Flora 206 (2011) 974–986

Contents lists available at ScienceDirect

Flora

journal homepage: www.elsevier.de/flora

Comparative morphometric study and relationships between the Caucasian species of wild pear (*Pyrus* spp.) and local cultivars in Georgia

Zezva Asanidze [a,*], Maia Akhalkatsi [a], Mirian Gvritishvili [b]

[a] *Ilia State University, Institute of Ecology, Cholokashvili Ave., 3/5, 0162 Tbilisi, Georgia*
[b] *Ilia State University, National Botanical Garden, Botanical str., 1, 0105 Tbilisi, Georgia*

ARTICLE INFO

Article history:
Received 21 December 2010
Accepted 26 April 2011

Keywords:
Caucasus
Domestication
Georgia
Pear cultivars
Pyrus caucasica
Pyrus spp.

ABSTRACT

Morphological diversity in *Pyrus* spp. occurring in wild populations in Georgia has been evaluated and their relationships to local and introduced pear cultivars were determined using statistical discrimination between taxa, based on leaf and fruit traits. Eight native for Georgia wild species of pear – *P. caucasica* Fed., *P. balansae* Decne., *P. salicifolia* Pall., *P. demetrii* Kuth., *P. georgica* Kuth., *P. ketzkhovelii* Kuth., *P. sachokiana* Kuth., *P. syriaca* Boiss. – and the non-native European pear – *P. pyraster* (L.) Burgsd. – have been compared with 36 local and introduced pear cultivars. A total of 237 individuals were sampled in natural habitats, living collections and peasant grounds in different regions of Georgia. The individuals were evaluated for 27 morphological traits, which included 6 quantitative and 6 qualitative leaf and shoot descriptors and 14 qualitative fruit descriptors. Shape of the leaf blade was analysed using Fourier outline shape analysis method. 20 harmonics of Fourier coefficients per leaf and 10 leaves per individual were used. Multivariate Canonical Discriminant Analysis showed close relations between cultivars and 4 wild species – *P. caucasica*, *P. balansae*, *P. pyraster* and *P. ketzkhovelii*. According to hierarchical cluster analyses, the endemic species *P. caucasica* and *P. balansae*, native for Georgia, are aggregated only with 15 domesticated Georgian aboriginal local cultivars. *P. pyraster* and *P. ketskhovelii* clustered with different introduced and local cultivars. Crossing of these two wild taxa might have been first domestication events of pear in prehistorically times. Local aboriginal Georgian edible pear cultivars might have been originated from the native wild species of pear, *P. caucasica* and *P. balansae*. Many other pear cultivars in Georgia are associated with *P. communis*, probably originated through breeding selection in past historical times and resulting from recent activities of breeding stations in Georgia.

Introduction

Pyrus caucasica Fed. and *P. pyraster* (L.) Burgsd. are regarded as the main wild ancestors from which the cultivated European pear (*P. communis* L.) has probably evolved (Zohary and Hopf, 2000; Volk et al., 2006; Yamamoto and Chevreau, 2009). *P. caucasica* ('Panta' in Georgian) is an endemic species of the Caucasus (Kuthateladze, 1980; Brezhnev and Korovina, 1981). Its occurrence outside of the Caucasus region (Volk et al., 2006; Yamamoto and Chevreau, 2009) might be explained by planting of this tree in Soviet time in orchards and forest gardens for producing vegetative and generative rootstocks for fruit trees (Sokolov et al., 1980). Originally, it is distributed in natural habitats of broad-leaved and mixed coniferous forests at low, middle and upper montane belts (500–1800 m a.s.l.) of the Greater and Lesser Caucasus Mountains (Ketskhoveli, 1960). Genetically it is differentiated from *P. pyraster* which is native to Eastern and Central European countries, the Balkan Peninsula and Turkey. However, both species show close genetic relations to domesticated pears (Volk et al., 2006). This situation put us into the idea to compare *P. cauacsica* with local Georgian cultivars of pear and reveal relationships between them.

Wild pear first was identified in the Caucasus as European pear – *P. communis* (Marschall von Bieberstein, 1808). Fedorov in a manuscript of 1943 described wild pear in the Caucasus as a Caucasian pear. Lately, Grossheim (1952) validated the status of a separate species to the Caucasian pear – *P. caucasica*, based on morphological differences between pear taxa of leaf margins. These are entire in *P. caucasica* and serrate in *P. communis* and *P. pyraster* (Grossheim, 1952; Fedorov, 1954). Browicz (1982, 1993) placed related pear species as wild subspecies to *P. communis* in the recent taxonomic treatment of the genus *Pyrus*. This successfully reflects close morphological relationships between subspecies in the "communis" group. However, Caucasian pear is considered as a separate species by many authors (Seifriz, 1932; Grossheim,

* Corresponding author.
E-mail addresses: zezva.asanidze.1@iliauni.edu.ge (Z. Asanidze), maia_akhalkatsi@iliauni.edu.ge (M. Akhalkatsi), mirian_550@yahoo.com (M. Gvritishvili).

0367-2530/$ – see front matter © 2011 Elsevier GmbH. All rights reserved.
doi:10.1016/j.flora.2011.04.010

1946; Ketskhoveli, 1960; Tuz, 1974; Brezhnev and Korovina, 1981; Bläsing, 2004), based on arguments that the differences are not only morphological features, but as well the separate geographic area of distribution. There are two other species of sect. *Pyrus* related to the "communis" group in the Caucasus. The one species is *P. balansae* Decne., distributed in western Georgia, Northern Turkey (Lazeti, former Georgian territory and thus closely linked with pear cultivation there) and on Greek islands (Chouliaras et al., 2003). The second relic species – *P. boissieriana* Buhse – occurs in Talish Mountains (Azerbaijan and Northern Iran). These species have serrate upper parts of the leaf margins (Kuthateladze, 1947); they were considered as synonyms of *P. communis* by Browicz (1993). The European wild pear, *P. pyraster*, occurs up to the middle regions of Turkey and does not reach the Georgian boundary.

The most probable centre of origin of the genus *Pyrus* is suggested the mountainous region of western China (Komarov, 1908, 1931). Wild species of pear appeared in the Caucasus, Asia Minor and the western regions of the Old World due to an exchange of floras with Central Asia in the Tertiary period (Rubzov, 1944; Yamamoto and Chevreau, 2009). Tertiary remains of leaves of the fossil species *P. theobroma* were found in western Europe (village Perschlug, Austria) and in the Caucasus (Kakheti's Kavkasioni Mountains, Georgia) in middle and lower-middle Sarmatian deposits together with representatives of a mixed flora that includes a number of evergreen plants, which attests to a subtropical or warm flora (Rubzov, 1944). Wild pear species have diverged into numerous local ecogeographical races and species, which are interfertile with the cultivated pear. These species have enriched the genetic variation of cultivated pears through hybridization and introgression (Rubzov, 1944; Watkins, 1986). Among these interfertile wild pears some are distributed in Georgia under the names *P. salicifolia* Pall., *P. syriaca* Boiss., *P. georgica* Kuth., *P. demetrii* Kuth., etc. (Brezhnev and Korovina, 1981).

According to Kuthateladze (1980) in total 11 taxonomic units of wild pear occur in Georgia, which territory comprises 67 000 km^2. Among them *P. caucasica* is most widespread. This species is considered as the main progenitor species of Georgian local pear cultivars (Khomizurashvili, 1973). According to literature data (Khomizurashvili, 1973; Likhonos et al., 1983) cultivated pears from Europe and Russia appeared in Georgia at the end of 19th century. Before there existed only the local cultivars. The local Georgian names of the cultivated pear 'Mskhali' and wild Caucasian pear 'Panta' exists in all Georgian dialects; they do not have analogues in any other language (Javakhishvili, 1930). The Georgian names of cultivated and wild pears are linked with geographic objects such as mountains (Skhaltbis Range in Kartli, Mt. Mskhal-Gori in Kakheti's Kavkasioni), rivers (R. Skhaltba), or villages (Pantiani, Skhalta, Skhlobani, etc.): Javakhishvili (1930). The name of wild Caucasian pear 'Panta' is used among cultivars called 'Panta Mskhali', i.e. cultivar with name of wild pear. Moreover, the classification of Georgian pear cultivars (Khomizurashvili, 1973) contains a group of landraces with the same name. This classification system divides Georgian cultivars into four groups: 'Gulabi', 'Panta Mskhali', 'Kalos Mskhali', and 'Khechechuri'. The name of each group represents the name of a cultivar, which is considered as a typical representative of a group. In the 'Gulabi' group are included both local and introduced cultivars with most high economic values, big juicy fruits with sweet taste. The 'Panta Mskhali' group contains local varieties with small fruits becoming black after maturation, as it is a character feature of wild Caucasian pear. The 'Kalos Mskhali' group includes local cultivars with bigger fruits than the second group. The 'Khechechuri' group matures in late autumn with juicy fruits containing a big amount of stone cells. According to Khomizurashvili (1973) the last three groups originated by direct domestication of wild pear in Georgia. Although, some signs of selective breeding are remarkable as well. Relationships between wild *P. caucasica* and local cultivars are mirrored by a high morphological variability of leaf and fruit forms.

Morphological criteria that include characteristics of leaves and fruits, together with the presence or absence of thorns on shoots, that best distinguish wild and cultivated forms, are traditionally used, based on statistical significance, to identify taxonomically *Pyrus* taxa (Paganova, 2003, 2009; Voltas et al., 2007). Even if fruit morphology may give more useful tree characteristics for identification purposes owing to the selection process undergone during domestication (Voltas et al., 2007), in particular the leaf form shows high variability in the wild Caucasian pear and the Georgian cultivars. Therefore, in this study, we compared quantitative and qualitative morphological characters of leaf and fruit that might enable to determine relationships between wild *Pyrus* spp. and cultivars. Besides *P. caucasica*, we included in the investigation the following Caucasian wild species: *P. balansae*, *P. salicifolia*, *P. georgica*, *P. demetrii*, *P. ketzkhovelii*, *P. syriaca*, *P. sachokiana* and also the European wild pear, *P. pyraster*, collected in Germany. Studied cultivars include both local and introduced varieties.

The aims of the present study were: (1) to evaluate the morphological diversity in *Pyrus* spp. occurring in the wild populations in Georgia and determine their relationships to cultivars using morphological discrimination between taxa; (2) to reveal possible relationships between Caucasian wild species related to domesticated pear and local cultivars of Georgia; and (3) to estimate the possible incidence of domestication events of wild *Pyrus* spp. based on morphological similarity with local cultivars.

Materials and methods

Plant material

A total of 237 wild and cultivated pear trees were sampled in natural habitats, from living collections and in peasant grounds in different regions of Georgia. Wild pear species were determined according to Kuthateladze (1947, 1980). The pear accessions evaluated in this study consisted of Caucasian endemic *P. caucasica* Fed. (=*P. communis* subsp. *caucasica* (Fed.) Browicz; $n = 100$), local Georgian and introduced pear cultivars ($n = 103$), *P. balansae* Decne. (=*P. communis* L.; $n = 8$), *P. salicifolia* Pall. ($n = 8$), Caucasian endemic *P. demetrii* Kuth. ($n = 5$), *P. pyraster* (L.) Burgsd. (=*P. communis* subsp. *pyraster* (L.) Ehrh.; $n = 4$), Caucasian endemic *P. georgica* Kuth. ($n = 3$), *P. syriaca* Boiss. recorded by M. Gvritishvili for the first time in Georgia ($n = 3$), Caucasian endemic *P. ketzkhovelii* Kuth. ($n = 2$), and one Georgian endemic *P. sachokiana* Kuth. ($n = 1$). *P. pyraster* was collected in Germany, Hessen, in surroundings of village Erda (N 50.681506°, E 8.507645°, 297 m a.s.l.) and village Eibach (N 50.752841°, E 8.320175°, 384 m a.s.l.) in Oak-Hornbeam forest edges. All other wild species were collected in different administrative regions of Georgia (Fig. 1).

Pyrus caucasica was sampled in 32 populations in different administrative regions of Georgia (Fig. 1). The trees were located at altitudes ranging from 234 m a.s.l. (Dabadzveli, Imereti region) to 1890 m a. s. l. (Damala, Meskheti). *P. caucasica* occurs in 4 different habitats: (1) Oak-hornbeam forests in East and South Georgia (234–1387 m a.s.l.) with *Quercus iberica*, *Carpinus caucasica*, *C. orientalis*, *Acer campestre*, *A. laetum*, *Cerasus avium*, *Fraxinus excelsior*, *Malus orientalis*, *Mespilus germanica*, *Prunus divaricata*, *Tilia begoniifolia*, *Cornus mas*, *Corylus avellana*, *Salix caprea*, *Clematis vitalba*, etc.; (2) Pine forests with Kolchic understory of *Rhododendron luteum* (Pinetum azaleosum), in Svaneti (1212–1887 m. a.s.l.): *Pinus kochiana*, *Picea orientalis*, *Quercus iberica*, *Carpinus caucasica*, *Crataegus kyrtostyla*, *Cornus mas*, *Daphne pontica*, *Frangula alnus*, *Rhododendron luteum*, *Ruscus ponticus*, *Sorbus torminalis*, *Tilia begoniifolia*, *Vaccinium arctostaphylos*, *V. vitis-idaea*; (3) Beech forests