THE REVISION OF TAXA *CRATAEGUS* FROM THE CARPATHIAN BASIN

VIKTOR KERÉNYI-NAGY

Supervisor: Prof. Dr. BARTHA DÉNES

Sopron
Hungary

2015
1. INTRODUCTION

The history and the borders are changing, but the species not quite take into account the it: this thesis is about the ecologically and floristically coherent Historical Hungary’s hawthorns. Hawthorns are constant companions of the Carpathian Basin’s degraded pastures, turkey-sessile oak forests, oak-hornbeam associations and beech forests.

The hawthorns are adapted quite diversely to the wide varieties of circumstances, which often abound in anthropogenic effects, and this divers adaptation manifests in their high richness in form. I wrote my diploma thesis in the Department of Botany in the Faculty of Horticultural sciences of Corvinus University of Budapest and also in the Botanical Garden of Soroksăr, where it has a tradition in research of wild relatives of cultivated species, so to fit in to the favoured image of my then department, and to satisfy foreign demands, I started my pilgrimage in my country and also in the Carpathian Basin, to collect species, based on the system of Prof. BARANEC TIBOR, from genus Crataegus.

Back then I introduced four years of work (2005–2008) in my diploma thesis. The topic seemed inexhaustible, more questions were formulated in me, so further research was carried out (2009–2014), now at the Institute of Botany and Nature Protection at University of West Hungary, led by Professor DÉNES Bártha, along with new perspectives and guidelines.

There’s three difficult part in the interpretation of hawthorns:
1. The extraordinary diversity of Common Hawthorn („Monogyna” aggr.)
2. The difficulties of long sepal hawthorns („Curvisepala” aggr.) in nomenclatural and taxonomic matters.
3. The assessment of the difficulty of hybrids.

The following aims I were set out in my work:
1.) To revision the formal, sometimes chaotic interpretations, and to do the clarification of the taxa based on:
   a.) by their original diagnosis,
   b.) by their type materials, and
   c.) by their nomenclatural point of view.
2.) To create their new classification system based on their real relationships.
3.) To give to the clarified taxa exact spread area based on:
   a.) museum materials and
   b.) literature materials.
4.) Exploration of so far undescribed taxa in the studied fields:
   a.) The revisions of cratologists former, unpublished materials, and their validation, and
   b.) discover new taxa by field research.
5.) To give a detailed description about infra-and intraspecific species of the taxa.
6.) To prove the right for existence of independent taxa by biometrical (morphometrical) methods.
7.) The clarification of Hungarian hawthorn and its morphological complex by genetic methods.
   a.) Is there any intraspecific difference based on cpDNA sequences between hawthorns with black fruits;
   b.) Is there relationship between C. nigra and C. chlorosarca, because the two species belongs to one section, despite the great geographical distance.
   c.) Is C. pentagyna and C. nigra separates; and
   d.) Can be verified the parental species (C.nigra and C. monogina) of C. xdegenti?
8.) To make a single, and valid identification key for all taxa from the region.
9.) To make a collection about the hawthorns, which were described and collected from the Historical Hungary’s territory.

2. MATERIAL AND METHODS

2.1. Used special technical terms

Because some certain terms not used nowadays, and their places taken by not quite good phrases, and for the clearance of taxonomic interpretation, I defined some technical terms: csontáralma áltermés (pseudo fruit), csontárcsokor valódi termésnel (bouquet of stones with real fruit), monogyroid, laevigatoid, hawthorns with „rövidcsészés” (short-sepal) and „hosszacsészés” (long-sepal), steady and primer hybrids. In case of nomenclatural (and taxonomic) problems, the only way what leads to solution is the comparison of the descriptions and the type materials, and these evaluation based on the „Melbourne Code” (International Code of. Nomenclature for algae, fungi, and plant) (McNeill et al. 2011).

In my systematization I tried to synthetize, but I kept the apomictic microspecies conception, however I summarized several taxa in hierarchical system. I tried less synonymising: I rejected the views of various taxonomists (”sensu” - perceptions) and synonymized only those taxa that have the type of original and copies of the diagnosis I was able to watch. In the matter of hybrids took the pattern from Sorbus, because their genetic „material” is the same, only the rate of inheritance is different. I took those hybrids, with the priority principle in my eyes, in hierarchic sequence which ascended from the same parents. However I distinguished the primer and the constant hybrids. I took those taxa for primer hybrids where the mark complexes varietal on a single individual (eg. where the sepals simultaneously erected-standing apart-reflexed). Because I think in microspecies, I rejected the merging of parental species. In every hybrids I wanted to choose a clear isolating mark.

Similarly to BARANEC (1986) work I keep the aggregates; those hybrids, which are formed between the same species aggregate, discussed in the same group of species, while hybrids between different groups treated in hybrid groups.

3.2 Field collections

During my field research I collected hawthorns from 174 (164 from the Carpathian basin, 12 European and pre-Asian) locations in total, this means the exact number in days of field work. During my field works I collected 63 fascicles, and quasi 6300 herbarium sheets, and from these a significant portion is hawthorn (Fig. 1.).
We collected the samples in Hungary from natural habitats (C. nigra: Szigetújfalu, 5K, 6AB woodpart; C. ×degeni: Szigetújfalu, the road between the 4A–5B woodpart; C. monogyna: Szigetújfalu, the border of 5K – 6AB woodpart) or from the live-collection of the Institute of Botany of the Hungarian Academy of Sciences, Vácrátót (C. chlorosarca; the origin of the shrubs were Vladivostok (Russia) and Beijing (China)) and C. pentagyna from Bukarest (Romania).

2.4.2 Genetical study
DNA amplification and sequencing
DNA was extracted from young leaves stored at -20 °C using a modified CTAB method (MSZ EN ISO 21571, 2005) originally introduced by DOYLE and DOYLE (1987). Standard polymerase chain reactions (PCR) were carried out in 20 µl final volume from ~30 ng template DNA under following conditions: 2 minutes denaturation at 94 °C was followed by 30 cycles of 30 secs denaturation at 94 °C, 30 secs primer annealing at 56 °C and 1 minute elongation at 72 °C. The reaction was closed by 5 minutes chain elongation at 72 °C.

For amplification of tmL-tmF (5’-AAACGCAGTTGGTCAAGTC-3’ and 5’-GATTGGACTGTTGACACGAG-3’) and psbA-trnH (5’-GGTATGCGTAACGTAATTGCT-3’ and 5’-CGGCGATGTTGGATTCACAATCC-3’) chloroplast intergenic regions, primers used by ALBAROUKI and PETERSON (2007) for hawthorns taxa were applied. Following 1.2% agarose gel-electrophoresis, the manufacturers instructions. Eluted PCR products were direct sequenced using traditional Sanger sequencing on the ABI 3100 (Apllied Biosystems) platform using both forward and reverse primers such accessing two times coverage.

Sequence and phylogenetic analysis
Reference sequences of taxa belonging to sections and Crataegus LBAROUKI et al. (2009) were fetched from GenBank for C. nigra, C. wilsonii, C. russanovii, C. sanguinea, C. chlorosarca, C. nevadensis, C. orientalis, C. chlorosarca, C. pentagyna (Poiret) DC. Multiple alignment of reference and raw sequences was carried out using the ClustalW2 tool (Letz et al. 2007). The raw sequences were then manually curated based on the electrophoreterograms and the alignment. Completely identical sequences were joined under one sample name. Phylogenetic analysis was carried out with 1.000 bootstrap replicates and the neighbor-joining method (SAITOU investigated sequence regions.

2.5. The morphotaxonomic examinations
The examination of herbarium sheets we’ve performed at the Hungarian Natural History Museums herbaria’s Carpato-Pannon collection. (C. brevispina, C. monogyna, C. ×deltoxyacantha, C. laevigata, C. rosaeformis, C. curvisepala, C. lindmani, C. nigra, C. ×degeni, C. pentagyna). The living specimens were examined by us in love-collection of the Institute of Botany of the Hungarian Academy of Sciences, Vácrátót (C. chlorosarca, C. pentagyna) and in the Budai Arborétum (Arboretum of Buda) (C. ‘Paul’s Scarlet’, C. monogyna ‘Plena’, C. monogyna ‘Compacta’) and also in the Buda Hills (C. ovalis), in their natural habitat. We’ve done leaf morphologic examinations on the basic species and on the hybrids (C. brevispina, C. monogyna, C. ×deltoxyacantha, C. laevigata, C. rosaeformis, C. curvisepala, C. lindmani, C. nigra, C. ×degeni), however we only could do flower- (C. laevigata, C. brevispina, C. monogyna, C. ‘Paul’s Scarlet’, C. monogyna ‘Plena’, C. monogyna ‘Compacta’, C. curvisepala) or fruit morphologic examination (C. monogyna ‘Compacta’, C. laevigata, C. curvisepala, C. nigra, C. ×degeni, C. pentagyna) on these taxa, thanks to the weather conditions. At the designing of the morphometric measurements and at the statistical examinations we’ve followed the protocols of GOSLER (1990), BARTHA and RAJSZ (2002), HARMOS and LADANYI (2005), DEPYPERE et al. (2006), and KERÉNYI-NAGY (2009). The leaf morphometric examination was done only on herbarium specimens: the vegetative and generative shoots were measured separately with emphasis on the generative shoots, because they are consistently carries the typical marks of the species. Where we could, we’ve measured whole shoots, but sometimes we
could only examined leaves one by one, to avoid the degradation of herbarium specimens. We’ve measured the parameters of each leaves from the top of the shoot to the base in case of generative shoots, on the vegetative shoots we’ve done it from the base to the top. The measured parameters are the followings (Fig. 1): The width of the first segment, the width of the half blade, the first lobes greatest diameter, length of the blade, length of petiole, number of lobes, angle of the leaf base margins, and the angle of the first segment’s sinus. We’ve done flower morphometric on living specimens, the fruits were examined on living and on herbarium specimens: number of flowers, average diameter, length and width of the fruit were measured. We used SPSS 20 suite to the evaluation of the results. SPSS is a user-friendly statistical software, which includes classical and modern statistical methods as well. The advantage of this program is it gives opportunity to use other methods in case of the absence of traditional conditions of the application.

During our comparative examinations we had enough data to do traditional, parametric methods (one-factor analysis of variance) for a reliable conclusion, the normality of the data from samples, and the homogenous deviation was met. We had used one-factor analysis of variance for the comparison of the quantitative properties (Fig.1). We would have liked to know how much the morphologic marks are features of the hawthorn taxa, significantly different, and they can be seen similar with each other, to support their taxonomic (species or subspecies in this case) ranks. We have used a Duncan significant difference post hoc analyses, for the supplement of average value comparison tests in analysis of variance, as the reason of this we’ve created homogenous groups of the treatments based on different attributes. For verifying of the in-group matching of variants we’ve used Levente-test. On the figures, the sequence of the alphabetic row shows the sequence of size, the different letters are significantly different. The comparisons were made by SPSS 20 program suit, with 95% level of significance. Correlation analysis can be used to examine causal connections and its closeness, between some properties. More closer the correlation and determination coefficient to 1, it means closer connection. The evaluation findings in 95% (strong correlation) and 99% (laws of association) can be accepted on level of significance. The correlation is positive, if one parameter is increase or decrease (the Pearson coefficient is positive) with the other; the correlation is negative in the case if the growth of one parameter comes with the decrease of other (the Pearson coefficient is negative). During our analyses we used the Person’s correlation coefficient by SPSS 20 program suite. The similarity groups were performed by hierarchical cluster analysis, based on the measured data. From the parameters we’ve determine by, K-middle method, ANOVA (analysis of variance), which features determinates best the classification into different clusters. The conclusions were reached 95% significance level. In the matter of hierarchic classification we went step by step, and always reduced the number of clusters by merging two cluster together. Here you can not only count the distance of two points in space by Euclidean distance, the program offers several methods for defining distance between two clusters as well. By the result of the distance can be determine the real number of group, after with the K-middle method, can the groups determinable. There’s an opportunity to see which features the most determines the classification to different groups (and also to see which are not). This method were used to diagnose that, hawthorn taxa how close or away from each other, based on all the examined features with together.

Fig. 1: Leaf parameters: ETAGOL- the length of the first segment, FELLEV- the width of the half blade, ELEGSZ- the first lobes greatest diameter, LÉVHESZ- length of the blade, NYELHSZ- length of petiole, KAREJS- number of lobes, VALLSZ- angle of the leaf base margins, OBOLSZ- the angle of the first segment’s sinus (SITUPAK, 2013)

3. RESULTS AND EVALUATIONS
3.1 Result of nomenclatural revision

The taxa *Crataegus oxyacantha* was described by LINNÉ at 1753. Usually under this name, the botanists understands, the species *Crataegus laevigata* (POIR.) DC., Often (and wrong) they use the previous name despite, that the taxon were under several taxonomic-nomenclatural correction.

I summarised below the nomenclatural and taxonomical problems of so-called „two-pistill” hawthorns on Carpathian-basin level.

The uncertain taxon emended by JAQUIN in 1775: *C. oxyacantha* L. em. JACQ., below he understands the already in modern sense *C. laevigata* (POIR.) DC. species and for separation describes the *C. monogyna* JACQ. species. Clear description given by POIRET (1778) as *Mespilus laevigata*, which DE CANDOLLE (1825) reclassified to the genus *Crataegus*. HRABĚTOVA-ÚHRÓVA (1974) thinks right the name *C. oxyacantha* L., because sin her opinion the diagnose is good. By contrast FRANCO (1967) thinks the name *C. oxyacantha* L. is doubtfull (nomen ambiguum), and he thinks it to the synonym of *C. monogyna* JACQ. Later HRABĚTOVA-ÚHRÓVA (1978) also uses the name *C. laevigata* (POIR.) DC. CINOVSKIS (1971) accepts the species *C. oxyacantha in JACQUIN-kind sense, moreover she classified *C. laevigata* under it (*C. oxyacantha* L. em. JACQ. var. laevigata (POIR.) BECK). BYATT (1974) discussed the problem in detail, she notes that from LINNÉ’s 4 herbarium specimens ,which are from garden, the one what DANDY (1946) designated as a type specimen (№ 643.12) equal to the *C. curvisepala* LINDM., species, Whilst the specimen № 643.13 is African, probably from garden, is a *C. monogyna* *C. laevigata* hybrid, the № 643.14. Also a *C. curvisepala* LINDM.; the № 643.15 specimen is *C. monogyna* JACQ. In her opinion the taxon is not specifiable based on LINNÉ description, so she call it „uncertain name” (nomen ambiguum) and thinks as a synonym of *C. curvisepala* LINDMAN. Based on the above we can say, that the *C. oxyacantha* is uncertain name, it concerns more taxa, it description is unacceptable. LINNÉ’s specimens are from multiple locations, species and specimens, thus the name can’t be used – to describe in a general sense, the name *C. laevigata* (POIR.) DC. to be used! The *Crataegus palmstruchii* based on the description of LINDMAN (1918) separates from the species *C. oxyacantha* (L.) JACQ. with its more vigorous growing; its larger leaves (3–5(–7) cm); hairs in its branchings of veins; longish, 2 longer than wider, pointed and standing apart sepals. In BYATT (1975) opinion it separates with its larger fruit too. It was revised in 1992 to *C. oxyacantha* L. var. palmstruchii (LINDM.) HEGI, in 1969 to *C. oxyacantha* L. subsp. palmstruchii (LINDM.) HRAB.-ÚHR., and in 1974 to *C. laevigata* (POIR.) DC. subsp. palmstruchii (LINDM.) FRANCO rank. CHRISTENSEN (1992) sees the synonym of *C. laevigata* (POIR.) DC. In my opinion is separates quite good from the other taxa, probably descendent from *C. lindmanii* and *C. laevigata* as their constant hybrid, independent species. In 1927 WALO KOCH publish a species without diagnose (nomen nudum) as *Crataegus helvetica*, thus HRABĚTOVA-ÚHRÓVA prove the taxon by its holotype: *C. oxyacantha* L. subsp. walokochiana Hrabětová-Úhróva (1968b). By the nomenclatural refinements HOLUB (1970) makes a new combination: *C. laevigata* (POIR.) DC. subsp. walokochiana (HRAB.-ÚHR.) HOLUB. In 1971 CINOVSKIS publishes as the unsteady *C. calycina* PéTERM´s variety (var. walokochiana (HRAB.-ÚHR.) CINOVSKIS). Later SOO (1974) erects to species rank in name *C. walokochiana* (HRAB.-ÚHR.) SOO, but his publication without basonim date is invalid. SCHMIDT (1981) gave the matching name to the nomenclatural rules, put the taxa on hybrid state (C. ×walokochiana (HRAB.-ÚHR.) P. A. SCHMIDT, which is the primer hybrid of *C. laevigata* and *C. palmstruchii*. SCHMIDT’S view is correct because its sepals are partly reflexed, partly erected. In BARANEC (1986) opinion this taxa’s synonym is *Crataegus oxyacantha* L. var. oxyacantha PÉNZES, nevertheless PÉNZES (1956)’s diagnose did not cover sepals too, and on the type specimens these are party missing, the extant ones are partly reflexed; however on the taxa’s aquarelle they are not. Because at the previous taxa PÉNZES described the *C. oxyacantha* with short and reflexed sepals, I think the aquarelle is a little bit rough and defective, and BARANEC made his decision based on this drawing.
3.1.2. Problem of „long sepal” hawthorns

The story of „long sepal” hawthorns had begun with the description of Crataegus macrocarpa HRISTENSEN (1870) had given a short description (“Bei den Her kulesbädern fand...” name. The species Crataegus macrocarpa, which were described by PETERMANN (1849) causes a lot of problems: previously every long sepal hawthorn were under this taxa. Unfortunately its gothic letter description contains very few morphological markers. FRANCO (1968) accepts the species, based on the vegetative and floral similarities he merge with other species (C. calycina PETERM. subsp. curvisepala (LINDM.) FRANCO). CINKOVIC (1971 a, b) concludes that is the hybrid C. oxyacantha L. near. JACQ. (today: C. laevigata (POIR.) DC.) and the C. calycina LINDM. (today C. lindmanii HRAB.-UHR.), also the name C. calycina LINDM. is not acceptable, instead the name C. lindmanii HRAB.-UHR. need to be used. The species C. calycina PETERM. against Hrabétova-Uhrová’s he does not consider the species equal to with C. macrocarpa HEGETSCHW.. The species C. macrocarpa HEGETSCHW. he considers to the hybrid of C. oxyacantha L. em. JACQ. (now: C. laevigata (POIR.) DC.) and C. xanthensis CINKOV. In his opinion C. xanthensis CIN is the hybrid of C. curvisepala LINDM. and C. lindmanii HRAB.-UHR., in my opinion this is can’t clearly separable from the taxa C. plagiosepala POJARK, so take it under. BYATT (1974) tried to clarify the taxa C. calycina PETERM: according to Hrabétova-Uhrová’s disclosure the PETERMANN-herbarium was lost at the world war, she stated by the species of a Kew Botanic Garden that, PETERMANN did not appointed type specimens, he did not marked the dates on his collections, only flowering specimens are found there, and there is a herbarium specimen which published under the name „C. macrosepala” near Leipzig, from the taxa’s locus classicus. In his opinion it is hopeless to separate from the taxa C. macrocarpa HEGETSCHW., thus he considers as a synonym of it, the Flora Europaea (FRANCO, 1968) uses this name wrongly. HOLUB (2003) treats the taxa C. calycina PETERM, as a hybrid, the mixture of C. laevigata (POIR.) DC. and C. lindmanii HRAB.-UHR. (see also; CINKOVIC 1971). The Atlas Florae Europaeae (KURTO et al. 2013) already treats as a synonym of C. macrocarpa HEGETSCHW. The first “long sepal” hawthorn could be the *Crataegus ovalis* (1863) which was described by KITABEEL, if he was published it in his life. Unfortunately the foreign botanist don’t knows it (eg. they equals it with the species C. insularis, which were described by CINKOVIC (1971), based on his diagnose and figure) or despite its one pistil they consider it as a multiple pistil species: 1.) Under C. macrocarpa HEGETSCHW. (C. × magna SCHERSON & HENDÁK, 1996; C. × magna INTEPARK, it as C. × media BECHT. (BECK, 1890; taken from: ASCHERSON – GRABNER, 1900–1905; SCHNEIDER, 1906; CINKOVIC, 1971). JÁVORKA (1915) misinterpreted work, „Crataegus ovalis kit. (Addit. 282. old.; herb. fasc. LIV. Nr. 128.), without naming a region, could give a base to the last interpretation. I think C. monogyna JACQ. is less lobed. At most the limbs can refer to it taxa C. oxyacantha, if their inner surface is a little hairy, but this can occur on the typical C. monogyna. KITABEEL’s specimen is with fruit, the half ripened fruit on it is fully from C. monogyna. The thesis (ASCHERSON et GRABNER SYN. VI. 36. pp.; SCHNEIDER C. K. Handb. Laubh. I. 178. pp.) that says C. ovalis is one hybrid form of C. monogyna oxycantha, which based on KITABEEL’s description is not acceptable,” and JÁVORKA S. (1926): Herbarium Kitaibelianum. p. 580: „[ovalis kit. Addit. P. 282. no. 1190.] monogyna? an species nova? Ab oxycantha floribus monogynis diversa, fructus certe monospermus. In monte Szmerkovicza, ad Hradek et ad acdidas ad Barthpenes. (no. 183.) – ovalis mihi. (LIV. No. 128.) monogyna JACQ.; laciniae fructus maturi revultuete. Fructus monospermus. Folia subitus in angulis varumius plus minus barbatum.”

The Melbourne code does not determines a taxa’s “good” or “bad” description, as the logic of CHRISTENSEN the majority of species would be without description. Moreover it refers to cursory, that he gives epithet „rosiformis [errore rosoformis],” even though neither at the 1870 and nor in the 1874 publication JANKA gives „rosiformis” name. The species C. curvisepala LINDM. HRAJAN (1991) states as invalid (nomen illegitimum), and write down a new name C. prasmonticola. In the latest processing (KURTO et al., 2013) they only taken the opinion of CHRISTENSEN. Based on the principle of a priority, the existing diagnose and the lectotype the valid name is C. rosaefórmis JANKA, its whole valued synonym is C. hippophylotha Gand., and at most its infraspecific taxa C. curvisepala LINDM. The taxa C. monogyna JACQ. var. rossingeri K. MALY was remained completely unknown, which rediscovered and revised by JANKIC (2002) (C. hippophylotha GANDGOGER var. rossingeri (K. MALY) JANKIC). For the obscurity in 1968 Hrabétova-Uhrová describes the species Crataegus lindmanii. Her taxa was merged, based on similarities of floral and vegetative properties on separate ranks: C. curvisepala LINDM. subsp. lindmanii (HRAB.-UHR.) BYATT (1974), C. rosaefórmis JANKA subsp. lindmanii (HRAB.-UHR.) K. L CHR. (1985), K. lindmanii (HRAB.-UHR.) K. L CHR. (1992), C. hippophylotha GANDGOGER. var. rossingeri (K. MALY) JANKIC (2002). Within the meaning of Melbourne code (§ 11.1 and 11.4) the valid taxa name is wich were described on the rank earlier, thus the rank of species of C. lindmanii HRAB.-UHR. is indispensible. POJARKOVÁ (1965) published the taxa C. plagiosepala POJARK, which sepals are quite longs, straitly erected, and mostly has only one stone, rarely two BARANEC (1986) thinks it to a hybrid of C. monogyna × C. lindmanii, despite that I think that the C. lindmanii × C. rosaefórmis × C. monogyna. Hrabétova-Uhrová (1968a) publishes as nomen novum the taxa, which is the synonym of C. calycina PETERM. em. LINDMAN, and the taxa C. calycina PETERM. see as the synonym of C. macrocarpa HEGETSCHW. Although HEGETSCHWIELER (1840) does not includes neither the length of the sepals, nor the states of them (HEGETSCHWIELER, 1840, p. 464., „392. C. macrocarpa nob. Langfrüchtiger W. Ein dorñinger Strauch von 15-20 Hho. Bltr. eirund oder erund-trapezoidisch, nach vorne 3-5flappig – die Lappen zugesetzt und spitzig gesigt. Blnn. weiss, meist eingriffelig. Fr. gross, cylindrisch, länger als dick, am Grunde 5 höher, meist einsteing. h 5. 6. In Hecken und Gebüschen, besonders in montanen Gendenden. Z. B. am Ezel und gegen Einsiedeln etc.”). As a summary it can be said that the name C. calycina PETERM is uninterpretable, and need to be rejected, the long sepal hawthorns in the area of the Carpathian can be separated the species and hyboids below:

- C. ×macracarpa HEGETSCHW. subsp. macrocarpa and subsp. calcipala (HRAB.-UHR.) HRAB.-UHR.,
- C. rosaefórmis JANKA subsp. rosaefórmis and subsp. curvispeala (LINDM.) KERÉNYI-NAGY,
- C. lindmanii HRAB.-UHR.,
- C. plagiosepala POJARK.

In the case of the basic species or great species, they are easily recognizable and called „good” species, by contrast some of their minor species the (hybrid) species with hybridogen origin and the primer hybids called „bad” species, their borders are faded. In matter of “bad” species the following solutions spread in the literature:

I. Microspecies:

1. The mix species are considered as apomorphic species, assumed the genetically isolation.
2. Sums them in hierarchical system.
3. Consider them as synonyms.
In my opinion their consideration as synonyms is a dead end: separation of local, typical characters and
natural conservational important taxa is justified - this perception of taxonomic (species-specific or
infra-peer) cannot tell an exact opinion.

II. In case of hybrids:
1. Like at Sorbuses every hybrid taxa treated as apomictic microspecies.
2. Certain stronger microspecies are kept: although the hybrid parental species are the same, but they
make difference by the mother (eg. BARANEC, 1986).
3. They distinguish the permanent and primer hybrids (eg. BARANEC, 1986, at roses KERÉNYI-NAGY,
2012).
4. The hybrids merged with the first validly described taxa and treated as synonyms (CHRISTENSEN,
5. The not clearly separable species, from different parents merged together by merging the parental
species (eg. CHRISTENSEN, 1992).

Each conception listed here have a rationality (eg. because of apomixis) but in my opinion following a
unilateral direction leads false outcomes. As an outlook a deductible consequences that this problem
the other hand, genetic analyses, but this genetic tests yet to evolve in botany – analysis of each
sequence does not lead to salvation. Of course not itemized the wide variety of ideas and
interpretations (“sensu”), what different researchers mean by under a name of a taxa, so the picture
gets more complicated. Above as I did not explain the nomenclature and its problem, because it is
relatively easy to decide the issue.

4.2 Taxa which founds in Carpathian basin are the followings (in my new classification):

„Monogyna” aggr.
1. Crataegus monogyna JACQ.
   subsp. monogyna
   var. monogyna
   f. arborensis PÉNZES
   f. fœcundii BRIQ
   f. pendula (LOUD.) DIPP.
   f. szafneri GÓSTYNSKA-JAKUSZEWSKA
   var. dissecta (BORKH.) GÓSTYNSKA-JAKUSZEWSKA
   var. laitmonogyna PÉNZES
   var. mundyi (PÉNZES) KERÉNYI-NAGY
   var. plexivecensis (HRAB.-UHR.) BARANEC
   var. tauscheri (PÉNZES) KERÉNYI-NAGY
   var. trilobata (BUA) GÓSTYNSKA-JAKUSZEWSKA
   var. spatulifolia KERÉNYI-NAGY
   subsp. nordica FRANCO
   subsp. acutiloba (J. S. KERNER) BARANEC
   var. acutiloba
   f. artisata-serrata KERÉNYI-NAGY
   var. vinetica HRAB.-UHR. ex KERÉNYI-NAGY

2. Crataegus brevispina KUNZE
   var. brevispina
   var. microphylla (CSATÓ) KERÉNYI-NAGY
   var. contracta (HRAB.-UHR.) KERÉNYI-NAGY

1×2. Crataegus xjavorkei (PÉNZES) KERÉNYI-NAGY

3. Crataegus denticulata HRAB.-UHR.

„Laevigata” aggr.
4. Crataegus laevigata (POIR.) DC.
   subsp. laevigata
   var. laevigata
   f. laevigata
   f. bicrenulata HRAB.-UHR. ex KERÉNYI-NAGY
   var. ovalxycantha (PÉNZES) KERÉNYI-NAGY
   subsp. vulgaris (M. J. ROMMER) BARANEC
   var. vulgaris
   var. carmoviennis (HRAB.-UHR.) KERÉNYI-NAGY
   var. integriifolia (WALLR.) KERÉNYI-NAGY
   var. matthei (PÉNZES) KERÉNYI-NAGY
   var. microphylla (LANGE) KERÉNYI-NAGY
   var. microxyacantha (PÉNZES) KERÉNYI-NAGY
   var. sorbifolia (LANGE) KERÉNYI-NAGY
   var. gyoerffyi PÉNZES ex KERÉNYI-NAGY

„Curvisepala” aggr.
5. Crataegus ovalis KIT.
   var. ovalis
   var. somodii KERÉNYI-NAGY

6. Crataegus roseaformis JANKA
   subsp. roseaformis
   subsp. curvisepala (LINDM.) KERÉNYI-NAGY
   var. curvisepala
   var. aceriformis (HRAB.-UHR.) KERÉNYI-NAGY
   var. carstica (HRAB.-UHR.) KERÉNYI-NAGY
   var. carpatica (HRAB.-UHR.) KERÉNYI-NAGY
   f. carpatica
   f. rigidula (HRAB.-UHR.) KERÉNYI-NAGY

7. Crataegus lindmanii HRAB.-UHR.
   var. lindmani
   var. rossigeri(K. MALY) KERÉNYI-NAGY
   var. extrasepala KERÉNYI-NAGY, BARANEC et BARTHA
   var. microsepala KERÉNYI-NAGY, BARANEC et BARTHA
   var. jodulii KERÉNYI-NAGY

5×7. Crataegus scornculata HRAB.-UHR. ex KERÉNYI-NAGY
   „Nigra” aggr.
8. Crataegus nigra WALDST. et KIT.
   var. nigra
   f. borossii KERÉNYI-NAGY et BARTHA
   f. csapodyae BARTHA et KERÉNYI-NAGY
   f. javorkae KERÉNYI-NAGY et BARTHA
   f. karpattii KERÉNYI-NAGY et BARTHA
   f. pappii BARTHA et KERÉNYI-NAGY
   f. penzesii KERÉNYI-NAGY et BARTHA
   f. prodani BARTHA et KERÉNYI-NAGY
   f. vajdai BARTHA et KERÉNYI-NAGY
"Pentagyna" aggr.
9. Crataegus pentagyna WALDST. et KIT.

"Orientalis" aggr.
10. Crataegus orientalis PALLAS
11. Crataegus azarolus L.

"Curvisepala" "Monogyna"-hybrids
5×1. Crataegus radnoti-gyarmatii KÉRÉNYI-NAGY
6.1. Crataegus ×subspapherica GAND. nothosubsp. subspapherica nothosubsp. jacquinii (KERNER ex PÉNZES) KÉRÉNYI-NAGY nothosubsp. scepsisalvii (PÉNZES) KÉRÉNYI-NAGY nothosubsp. ruradensis (RAUN.) KÉRÉNYI-NAGY nothosubsp. fallacina (KLOK.) KÉRÉNYI-NAGY nothosubsp. negreani KÉRÉNYI-NAGY
6×2. Crataegus ×monostevenii PÉNZES ex KÉRÉNYI-NAGY
7×1. Crataegus ×kyrostyla PÉNZ. nothosubsp. kyrostystyla nothovar. kyrostystyla nothom. baksayana PÉNZES ex KÉRÉNYI-NAGY nothosubsp. cupeoyae (PÉNZES) KÉRÉNYI-NAGY

"Curvisepala" "Laevigata"-hybrids
5×4. Crataegus ×seutaticus (HRAB.-UHR.) KÉRÉNYI-NAGY
6×4. Crataegus ×pseudoxyacantha CIN. nothosubsp. pseudoxyacantha nothosubsp. longisepala (HRAB.-UHR.) KÉRÉNYI-NAGY

"Laevigata" "Monogyna"-hybrids
1×4. Crataegus ×melie BECH. nothosubsp. media nothosubsp. deltoxyacantha (PÉNZES) KÉRÉNYI-NAGY nothovar. deltoxyacantha nothom. crassus HRAB.-UHR. ex KÉRÉNYI-NAGY nothom. subrotundifolia HRAB.-UHR. ex KÉRÉNYI-NAGY nothom. monoxyacantha (PÉNZES) KÉRÉNYI-NAGY nothosubsp. intermediata (WENZIG) KÉRÉNYI-NAGY
2×4. Crataegus ×oxystevenni PÉNZES ex KÉRÉNYI-NAGY

"Nigræ" "Monogyna"-hybrids
8×1. Crataegus xdegeni KÉRÉNYI-NAGY nothom. degeni nothom. monoxyacantha (SÁK) KÉRÉNYI-NAGY nothom. szakii BOROS ex KÉRÉNYI-NAGY nothom. borosti (PÉNZES) KÉRÉNYI-NAGY

"Pentagyna" "Monogyna"-hybrids
9×1. Crataegus ×rubrinesis LANGE

"Monogyna" "Curvisepala" "Curvisepala"-hybrids
1×6×7. Crataegus ×plagiossepala POJAR, nothosubsp. plagiossepala nothosubsp. duenesis (CIN.) KÉRÉNYI-NAGY

In my system there is 12 species, 7 subspecies, 36 variety (varietas) and 19 form (forma), and 15 nothosubsp. The suspected hybridization connection between groups (1. figure) and species (2. figure). The suspected connections drawn based on morphological characters, their clarity needs further studies (genetically, chemo-taxonomically, morphogenetic). In two cases (C. pentagyna–C. laevigata and C. nigra–C. laevigata) likely developed hybrids, but these has not been discovered yet. The Hungarian and the two pistil hornweth occurs together, at Dunajtavárás I collected specimens of this kind, but their separation from C. xdegeni is very difficult. Of course, in addition the interpreted hybrids the basic species, outside the Carpathian Basin, also be able to create hybrids with other species and other hybrids.

3. 3 Result of genetic study

Sequence diversity

From the two investigated chloroplast intergenic regions, trnL-trnF was less variable. The 6 bp indel identified earlier between positions 99–104 (ALBAROKUI and PETERSON, 2007) remained monotypic for C. azarolus L. var. aronia L. New polymorphic sites were identified at position 62 of the alignment, where a 1 bp deletion was recognized exclusively in the two C. xdegeni specimens; and at position 134, where a G/T single nucleotide polymorphism (SNP) was identified, T being monotypic for C. pentagyna. The psbA-trnH intergenic region proved to be more polymorphic. A new T/A SNP was identified at position 259 of the alignment (alignment positions are based on positions published by ALBAROKUI and PETERSON, 2007), where A is monotypic to C. pentagyna. Based on the sample set investigated by ALBAROKUI and PETERSON (2007), the authors proposed four indel regions between positions 130 and 190 of the alignment. In our sample set, this region of the alignment proved to be highly variable (fig. 1.), which makes objective
interpretation challenging. First domain of the hyper-variable (HV) is monotypic in section Crataegus, while it is variable in Sanguineae, showing intra-specific variability in the case of C. chlorosarca. This first domain is missing from C. nigra, C. degeni and C. wilsonii completely. Second domain of the HV region is a T mononucleotide repeat, which is less informative and in this case the opportunity of sequencing errors is high. We didn't observe any intra-specific variation in this domain. The third domain has two main characteristics. There is a CGGTT motif monotypic for all investigated C. chlorosarca, but not for the reference C. chlorosarca samples nor any other taxa. The second motif is a G/T SNP, which seems to be highly variable (data not shown). C. russanovi and C. dahurica sequences submitted by Lo et al. (2009) having an ambiguous characters at this position, the reference and the investigated Hungarian C. pentagyna samples have different states at this position. This is also the one and only of the investigated nucleotide positions, where sequences from C. nigra and C. xdegeni samples are differing. Last domain of the HV region is built up from an A mononucleotide repeat. Similar to domain two, it is less informative and error-prone. Because of possible ambiguities, domain two and four, further the G/T SNP motif of domain three were excluded from further analysis.

Intraspecific variations, Phylogenetic relations

Main goal of this study was to clarify, if genetic relationships of the East-Asian C. chlorosarca, the Carpathian Basin endemism C. nigra and one hybrid taxon of the latter, C. xdegeni are coherent with the high morphological similarities of these species. On the neighbor joining tree of the investigated taxa and sequences from Genbank (fig. 2.) high similarity can be observed between C. nigra and its hybrid, C. xdegeni with 100% bootstrap support. Based on our data, C. nigra can be approved being maternal parent of the investigated C. xdegeni hybrids. The other parent C. monogyna can't be proved, as both hybrid samples are of same direction of the hybridization. The C. pentagyna is on the different clad, but this needs further investigation. It must be noted however, that this region might be less appropriate for phylogenetic analysis, but it might be very useful in barcoding studies or to identify Crataegus taxa.

Fig. 1. Alignment of the hypervariable region of the psbA-trnH chloroplast intergenic region. shaded background denotes conserved positions.

Fig 2. NJ tree of the joined chloroplast intergenic sequences. Prunus persica and P. laurocerasus were used as outgroup. Numbers indicate bootstrap support from 1000 replicates.

3.4. Results of herbarium revisions

I have done the typification works: I revised 4 from KITABEL’s, 1 from WIERZBICKI’s, 19 from PÉNZES’S and 38 from HRAĐETOVÁ-ÚHROVÁ’S type material. I validated 9 taxa which were unpublished in herbarium but marked on individual rank by taxonomists, which are valuable in my opinion. I with my co-authors described 8 new forms based on herbarium revisions. I put 41, previously unpublished taxa on new status and rank (from these were published 12 by PÉNZES, and 20 by HRAĐETOVÁ-ÚHROVÁ).

As a result of my field researches 9 taxa (1 species, 1 hybrid species (nothospecies), 1 hybrid subspecies (nothosubspecies), 6 variety (varietas) and 1 form (forma)) were described to the science as new. I revised 4400 herbarium sheets in: Herbaria of Hungarian Natural History Museum (BP) – Jeney-collection (35 pieces), at Herbaria of Hungarian Natural History Museums (BP) – Core material (approx. 2000 pieces), at Eötvös Lóránt University Botanical garden (BPU) (10 pcs.), Szent István University at Gödöllő (GAIH) (35 pcs.), Eszterházy Károly University of Applied sciences at Eger (EGR) (4 pcs.), University Babeș-Bolyai at Cluj-Napoca (CL) (quasi 280 pcs.), Herbarium Croaticum at Zagreb (ZA) (99 pcs.), Herbarium Ivo and Marija Horvat also in Zagreb (ZAHO) (54 pcs.) collections. For European outlook I checked of the material in the herbaria of the University of Masaryk, Faculty of Naturalsciences, Department of Animal and Plant Sciences at Brno (BRNU) (quasi 900 pcs.) and in the Herbaria of Albert-Ludwigs University at Friedeburg (FB) (20 pcs.).

3.5. Results of morphometrical investigations

3.5.1. Leaf morphologic

By the results of the one-factor analysis of variance about the width of the first segment we can say that the measured parameters are significantly separates at the species, and the Duncan's significant post hoc analysis showed that four homogenic group can be made. It can be sad based on the width of the first lobe there is a significant difference between C. monogyna and C. brevispina; the deviation reflects well the kinship relations of C. laevigata – C. deltoxyacantha – C. monogyna. It supports the kinship of the species of Curvisepala agg., only separates the C. rosaeformis for a little: it makes a common group with C. nigra, which can be explained by the short and shallow lobes of the two species. Although the C. xdegeni shares a group with the taxa of Curvisepala, but the parameters shows it is rather close to the group of C. monogyna. By the results of the one-factor analysis of variance about the width of half blade it can be said, that the measured parameters are significantly separates at the species, and the Duncan's significant post hoc analysis showed that six homogenic group can be made. The division show clearly the hybrid nature of C. degeni, because it is shares of a group between its parental species (C. monogyna and C. nigra), and based on the measured parameters its closer to C. nigra. The group Curvisepala based on the half-bade-width separates from the other groups. C. brevispina also markedly distinct from its collector species (C.
The classification of species based on the measured parameters

The similarity groups of hawthorn taxa were made based on the measured parameters of hierarchical cluster analysis. Two kind of dendrogram were made, at the first we’ve taken account the measured parameters from all the generative and all the vegetative shoot’s leaves, while at the second we’ve only used the parameters measured from generative shoot leaves. From the parameters we’ve determine by, K-middle method, ANOVA (analysis of variance), which features determines best the classification into different clusters. In doing so the angle of the first segment’s sinus and the angle of the leaf base margins were proved to be the most significant parameters, which were supressed the significance of the others, and because the resulting dendrogram did not reflect to the taxonomic relationship we’ve performed the grouping without these two parameters. This statement supported by Person-correlation analysis, because these two parameters shown less connection with other parameters. On the other two figures is clearly visible that against the leaves which from the vegetative shoots with leaves of generative shoots shows more better the relationshps: the taxonomic connection.

In the matter of floral sizes the great deviation’s cause can be that the individual plants are lives in regions with variant climatic conditions. The difference between the minimum less than between the maximums, this is also can be descends from the different climate, and the different soil water management. From the measured species C. nigra, C. monogyna and C. ×degeni has the greatest flower averagely, the biggest deviation can be found at C. laevigata floral size. C. curvisepala stand outs its length of the fruits: compared with C. monogyna it has one and a half or twice the size of that fruits, but with the other taxa there is outstanding differences. In the matter of fruit width C. ×degeni is averagely the widest, but its standard deviation is the greatest too, which shows that the forms of the fruits are not uniform, it deeply closed with the developed stones inside the fruit. Considering the length and widths of the fruits C. curvisepala has the longest and C. degeni has the widest fruits.

3.6 Identification of native hawthorns

In my dissertation I publish the markercomplexes which provides to get to know better the Carpathian basin’s and Croatia’s hawthorns, and three identificationkey of theirs (identificationkey of collectorspecies, species and subspecies and species, subspecies and hybrids)

3.7. Presentation of hawthorn species

I discuss in detail of the nomenclature, morphologic description, and variability within species, chromosome number, and spreading area of certain species. I help the better interpretation of the variability within species with line art images.
4. NEW SCIENTIFIC RESULTS

I presented in my doctoral dissertation the hawthorns of the Carpathian basin in detail, discussed in historical overview the literature which includes the Carpathian basin with their European correlations with outlooks to Asian and North-American. I introduced generally the kinship, the spread area and the special technicus terminus of genus hawthorn.

1.) I clarified the examined area’s hawthorn’s nomenclature and taxonomy, I detailed discussed the problem of "two pistil" and "long sepal" hawthorns. I have done the typification works. I revised 4 from KITTEL’S, 1 from WIERZBICKI’S, 19 from PÉNZES’S and 38 from HRAJETOVÁ-UHROVÁ’s type specimens.

2.) I discussed in details the hawthorn’s genus so far classifications, and after I created a new classification which taking account the real relations of kinships, their complex and very complicated relations, and which is valid for the whole Carpathian basin. In my system there is 12 species, 8 subspecies, 35 variety (varietas) and 18 forms, and 15 hybrid species (nothospecies), with 15 hybrid subspecies (nothosubspecies), with 14 hybrid varieties (nothovarietas) and with 13 hybrid forms (nothomorpha). I indicated only those taxa which are truly found and natives at the territory of the Historical Hungary (broadly interpreted Carpathian Basin). In matter of two species (C. azarolus and C. orientalis) the nativeness is questionable, despite that I included them.

3.) I validated 9 taxa which were unpublished in herbarium, but marked on individual rank by cytologists, which are valuable in my opinion. I with my co-authors described 8 new forms based on herbarium revisions. I put 41, previously unpublished taxa on new status and rank (from these were published 12 by PÉNZES, and 20 by HRAJETOVÁ-UHROVÁ). As a result of my field researches 9 taxa (1 species, 1 hybrid species (nothospecies), 1 hybrid subspecies (nothosubspecies), 6 variety (varietas) and 1 form (forma)) were described to the science as new.

4.) I revised 4400 herbarium sheets in: Herbaria of Hungarian Natural History Museum (BP) – Jeney-collection (35 pieces), at Herbaria of Hungarian Natural History Museums (BP) – Core material (approx. 2000 pieces), at Ervís Lóránt University Botanical garden (BPU) (110 pcs.), Széchenyi István University at Gödöllő (GAH) (53 pcs.), Eszterházy Károly University of Applied sciences at Eger (EGR) (4 pcs.), Universitatea Babeş-Bolyai at Cluj-Napoca (CL) (28 pcs.), Herbarium Coraticum at Zagreb (ZA) (99 pcs.), Herbarium Ivo and Marija Horvat also in Zagreb (ZAHO) (54 pcs.) collections. For European outlook I checked of the material in the herbaria of the University of Masaryk, Faculty of Naturacles, Department of Animal and Plant Sciences at Brno (BRNU) (quasi 900 pcs.) and in the Herbaria of Albert-Ludwigs University at Freiburg (FB) (20 pcs.). During my field research I collected hawthorns from 174 (164 from the Carpathian basin, 12 European and pre-Asian) locations in total, this means the exact number in days of field work. During my field works I collected 63 fascicles, and quasi 6300 herbarium sheets, and from these a significant portion is hawthorn Based on my field-, herbaria- and literature research I could clarify the spread area of certain taxa, which I impart in point map.

5.) I assembled an identification key system which uniform for every taxa of the region: it includes 1. the collector species,2. the species and the subspecies and 3. the species subspecies and hybrid species.

6.) I discuss in details the species and their infra-and intraspecific taxa in chapter Presentation of species, and for to help the recognition I’ve made photos and drawings.

7.) I presented the ecological and coenological demands of hawthorn species based on their literature, and after I amend it relied on my experiences.

8.) The morphometrical measurements I performed together with SZTUPÁK MÁRTON professional staff and with Mrs. Dr. SZABÓ Nő Dr. ÉRDELDY ÉVA head of department: we were measured 11 parameter: the length of the first segment, the width of the half blade, the widest diameter of the first segment, length of the blade, length of petiole, number of lobes, the angle of the leaf base margins, the angle of the first segment’s sinus and the flowers diameter and the diameter and length of the fruits. Based on the leaf analysis of variance that the origin of C. ×degeni (C. nigra – C. monogyna), the C. ×media nothosubsp. deltosyacanthus (C. monogyna – C. laevigata) almost all parameters confirmed, C. brevispinus significantly separated from C. monogyna, while from the species of group Curvisepala the C. rosaeformis subsp. rosaeformis in most cases slightly separated from the other members of the group, while their parameters almost were close together. The Pearson-correlation shows that the parameters interdependence is great, and at every species a complex harmony can be observed, that is to say all of the parameters changing properly with the other parameters, so they taxonomic relevance is less outstanding. The similarity groups were performed by hierarchical cluster analysis, based on the measured data. Two kind of dendrogram were made, at the first we’ve taken account the measured parameters from all the generative and all the vegetative shoot’s leaves, while at the second we’ve only used the parameters measured from generative shoot leaves. From the parameters we’ve determine by, K-middle method, ANOVA (analysis of variance), which features determines best the classification into different clusters. In doing so the angle of the first segment’s sinus and the angle of the leaf base margins were proved to be the most significant parameters, which were expressed the significance of the others, and because the resulting dendrogram did not reflect to the taxonomic relationship we’ve performed the grouping without these two parameters. This statement supported by Person-correlation analysis, because these two parameters shown less connection with other parameters. Our experiments proved that against the leaves of vegetative shoots with the leaves of generative shoots shows more better the real relationships: the C. nigra and the C. ×degeni separates from the other, just like C. laevigata and C. xdelosyacanthus, which were together in analysis of variance too. The known kinship between them thus won support. The Monogyna and Curvisepala aggregates did not separates sharply during the cluster analysis, because cause can be the high degree of variability of leaves of C. monogyna. On the other hand, the measured parameters are not able to take into account such parameters, like the integrity or serrated of the leaf margins, hairs, leather-likeness, that’s why C. brevispina and C. laevigata and its hybrid can be in close clusters, because the test can’t filter out that besides the similar parameters there are differences in leaves. We have experienced a great deviation in the matter of floral sizes which cause can be that the individual plants are lives in regions with variant climatic conditions. The difference between the minimum less than between the maximums, this is also can be descends from the different climate, and the different soil water management. From the measured species C. nigra. C. monogyna and C. ×degeni has the greatest flower averagely, the biggest deviation can be found at C. laevigata floral size. Curvisepala stands out its length of the fruits: compared with C. monogyna it has only 1/3 length of the fruits, but with the other taxa stands out its length. In the matter of fruit width C. degeni is averagely the widest, but its standard deviation is the greatest too, which shows that the forms of the fruits are not uniform, it deeply closed with the developed stones inside the fruit. Considering the length and widths of the fruits C. rosaeformis subsp. curvisepala has the longest and C. degeni has the widest fruits.

9.) The genetic examinations I performed together with DEÁK TAMÁS, KOSA GÉZA, and BARTHA DÉNES. For the clarification of Hungarian hawthorn (C. nigra) and its morphological complex we have examined its hybrid (C. degeni), the morphologically very different, but in literature often mixed small-flowered black hawthorn (C. pentagyna) and the morphological very similar, but far Eastern, C. chlorosarca, based on chloroplast DNA (cpDNA). As a result of our research we have found new variable sequences in C. chlorosarca and C. pentagyna, the C. nigra significantly separated from the genetically and morphologically different C. pentagyna, however it separates too genetically from the morphologically very similar C. chlorosarca. We have verified that C. nigra is one of the parental species of C. ×degeni, the examined sample showed an outstanding similarity, which cause can be the great dominance in population of C. nigra at the xpanse of C. monogyna.
10.) I present shortly, based on the literatures, the horticultural importance of hawthorns, their applicability as ornamental plants, their medicinal use, and I refer to our research about their nutritional values, and their deployment in public areas for experimental-like green areas. I present shortly our established gene banks.

11.) One of the most important aim of taxonomy is the conservation of variability of biology, thus I present in details the conservational state of hawthorns. Based on our work the Hungarian hawthorn (C. nigra) erected to highly protected state!

12.) I have compiled a bibliography of the Carpathian Basin Hawthorns.

13.) I have compiled a list of hawthorn wich were described in the Historical Hungary’s territory.

5. OUTLOOK

It is very important that theoretical knowledge could be planted to the side of practical use. Hawthorn taxa, which thrives in the Carpathian basin, are roughly well known, in taxonomic point of view further research is appropriate in collector species C. monogyna, mostly relied on the revision of Russian-Ukrainian-Baltic taxa.

In this paper I work only with microspecies, but I merge the hybrids together for the manageability- the examination of these hybrids, mostly further research is needed in their reproductive management (their production with artificial crossing) and in genetics. With the establishment of living collections (gene banks) it became possible to start phenological comparisons in one habitat, and to start research in reproductive management.

It is necessary to follow the ongoing comparative evaluations in urban green space managements. It is important to use hawthorn (and native shrubs) in public places, it has outstanding significance in conservational ways too: the last refugium habitat for the survived trees.

The most important research profile in my opinion is their nutritional values, their medicinal usability and their possible role in pomiculture. By their placement in cultivation can be recycle areas, which by their product in cultivation can be recycle areas, which can be a solution, for regions like eastern Hungary, where unemployment is high, it could provide seasonal work.

The once deployed plantations would be compatibles with conversational criterias, it could be a good example for our national gene treasure’s property managements.

6. LIST OF PUBLICATIONS RELATED TO THE THESIS

Book:


Book chapter:

Domestic in foreign language:

Domestic in native language:


Published in scientific journals, peer-reviewed, full article in a foreign language:


Published in scientific journal, peer-reviewed full article:


Summary published in scientific journal:


DE CANDolle, A. P. (1825): Prodomus Systematis Naturalis Regni Vegetabilis II. – Párizs


HIEGL, G. (1922): Illustrierte Flora von Mittel-Europa IV/2. – J. F. Lehman Verlag, München


Magyar szabvány MSZ EN ISO 21571:2005: CTAB alapú DNS extrakciós módszer


