cornelian cherry has according to Ms. Sofija medical properties. She is strongly recommending to cook the Cornelian cherries as short time as possible. The shorter the better. Cornelian cherries are considered healthy in general, but particularly beneficial for stomach problems. The most effective is the juice without sugar. On the scale from one to ten, Ms. Sofija assesses that health impact of the Cornelian cherry is eight. There she mentions juice as the best and the uncooked jam also as a very good and 'healthy' product.

Interview 9

Milorad, 54 years old

Mr. Milorad maintains his trees on the family property by putting manure under the trees and by clearing vegetation around them. He also removes the rotten branches. The trees on his property have different origin. Some trees have sprouted by themselves and if they were good they were further maintained; other trees were sown or planted by the family, while some were brought from the neighbouring good trees and growers. He described the method of propagating the Cornel that was told to him by his grandfather. It is done in this way: one takes a handful of fruit from the good tree, which one with a high yield and big and sweet cherries, and plant the cherries at the desirable spot. Mr. Milorad says that all the cherries originate from the area and that he has no of knowledge that there has ever been any seedling or Cornelian cherry tree brought from outside into the Drvar Valley. No pesticides or other chemicals have ever been needed or used for the Cornelian cherry.

Milorad's family produces fruit brandy, dried fruit and the juice from the cherries. Jam and slatko were prepared by the late grandmother, but it is not made in the household anymore. All the products are prepared from the

cherries originating from the garden. The sweeter ones are used for the juice, the bigger ones for the dry cherries and the other ones are distilled into the brandy.

The Cornelian cherry has medical properties and it is the best for stomach problems. Dry cherries are the best product for that matter. General health impact of the Cornelian cherry is assessed with ten.

Interview 10

Mirko, 57 years old

Mr. Mirko inherited the Cornelian cherry orchard from his ancestors. The oldest trees are more than 200 years old. He manages it in the way that manure is put around the trees 'every several years', surrounding vegetation is cut and old rotten branches are removed. He has not yet fully returned to the family property that was devastated during the war and has no time to commit fully to the orchard. He is sure that the Cornelian cherries in the orchard originate from the area. There have been never any pesticides or other chemicals needed or used for the Cornelian cherry. When cutting the wood the Cornelian cherry is always spared.

There are many products of the Cornelian cherry used in the household: fruit brandy is distilled, juice, syrup, liqueur and dry cherries are prepared. All the products are prepared only from the cherries picked in the family's orchard. He emphasizes that for preparation of juice, the cherries have to be picked from the ground, since then fruit is surely fully ripe, sweet and with no astringency.

Mr. Mirko considers that Cornelian cherry has medical properties, which he assesses with the mark seven. The product he specially emphasizes to be 'healthy' is the juice prepared with no sugar. He attributes a little bit less medical properties to brandy and jam made of the Cornelian cherries. Cornelian cherry is most effective for treating stomach problems.

Mr. Mirko says that the Cornelian cherry is a very useful fruit, with the remark that this year is not so good for the Cornelian cherry. He concludes that it would be yielding a lot and would be bearing a lot of good quality fruit if maintained and managed regularly. The problem is, as he sees it, that nobody including himself takes much care about the Cornelian cherry and most of the growers take it for granted, by just clearing surrounding vegetation and grass in order to be able to pick cherries and putting manure from time to time under the tree.

Appendix 4 – Comparison of populations per descriptors

Table 4.1. Mean values and standard errors (±) of the morphological descriptors between the cultivated (Cul.) and wild populations of Conelian cherry, with F values and significance scores (Signif.) according to one-way ANOVA. The capital letters indicate significant differences and grouping of the populations according to Tukey's multiple range tests with 95% significance.

Character	Cul. 1	Cul. 2	Cul. 3	Wild 1	Wild 2	Wild 3	F	Signif.
Fruit length	17,328	16,938	18,210	14,211	13,919	15,545	22,668	0,000
	±0,229	±0,323	±0,391	±0,309	±0,385	±0,505		
	A	A	A	C	C	B		
Fruit diameter	12,675	12,974	13,663	9,089	8,664	12,044	72,510	0,000
	±0,101	±0,237	±0,280	±0,225	±0,215	±0,358		
	B	AB	A	C	C	B		
Fruit weight	1,703	1,880	2,175	0,770	0,687	1,523	44,706	0,000
	±0,042	±0,091	±0,107	±0,052	±0,055	±0,147		
	BC	AB	A	D	D	C		
Fruit discoloration	1,280	1,113	1,160	2,558	3,386	1,107	32,735	0,000
	±0,176	±0,064	±0,070	±0,144	±0,332	±0,042		
	A	A	A	B	C	A		
Fruit cracking	1,113	1,227	1,100	1,884	2,573	1,240	32,562	0,000
	±0,059	±0,095	±0,040	±0,123	±0,176	±0,065		
	A	A	A	B	C	A		
No. of fruit together	2,013	1,907	1,707	1,129	1,248	1,287	10,700	0,000
	±0,179	±0,158	±0,109	±0,042	±0,064	±0,066		
	A	A	A	B	B	B		
Fruit volume	1,603	1,689	2,025	0,688	0,605	1,397	41,850	0,000
	±0,037	±0,090	±0,109	±0,054	±0,048	±0,142		
	B	B	A	C	C	B		
Leaves near fruit	3,140	3,613	3,053	3,440	3,499	3,247	2,301	0,052
	±0,167	±0,195	±0,135	±0,129	±0,099	±0,121		
	A	A	A	A	A	A		
Stalk length	8,454	7,466	8,044	7,904	8,181	7,194	2,166	0,066
	±0,317	±0,235	±0,317	±0,284	±0,434	±0,280		
	A	A	A	A	A	A		
Stalk width	0,681	0,683	0,672	0,630	0,594	0,580	9,208	0,000
	±0,016	±0,018	±0,018	±0,010	±0,015	±0,010		
	A	A	A	AB	B	B		

Table 4.1.. (continued)

Character	Cul. 1	Cul. 2	Cul. 3	Wild 1	Wild 2	Wild 3	F	Signif.
Flesh weight	1,383 ±0,040 B	1,568 ±0,081 AB	1,843 ±0,099 A	0,537 ±0,048 C	0,463 ±0,048 C	1,278 ±0,133 B	47,000	0,000
Flesh firmness	2,387 ±0,126 A	1,840 ±0,119 B	2,020 ±0,151 AB	2,439 ±0,126 A	2,504 ±0,169 A	1,713 ±0,132 B	5,953	0,000
Flesh taste	1,967 ±0,117 C	2,833 ±0,069 A	2,347 ±0,096 B	1,858 ±0,074 C	2,310 ±0,092 B	2,453 ±0,096 B	14,623	0,000
Flesh quality	3,247 ±0,217 B	4,760 ±0,084 A	4,173 ±0,139 A	1,861 ±0,142 C	1,767 ±0,236 C	4,187 ±0,105 A	60,397	0,000
Flesh thickness	3,407 ±0,061 B	3,465 ±0,097 AB	3,833 ±0,123 A	1,923 ±0,108 C	1,674 ±0,101 C	3,237 ±0,132 B	70,983	0,000
Flesh volume	1,342 ±0,037 B	1,432 ±0,080 B	1,755 ±0,102 A	0,485 ±0,052 C	0,412 ±0,042 C	1,189 ±0,130 B	44,230	0,000
Pit length	13,428 ±0,187 A	13,326 ±0,675 A	13,308 ±0,304 A	12,505 ±0,210 AB	12,047 ±0,308 AB	11,542 ±0,370 B	4,328	0,001
Pit diameter	5,862 ±0,099 AB	6,044 ±0,097 A	5,997 ±0,100 A	5,243 ±0,103 C	5,292 ±0,074 C	5,570 ±0,134 BC	11,777	0,000
Pit weight	0,319 ±0,011 A	0,311 ±0,015 A	0,332 ±0,014 A	0,233 ±0,010 B	0,221 ±0,010 B	0,245 ±0,016 B	14,369	0,000
Pit volume	0,261 ±0,008 A	0,257 ±0,014 A	0,270 ±0,013 A	0,200 ±0,009 B	0,193 ±0,008 B	0,208 ±0,014 B	9,862	0,000
Leaf length	51,715 ±1,580 AB	54,877 ±0,999 A	50,398 ±1,091 ABC	47,390 ±1,140 BCD	46,477 ±1,172 CD	43,844 ±1,171 D	10,905	0,000
Leaf width	23,276 ±0,634 BC	26,077 ±0,724 A	24,882 ±0,780 AB	21,681 ±0,721 C	21,933 ±0,579 C	21,055 ±0,703 C	8,164	0,000

Table 4.1.. (continued)

Character	Cul. 1	Cul. 2	Cul. 3	Wild 1	Wild 2	Wild 3	F	Signif.
Petiole length	7,960 ±0,212 A	8,314 ±0,216 A	7,475 ±0,287 A	5,981 ±0,678 B	5,973 ±0,212 B	6,083 ±0,169 B	9,848	0,000
Petiole width	0,778 ±0,018 A	0,883 ±0,063 B	0,774 ±0,016 A	0,686 ±0,012 A	0,700 ±0,010 A	0,710 ±0,012 A	6,632	0,000
Leaf discoloration	2,160 ±0,155 AB	1,700 ±0,116 A	1,933 ±0,138 AB	1,967 ±0,121 AB	2,387 ±0,139 B	1,953 ±0,170 AB	2,719	0,025
Leaf weight	0,123 ±0,006 A	0,126 ±0,011 A	0,117 ±0,009 A	0,086 ±0,006 B	0,077 ±0,004 B	0,088 ±0,004 B	8,952	0,000
Tree vigour	2,933 ±0,067 A	2,867 ±0,133 A	3,000 ±0,000 A	1,467 ±0,133 C	1,667 ±0,126 BC	1,933 ±0,153 B	36,915	0,000
Yield of the tree	3,733 ±0,118 B	3,933 ±0,118 B	4,533 ±0,133 A	1,133 ±0,091 D	1,067 ±0,067 D	1,600 ±0,131 C	194,965	0,000
Tree damage	1,267 ±0,118 A	1,000 ±0,000 A	1,000 ±0,000 A	1,000 ±0,000 A	1,333 ±0,159 A	1,267 ±0,118 A	2,883	0,019
Num. of stems	3,400 ±0,349 BC	1,000 ±0,000 C	1,467 ±0,215 C	6,133 ±1,077 A	2,133 ±0,256 C	5,400 ±1,081 AB	10,507	0,000