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The Genus *Crataegus* L. (*Rosaceae*) with Special Reference to Hybridisation and Biodiversity in Turkey

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Abstract: The genus *Crataegus* L. has approximately 200 species worldwide. However, the number of the species is increased to 1200 species by some taxonomists. Traditionally, the genus is placed in the subfamily *Maloideae* and it is closely related to the genera *Pyracantha* M.Roem., *Mespilus* L. and *Hesperomeles* Lindl. The latest phylogenetic analysis of the genus shows that it is closest to the genus *Osteomeles* Lindl. *Crataegus* is divided into 40 sections by various taxonomists. The genetic diversity centre of the section *Crataegus* ranges from Turkey to Iran. According to field observations in Turkey, new diversity centres are proposed. The latest studies on Turkish *Crataegus* species show that there are more species than hitherto known. Hybridisation is common between the *Crataegus* species in Turkey and the biogeographic distributions of them and their parents are given. Some features of the genus, including leaf and pyrenes morphology, pyrenes number and fruit colours, are polymorphic. Polymorphism and hybridisation are the main reason for abundance of the synonyms of the *Crataegus* species.

Key Words: *Crataegus*, *Rosaceae*, taxonomy, Turkey

Crataegus L.'un (*Rosaceae*) Türkiye'deki Durumu: Biyçeşitlilik ve Melezlenme

Özet: *Crataegus* L. cinsi yeryüzünde 200 kadar türe sahiptir. Bununla birlikte bu sayı bazı taksonomistler tarafından 1200'e kadar çıkarılmıştır. Bu cins eskiden beri *Maloideae* altfamilyası içine konmuş, *Pyracantha* M.Roem., *Mespilus* L. ve *Hesperomeles* Lindl.'in yakın cinsleri olarak değerlendirilmiştir. En son yapılan filogenetik analizlere göre, *Osteomeles* Lindl. cinsine daha yakın olduğu ortaya konmuştur. *Crataegus* çeşitli araştırmacılar tarafından 40 seksiyona bölünmüştür. Bu seksiyonlar arasında *Crataegus* seksiyonunun genetik çeşitlenme merkezi Türkiye'den İran'a doğru uzanır. Arazi gözlemlerimize göre, Türkiye'de bazı yerlerin bu cinsin çeşitlenme merkezi olacağı düşünülmektedir. Yaptığımız araştırmalar bu cinsin Türkiye'de bilinenden daha fazla türü olduğunu göstermektedir. Türkiye'deki *Crataegus*'larda melezlenme yaygın bir durumdur. Tüm türlerin biyocoğrafik dağılışı ve melez türlerin ataları belirtilerek tartışılmıştır. Cinsin yaprak ve çekirdek morfolojisi, çekirdek sayısı, meyve rengi gibi bazı özellikleri polimorfittir. Polimorfizm ve melezlenme, *Crataegus* türlerinde bu kadar çok sinonim olmasının nedenlerindedir.

Anahtar Sözcükler: *Crataegus*, *Rosaceae*, taksonomi, Türkiye

Introduction

Linnaeus recognised the genera *Crataegus* L. (nine species), *Mespilus* L. (seven species), *Pyrus* L. (four species) and *Sorbus* L. (two species) in the subfamily *Maloideae* (Linnaeus, 1754; Robertson et al., 1991). Intrageneric classification of the maloid genera has been studied in detail by Phipps (1983a), Phipps et al. (1991) and Campbell et al. (1990). A comprehensive monographic study of the Asiatic and European *Crataegus* species was carried out by Christensen (1992) and included the Turkish *Crataegus* species. The taxonomic treatments on the Turkish taxa were based on herbarium specimens and some previous literature records, such as

Flora Caucasica (Grossheim, 1934) and the Flora of Turkey (Browicz, 1972).

I have performed a literature survey, conducted field studies and examined herbarium specimens and have seen that the taxonomy of *Crataegus* is problematic due to polymorphic characters, hybridisation, insufficient collections and lack of field observations.

The *Crataegus* account in the Flora of Turkey recognises 17 species, one subspecies and three varieties (Browicz, 1972). The taxonomic treatment of the Turkish *Crataegus* species by Christensen (1992) differs from that of Browicz. He accepted 19 species, one subspecies, and two varieties. In addition, he reported 5

species as new records for Turkey and he has also recently described two new species. He changed the status of 11 species recognised by Browicz in the Flora of Turkey either by reducing into synonymy or by making new combinations or status.

The genus *Crataegus* has been divided into many sections and subsections by various authors in the last century. The sections were treated taxonomically and all were reorganised by Phipps (1983a); one of which, the section *Orientalis* Zabel ex C.K.Schneid. sensu Christensen, is present in Turkey. The nothosection *Crataeguinae* K.I.Chr. has recently been described by Christensen (1992), though it is not represented in Turkey.

Materials and Methods

The plant specimens used in this study were collected from different parts of Turkey over 8 years. Materials from various herbaria in both Turkey (HUB, GAZI, VAN and ANK) and Europe (P, JE, PR) were also examined. To collect both flowering and fruiting materials, most of the localities were visited twice. Observations on habitat, life form, phenology and some morphological features were noted and photographed.

Taxonomic treatments by Browicz (1972) and Christensen (1992) on the Turkish *Crataegus* taxa are quite different from one another. In this study, for the taxonomy of *Crataegus*, the changes made by Christensen are explained under the related species. The taxonomic treatment of the genus based on Christensen's revision and the synonyms of the taxa are not given here.

Results

A detailed examination of the collected specimens, herbarium material, and literature surveys show that 21 *Crataegus* species grow naturally and two species grow in cultivation in Turkey. All the species present in herbaria or collected from the field have been examined and the accepted taxonomic ranks are given here. Diagnostic features of the species and comparisons between the revisions by Browicz, Christensen and my own suggestions are discussed under the related taxa.

The following characters are used in delimiting species:

Habit: Tree or polycormic shrubs, and mostly armed. There are two types of thorn; the first one is small and lacks leaf and inflorescence, and the second one is stout and bears inflorescence. Short thorn possibly turns to stout over time. Both types of thorn are on all trees of some species. To prepare an accurate herbarium sheet bearing thorns, thorny branches of trees should be pruned.

Indumentum: Five kinds of indumentum are seen on the *Crataegus* specimens in Turkey: (1) villous, (2) lanate, (3) sericeous, (4) tomentose and (5) appressed-pubescent. Hairs of the plants usually decrease during transition from flowering stage to fruiting stage.

Leaf and stipule: Both leaf and stipule characters are frequently used in the taxonomy of the genus and there are three types of leaves (Smith & Phipps, 1984; Dickinson, 1986). *Leaves of elongated shoots:* these develop from the axis of main branches or originate from the apex of previous years' branches on the same plant. Leaves of the elongate shoots are largest on one of the plants and there is no flower on it. Similarly, stipules of the elongated shoots are also the most robust among all stipules of the same plant. The incision is deeper than that of the others. *Leaves of short shoots:* leaves appear below the inflorescence and they show variation in shape and size. This variation is called leaf heteroplasty (Smith & Phipps, 1984; Dickinson & Phipps, 1986). Leaf variation is also present on leaves of sterile shoots of the short shoot. Subterminal leaves of the short shoot are a characteristic and useful taxonomic character. Number of lobe pairs, depth of division, and number of teeth are also commonly used. *Leaves of sterile shoots:* similar to flowering shoots in both shape and size, but these are clustered on the top of the short shoots.

Inflorescence: Corymbs, rarely umbel, terminal on flowering shoots. The number of flowers in the inflorescence varies from a few to 50. *Crataegus pentagyna* Waldst. and Kit. ex Willd. is characterised by many flowers among the other *Crataegus* species. *Bracts:* their serration, glands and duration are frequently used for taxonomic purposes. The bracts usually fall off after anthesis. Hence, they should be observed in the field and kept in an envelope. *C. tanacetifolia* (Poir.) Pers. is characterised by persistent bracts and prominent glands.

Flower: Five-merous, however, a few fruits with 4, 6 and 7 sepals of *C. ambigua* C.A.Mey. ex Backer have been

collected from Central Anatolia. Sepals are indurate in the Turkish *Crataegus* species and are commonly reflexed or patent. Erect sepals are characteristic for *C. microphylla* C.Koch. *C. orientalis* M.Bieb. shows variation in the erect patent or reflexed sepals. However, the other *Crataegus* species usually have one-positioned sepals. Its shape changes slightly from species to species, but it is not characteristic for many species. Moreover, various shapes of sepal are seen in the same flower and inflorescence. The main colour for petals is white, but pinkish petals are seen in *C. rhipidophylla* Gand., while cream and greenish petals are seen in *C. pentagyna*. Style number is closely related to pyrene number, both of which are very important for the taxonomy of the *Crataegus* species and which should be noted in the field. The basal part of the style is hairy on few species of the genus. Apices of style have enlarged surfaces for pollination.

Fruit: The colour of mature fruits is used for taxonomic purposes. Yellow, red and black are basic colours for mature fruits. However, there are also many intermediate colours. *C. azarolus* L., *C. tanacetifolia* and *C. x bornmuelleri* Zabel have various tones of yellow while *C. pentagyna*, *C. davisii* Browicz and *C. caucasica* C.Koch are black-fruited species in Turkey. The fruits of the rest of the species are either red or yellowish-red or various tones of red. **Flesh:** the edible part of fruit between the skin and pyrene is sometimes used for the identification of some species. It is usually pale yellow, but if the fruit is black, then the flesh is mostly red and dark-red-veined.

Pyrenes: The number of pyrenes is frequently used in the taxonomy of the genus. Dorsal and ventral surfaces have grooves that are of taxonomic importance.

Chromosome counts on Turkish *Crataegus* species

Basic chromosome number is $(n) = 17$ for the *Crataegus* species (Gladkova, 1968; Campbell et al., 1991). Additionally, most of the species are polyploid. Polyploidy is a common phenomenon among the *Crataegus* species. Its current known rate of polyploidy is 60% in Turkey (Christensen, 1992; IPCN, 2002), (Table 1). Due to some difficulties in studying the chromosome morphology of woody plants including *Rosaceae*, I have not yet completed the chromosome counts. Agamospermy and apomixis are common in *Crataegus* (Muniyama & Phipps, 1983; Dickinson & Phipps, 1986; Dickinson & Campbell, 1991; Campbell et al., 1991).

Table 1. Chromosome numbers of the *Crataegus* taxa in Turkey.

Taxa	Chromosome numbers ($x = 17$)
<i>C. tanacetifolia</i>	?
<i>C. azarolus</i> var. <i>aronia</i>	$2n (2x) = 34$
<i>C. pontica</i>	$2n (4x) = 68$
<i>C. orientalis</i>	$2n (4x) = 68$
<i>C. pentagyna</i>	$2n (2x) = 34$
<i>C. davisii</i>	?
<i>C. meyeri</i>	$2n (3x) = 51$; $2n (4x) = 68$
<i>C. caucasica</i>	$2n (3x) = 51$
<i>C. ambigua</i>	$2n (3x) = 51$
<i>C. heterophylloides</i>	?
<i>C. longipes</i>	?
<i>C. microphylla</i>	$2n = 32$; $2n (2x) = 34$
<i>C. rhipidophylla</i>	$2n (2x) = 34$; $2n (3x) = 51$; $2n (4x) = 68$
<i>C. pseudoheterophylla</i>	$2n (3x) = 51$; $2n (4x) = 68$
<i>C. monogyna</i>	$2n (2x) = 34$
<i>C. x bornmuelleri</i>	?
<i>C. x yosgatica</i>	?
<i>C. x sinaica</i>	?
<i>C. x rubrinervis</i>	?
<i>C. x browicziana</i>	?
<i>C. x kyrtostyla</i>	$2n (2x) = 34$; $2n (4x) = 68$

Hybridisation in the Turkish *Crataegus* species

The taxonomic treatment by Christensen showed that 30% of the species were hybrid in origin (Table 2). His judgement of hybrid species was based only on morphological features. No evidence from molecular or cytological studies so far available supports hybridisation. On the other hand, I observed that *C. x browicziana* K.I.Chr. and *C. x bornmuelleri* have few flowers and fruit, in two successive years, whereas *C. x yosgatica* K.I.Chr. and *C. x sinaica* Boiss. have many flowers and fruits. Apomixis is a common breeding strategy in *Crataegus*, which would result in polyploidy (Smith & Phipps, 1988a,b; Campbell et al, 1991; Well & Phipps 1989).

Flowering phenology

The flower bearing period of a tree ranges from 1 to 2 weeks under natural conditions in Turkey. The time of flowering is almost species-specific and it is controlled by environmental conditions. One- and two-pyrened species (series *Crataegus* L.) of the genus blossom first. This

Table 2. Hybrid species of *Crataegus* in the flora of Turkey.

Hybrid species	Parent species 1	Parent species 2
<i>C. x bornmuelleri</i>	<i>C. orientalis</i>	<i>C. tanacetifolia</i>
<i>C. x yosgatica</i>	<i>C. monogyna</i>	<i>C. tanacetifolia</i>
<i>C. x sinaica</i>	<i>C. azarolus</i>	<i>C. monogyna</i>
<i>C. x rubrinervis</i>	<i>C. monogyna</i>	<i>C. pentagyna</i>
<i>C. x browicziana</i>	<i>C. microphylla</i>	<i>C. rhipidophylla</i>
<i>C. x kyrtostyla</i>	<i>C. monogyna</i>	<i>C. rhipidophylla</i>

group includes the species *C. monogyna*, Jacq. *C. rhipidophylla* and *C. x sinaica* Boiss. In addition, there is a variation in time between these species. The species with three to five pyrenes belonging to the *Orientalis* (C.K.Schneid.) Pojark. series blossom 1 month later than the member of the series *Crataegus*. The series *Pentagyna* (C.K.Schneid.) Russanov is represented by *C. pentagyna*, which blossoms between these two groups.

According to my field observations, *Crataegus* species blossomed late in 2002, possibly because of lower temperatures in the winter than in the previous year. Due to the very diverse topography Turkey, it is difficult to collect all flowering specimens of the genus in one season.

Pharmacological activities of the *Crataegus* species

Some important compounds have been obtained from the leaves, flowers and fruits of the species. *C. monogyna*, *C. oxyacantha* L. and *C. pentagyna* were extensively studied for their pharmacological peculiarities (Meriçli, 1989). In addition to these species, *C. orientalis*, *C. tanacetifolia* and *C. monogyna* were studied in detail in respect to heart disease (Meriçli & Ergezen, 1994; Melikoglu & Meriçli, 2000; Birman et al., 2001). Flavonoid compounds, oligomers, procyanidins and chardiotonic amines are the main chemical compounds used for heart disease.

Turkish species of *Crataegus*.

1- *C. tanacetifolia* (Poir.) Pers. in Syn. Pl. 2: 38. 1807.

Type: *Mespilus orientalis tanacetifolia* folio villosa magno fructo pentagono e viridi flavescente, *Tournefort s.n.* (holotype: P!; isotype: JE!).

The species is characterised by persistent bracts. The species grows well in the transition zone of the Euro-

Siberian and Irano-Turanian phytogeographical regions. Its distribution area also extends to Central Anatolia. Local populations are found close to *Quercus* scrub or clearing areas of deciduous scrub. The species prefers relatively humid scrubby areas. It is a distinct species taxonomically. Fruits are commonly used by local people as food.

2- *C. orientalis* M.Bieb. Fl. taur.-caucas. 1: 387. 1808, non *Crataegus orientalis* (Poir.) Bosc ex DC.

Type: U.S.S.R., the Crimea, *Marshall von Bieberstein s.n.* (lectotype: B-W 9271-2, photo: C, isolectotypes: B-W 9271-1, B-W 9271-3, photos: C, HAL).

According to Christensen, the species is distributed in Eastern Anatolia, Central Anatolia and surrounding areas. It is represented by two subspecies, namely subsp. *orientalis* and subsp. *szovitsii* (Pojark.)K.I.Chr. in Turkey, and *C. orientalis* var. *obtusata* Browicz is reduced to a synonym. *C. orientalis* prefers man-made habitats, clearing areas in the steppe and other open places. The species has many local types and extreme forms. Fruits are commonly used as food.

3- *C. x bornmuelleri* Zabel in Beissner, Schelle & Zabel, Handb. Laub-holzben. 179. 1903.

Type: Germany, cultivated at "Forstakademie Münden." (*Zabel s.n.*, JE!).

The species is a hybrid of *C. orientalis* and *C. tanacetifolia*. It is distinguished from *C. orientalis* by glandular bracts and from *C. tanacetifolia* by deciduous bracts on mature fruit. The distribution pattern of the species is similar to that of *C. tanacetifolia*, but its distribution area is narrower than that of the latter. It prefers relatively humid habitats.

4- *C. azarolus* L. Sp. Pl. 477. 1753.

Type: France. Herault, Montpellier, Maguelonne Cathedral, *Moullefarine s.n.* (neotype: CGE).

The species is represented by two varieties, var. *aronia* L. and var. *pontica* (C.Koch) K.I.Chr., in Turkey according to Christensen. Both of the varieties were considered different species by Browicz (1972). On the other hand, Browicz described two new varieties, namely var. *dentata* Browicz and var. *minuta* Browicz, in the *Crataegus* account of the Flora of Turkey. Both varieties are reduced to a synonym by Christensen. According to my own examinations of specimens and field observations the var. *minuta* is distinct from the other varieties of

azarolus. The species occurs in the transition zone of the Mediterranean and Irano-Turanian regions. Additionally, its distribution area reaches South-east Anatolia with the exception of drier Mesopotamian plains. *C. azarolus* forms pure stands in Elazığ province. It is the most xeric species in Turkey.

5- *C. pontica* C.Koch Verh. Vereins Beförd. Gartenbaues Königl. Preuss. Staaten 1: 269. 1853.

Type: Turkey. Prov. Çoruh, in der Nahe von Ardanuç, Koch 187 (holotype: B, destroyed). Neotype, drawing of holotype, Figure 6b in Pojarkova, 1939b.

The species has been evaluated under *C. azarolus* as a variety by Christensen. The species was collected from Ardanuç (Artvin) and it does not have an abundant population there. It needs further taxonomic studies to understand its relationship with *C. azarolus*.

6- *C. pentagyna* Waldst. and Kit. ex Willd. Sp. Pl. 2(2): 1006. 1800.

Type: Hungary/Yugoslavia. In Dunato et Syrmio, (Danube and Serbia), *Kitaibel s.n.* (holotype: B-W 9718, photos: C).

This species is easily distinguished from the other *Crataegus* species growing in Turkey by its rich flowered inflorescence, smaller flowers, 5 styles, black fruits and small pyrenes. The species is common in the Thracian, central and western Black Sea regions. *C. davisii* has been reduced to a synonym of *C. pentagyna* by Christensen. However, my field observations and examinations of the

specimens collected from the type locality reveal that *C. davisii* is a different species from *C. pentagyna*.

7- *Crataegus davisii* Browicz, Notes Ry. Bot. Gard. Edinburgh 3: 323. 1972.

Type: Turkey, Hakkari, Şemdinli to Yüksekova 1650 m, *Davis 45168* (holotype: E, photo: W).

This species was collected from the type locality and its environs. It was recognised as a synonym of *C. pentagyna* by Christensen. However, my observations on habitat and phenology and examinations of the specimens show that there are many prominent differences between them. Hence, I regard it as a different species. However, further studies are needed.

8- *C. meyeri* Pojark. in Komarov, Fl. URSS 9: 500, Figure XXIX.3.1939.

Type: U.S.S.R., Armenia in vicinitate urbis Jerevan, in faucibus fl. Gjarni-czai, prope monasterium Gehart. 11 Oct 1936, *Pojarkova 792* (holotype: LE, photo: C).

This species is distributed in Central and East Anatolia. *C. dikmensis* is reduced to a synonym of this species. Some specimens collected from Ankara belong to *C. dikmensis*. However, further studies and examinations of type specimens are needed for taxonomic accuracy.

9- *C. caucasica* C.Koch, Verh. Vereins Beförd. Gartenbaues Königl. Preuss. Staaten 1: 286. 1853.

Type: U.S.S.R., Caucasus, *Wilhelms s.n.* (holotype: B, destroyed, neotype U.S.S.R., Azerbaijan, Kirovabad, *Pojarkova 288* (LE).

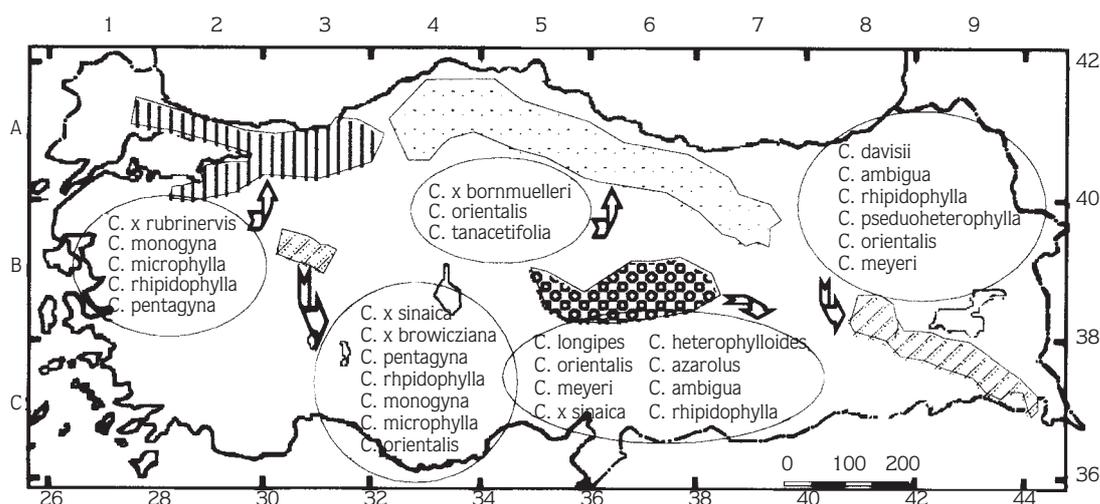


Figure 1. Diversity areas of the genus *Crataegus* in Turkey.

The species grows in north-east Turkey according to Grosheim's map, but it was not been recorded in the Flora of Turkey by Browicz. Flowering and fruiting specimens were collected from Iğdir and a new locality in Artvin.

10- *C. ambigua* C.A.Mey. ex Backer, Bull. Soc. Imp. Naturalistes Moscou 31: 12, 34. 1858.

Type: U.S.S.R., Sarepta (Krasnoarmeiski Gorod), 24 May 1851, *Becker s.n.* (holotype: LE; isotype: LE, photos: C).

The species was recorded by Browicz as *C. atosanguinea* Pojark. It has been collected from many localities in Turkey and has many local populations which are different from each other morphologically.

11- *C. heterophylloides* Pojark. ex K.I.Chr. in Rev. of *Crataegus* Sect. *Crataegus* and Nothosect. *Crataeguineae* (*Rosaceae-Maloideae*) in the Old World. 82, 1992.

Type: Turkey, prov. Elazığ, in collibus pr. Harput, Oct 1865, *Hausknecht s.n.* (holotype: JE!).

It has been recently described from Turkey (Elazığ) based on previously collected herbarium materials. In addition to type locality, other collections have been carried out from Malatya and the adjacent regions. Fruits are black and leaf shapes are the most prominent features for identification. Both characters have variations and pure black-fruited material has not been collected yet.

12- *C. longipes* Pojark., Novit. Syst. Pl. Vasc.1964a: 171, Figure 6. 1964.

Type: Turkey, Anatolia orientalis, 1890, *Bornmueller s.n.* (holotype: JE!).

The species was described from Turkey and it is also present in Syria.

13- *C. microphylla* C.Koch, Verh.Vereins Beförd. Gartenbaues Königl. Preuss. Staaten 1: 288. 1853, non *Crataegus microphylla* Gand., 1871.

Type: U.S.S.R., Talish, ad marginem sylvarum prope Lenkoran, 1838, *Hohenacker s.n.* (holotype: W; isotype: BM).

The species is common in Turkey. It is characterised by erect sepals in fruit and smaller leaves.

14- *C. rhipidophylla* Gand., Bull. Soc. Bot. France 18: 447. 1871.

Type: France, Rhone, Liergues, a la Combe, 2 Oct 1870, *Gandoger 3* (holotype: LY).

This species has been included in *C. curvisepala* Lindman by Browicz. It is common in Turkey and is characterised by leaf serration and lobes. However, it is frequently confused with *C. monogyna*. There are many extreme forms of this species.

15- *C. pseudoheterophylla* Pojark. in Komarov, Fl. USSR 9: 507, Figure XXX.5.1939.

Type: U.S.S.R., Armenia, distr. Jerevan, prope monasterium Gehart, in faucibus fl. Gjarni-czai, 11 Oct 1936, *Pojarkova 793* (holotype: LE; isotype: LE).

C. pseudoheterophylla Pojark. *C. turcomanica* Pojark. and *C. turkestanica* Pojark. have been described as different species by Pojarkova. The second and third have been recognised as subspecies of *C. pseudoheterophylla* by Christensen. Neither of the subspecies have been recorded in the Flora of Turkey. Some specimens collected by the author are attributed to these varieties. However, further studies are needed to confirm the presence of these taxa in Turkey.

16- *C. monogyna* Jacq., Fl. austriac. 3: 50, Table 292. 1775.

Type: Austria, *Jacquin s.n.* (lectotype BM; isolectotype: TO, photo: C).

This species is widespread in Turkey. It has been given as *C. monogyna* var. *monogyna* and var. *azarella* (Grisebach) Koehne by Browicz. Variety *azarella* is reduced to a synonym and the species have been given as var. *monogyna* and var. *lasiocarpa* (Lange) K.I.Chr. Both varieties are growing in Turkey according to Christensen. Specimens of them have been collected by me.

17- *C. x yosgatica* K.I.Chr. in Rev. of *Crataegus* Sect. *Crataegus* and Nothosect. *Crataeguineae* (*Rosaceae-Maloideae*) in the Old World. 121, 1992.

Type: Turkey, prov. Yozgat, ca. 27 km west of Akdağmadeni along Sivas-Yozgat rd, 1350 m, 13 Jun 1975, Browicz & Zielinski 574 (holotype: KOR; isotype: KOR).

This species is rather rare in the localities given as Yozgat and Tunceli. The species was collected from relatively humid places in *Quercus* scrub. Christensen wrote that divided sepals are characteristic for the species. However, I have collected other species with divided sepals from various localities.

18- *C. x sinaica* Boiss., Diagn. Pl. orient. 2(2): 48. 1856.

Type: Egypt, South Sinai, in praeruptis St. Catharinae, 19 May; 11 Aug 1835, *Schimper 271 & 373* (lectotype: G; isolectotypes: G, W).

This species is common in Turkey and it slightly differs from *C. rhipidophylla*. According to my field observations and examinations of the specimens, the thorn, with recurved tip is not specific to this hybrid species.

19- *C. x rubrinervis* Lange, Bot. Tidsskr. 13: 25. 1882-1883.

Type: Denmark, cultivated at the Botanical Garden of the University of Copenhagen, 20 Oct 1881, *Lange s.n.* (holotype: C).

The species has been recorded from İstanbul. The area was visited several times and specimens were collected at both flowering and fruiting stages. Fruit is mainly purple or dark purple, but not pure black.

20- *C. x browicziana* K.I.Chr. in Rev. of *Crataegus* Sect. *Crataegus* and Nothosect. *Crataeguineae* (*Rosaceae-Maloideae*) in the Old World. 153, 1992.

Type: Turkey, prov. Kütahya, Kütahya to Eskişehir, 900 m, in calcareous gorge 10-15 km north of Kütahya; 7 July 1962, *Davis & Coode 37,006* (holotype: E).

Type locality and its surrounding areas have been widely surveyed. Only one bush has been found in the type locality. *C. x browicziana* would be an extreme form of *C. rhipidophylla*.

21- *C. x kyrstostyla* Fingerh., Linnaea 4: 379, Table III.1.1829.

Type: unknown; neotype: Luxembourg, a 50 m de la frontiere belge, en face du pont de Romeldange sur la Sure, 11 Aug 1960, *Lawalree 11088* (BR).

The species is a hybrid of *C. monogyna* and *C. rhipidophylla*. According to Christensen, it has been recorded from the Thracian region of Turkey. Unfortunately, I was unable to collect it from the locality given or another places. Further field and herbarium studies are needed for the species.

22- *C. laevigata* (Poir.) DC., Prodr. 2: 630. 1825.

Type: unknown locality, *Poiret s.n.* (lectotype: P-herb. Moquin-Tandon).

This species is commonly cultivated for its showy flowers in gardens and parks in major cities in Turkey.

23- *C. crus-galli* L., Sp. Pl. 476 (1753).

Type: not indicated.

C. crus-galli has examined in a living collection in the Atatürk Arboretum of the Forestry Faculty of İstanbul University.

Discussion

There have been many different taxonomic treatments of *Crataegus* and there are still disagreements about the taxonomy of some species. Many *Crataegus* species are polyploid. Grant (1971) explains the correlation between polyploidy and various factors including climate, latitude, elevation, type of habitat, life form, breeding system, hybridity, cell size, chromosome size, chromosome structure, sex chromosome mechanism and genotype. Turkey has many diverse areas in terms of climate, latitude and elevation type of habitat. Each *Crataegus* species has many local populations, some of which have been described as new taxa.

Some regions of Turkey have specific climate and habitat for the *Crataegus* species. The areas have at least one characteristic species and other secondary or common species with local varieties. These areas are given along with their interesting features below (Figure 1).

The İstanbul-Bolu region: This area is characterised by *C. x rubrinervis*, which is a hybrid of *C. monogyna* and *C. pentagyna*. The type locality of the species has been visited several times and there is not an abundant population. The area (Büyükdere-İstanbul) is under threat of urbanisation. Low altitudes and high humidity are characteristic for the area. Similar habitats have been investigated to find another locality of the species. Unfortunately, the species has not been found yet. There are many rich populations of *C. microphylla*, *C. rhipidophylla*, *C. monogyna* and *C. pentagyna* and their intermediate forms.

The Kastamonu-Ankara region: This area is situated in the transition zone of the central part of the

Black Sea and Central Anatolia. Low humidity and scrub areas are best for *C. x bornmuelleri*, which is the characteristic species of the area. There are scattered specimens of *C. rhipidophylla*, *C. monogyna* and *C. pentagyna*. However, *C. tanacetifolia* and *C. orientalis* flourish better and many local populations form pure stands.

The Kütahya region: This is a small area covering Kütahya vilayet and its environs, characterised by *C. x browicziana*. There are some deciduous scrub stands predominated by many *Crataegus* species. *C. microphylla*, *C. rhipidophylla*, *C. monogyna*, *C. x sinaica*, *C. pentagyna* and *C. orientalis* are found in the area.

The Sivas-Erzincan-Tunceli region: This is a geographically large and diverse area. It includes some steppe and deciduous scrubby areas. Characteristic species of the region are *C. x yosgatica*, *C. longipes* and *C. heterophylloides*. In addition to these species, the area is rich in other secondary *Crataegus* species, such as *C. microphylla*, *C. rhipidophylla*, *C. meyeri*, *C. x sinaica*, *C. ambigua*, *C. azarolus* and *C. orientalis*.

The Bitlis-Van-Hakkari region: The area is characterised by *Quercus* and other deciduous scrub species. Open places of the scrub and the surrounding settlements are rich in *Crataegus* species. *C. davisii* is especially characteristic of the area. In addition, *C. ambigua* and *C. meyeri* both have rich populations around the south of Van Lake. *C. pseudoheterophylla* and *C. orientalis* are also seen in the area.

Many *Crataegus* species have survived in man-made habitats or places close to human settlements. There are no *Crataegus* species growing either in the high mountain zone or in forests far from settlements in Turkey. During my field studies, I observed that the fruits of the *Crataegus* species are eaten by birds and some mammals. These animals serve as vectors in the distribution of the *Crataegus* species. On the other hand,

honeybees and various insects are vectors for their pollination.

Hybrid species are common in the genus *Crataegus*. Lower flower and fruit set have been observed in *C. x browicziana* and *C. x bornmuelleri*. This situation might be attributed to their hybrid nature. In contrast, hybrid species, *C. x sinaica* and *C. x yosgatica*, have both a high number of flowers and fruit set. Although the abundance of flowers and fruit set and other morphological observations provide only some clues to the hybrid origin of the plants, hybridisation and the parent species should also be detected by molecular techniques.

In spite of the fact that there have been several taxonomic studies on the *Crataegus* species, some taxonomic problems remain unresolved. There are few taxonomic studies on the Turkish *Crataegus* species in comparison to those on European and American taxa. Many new taxa have been described from Asia and Europe by Poiret, Koch, Gandoger, Cinovskis, Pojarkova and others. The Russian taxonomist Pojarkova described some species from Turkey (Pojarkova, 1941). Many new species have been described from North America by Ashe, Beadle and Sargent (Christensen, 1992). Hence, the species number of the genus has been increased to 1200. Nevertheless, accepted species currently number about 200 and many of the described species have been reduced to synonyms by later taxonomists.

Due to polymorphism, hybridisation, apomictic breeding strategies and other reasons, the species of this genus show great variations in populations. Therefore, most of the taxa described by former taxonomists should be regarded as synonyms because of the diverse nature of the genus.

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