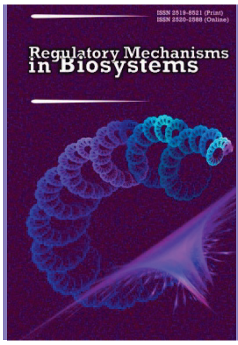

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First blooming of a new intergeneric hybrid between *Chaenomeles* and *Pyrus* (Rosaceae)

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Remote hybridization plays an important role in the evolution and breeding of plants, especially in subtribe Malinae (Rosaceae). The study deals with the issues of introducing and flowering of a new artificial intergeneric hybrid ×*Pyromeles* (= *Chaenomeles* × *Pyrus*). The Japanese quince (*Chaenomeles japonica*) is a plant that is widely appreciated for its ornamental qualities and is being considered as a novel and promising fruit option. Following the apple tree, the pear (*Pyrus communis*) is recognized as the second most important pome crop. There are natural and artificial intergeneric hybrids derived from *Pyrus* such as ×*Pyraria* (= *Aria* × *Pyrus*), ×*Pyronia* (= *Cydonia* × *Pyrus*), ×*Pyralus* (= *Malus* × *Pyrus*), and ×*Sorbopyrus* (= *Pyrus* × *Sorbus*), which have nutritional value and are also used as rootstocks, virus indicators, and in the breeding of pears and other pome fruit crops. Many scientists have crossed Japanese quince with quince, pear, rowan and apple trees in the last century, but no true hybrids have been produced. Only ×*Pyromeles* was developed in 1988 from a cross between *Chaenomeles japonica* and *Pyrus communis*. This cross combination resulted in a seedling with intermediate morphological characteristics. The original seedling was propagated and preserved by grafting onto a quince rootstock but the grafted plants were characterized by stunted growth and a prolonged lack of flowering. Over the course of several decades, the putative hybrid did not advance to the generative phase and was at risk of extinction on multiple occasions due to accidental causes. In 2017–2018, the hybrid was grafted into the crown of pear and Swedish whitebeam trees. These six-year-old grafts flowered for the first time in 2024. The hybrid bloomed later, after the parent species had already finished flowering. The molecular methods were not used to identify the hybrid nature of this genotype, instead intermediate morphological features provided confirmation. Its flowers are of intermediate morphology, with pink petals like Japanese quince and purple anthers like pear, confirming the hybrid origin of the plant. Pollen is formed in the anthers and eggs are produced in the ovaries. One fruit was formed from the six inflorescences available, but it did not reach the ripening stage because it fell off prematurely. The cultivar ×*Pyromeles* 'Claude Weber' has been described, which may be valuable as a bonsai due to its ornamental flowers and super dwarf habit.

Keywords: ×*Pyromeles*; Japanese quince; remote hybridization; chemical mutagenesis; nothotaxon; new cultivar; morphology; flowering.

Introduction

The subtribe Malinae of the subfamily Amygdaloideae within the Rosaceae includes the genera *Pyrus* and *Chaenomeles* although they are not related (Campbell et al., 2007; Ulaszewski et al., 2021; Sun et al., 2024). Pears (*Pyrus communis*) are economically important fruit trees throughout the world. Pears are consumed fresh, canned, dried, as juice, and fermented as perry. Pears rank second to apples in the amount of worldwide production of deciduous tree fruit species (Yamamoto & Chevreau, 2009). Japanese quinces (*Chaenomeles* spp.) are popular ornamental shrubs (Weber, 1963; Mezhenskyj et al., 2019). Their decorative value is equal to that of the ornamental apple trees, other members of Malinae, which also have a wide range of colors in their blossoms (Mezhenskyj & Mezhenska, 2023). The fruits of Japanese quinces are suitable for processsing into liqueurs, syrup, marmalade, jam, preserves, candied fruit, and compote (Rumpunen, 2011; Mezhenskyj et al., 2019; Mezhenskyj, 2021). It seems to be promising as a functional food and as an anti-diabetic agent (Rutkowska & Olszewska, 2023). Japanese quince is used as a rootstock (Entelmann et al., 2009). It is also a fodder plant for some insects (Lv et al., 2022).

Intergeneric hybrid ×*Sorbaronia* has commercial value for modern horticulture (Mezhenskyj et al., 2024). In Malinae there are also natural and artificial intergeneric hybrids derived from *Pyrus*, including ×*Pyraria* (= *Aria* × *Pyrus*), ×*Pyronia* (= *Cydonia* × *Pyrus*), ×*Pyralus* (= *Malus* × *Pyrus*), and ×*Sorbopyrus* (= *Pyrus* × *Sorbus*). They have nutritional value and are also used as rootstocks, virus indicators, and as a source of new traits in the breeding of pears and other pome fruit crops (Bell & Itai, 2011; Postman, 2011; Mezhenskyj & Mezhenska, 2023).

Many scientists have crossed Japanese quince with quince, pear, rowan and apple trees: in Poland (Gleichgewichtówna, 1922), in Russia (Vekhov, 1937; Michurin, 1948), in Armenia (Gabrielian-Beketovskaya, 1955), and in Uzbekistan (Kalmykov, 1962). The crossing of quince with Japanese quince was unsuccessful (Gabrielian-Beketovskaya, 1955). We have recently obtained similar results. All seedlings from the rowan and Japanese quince crosses were of the rowan type (Kursakov, 1976). This is probably due to pseudogamy. Several authors have reported obtaining viable seedlings with intermediate-type characteristics. But Kalmykov's apple-Japanese quince hybrids are apomicts (Rudenko, 1970). The same can be said for similar Ryabov'i hybrids, although the author believed they have Japanese quince characteristics in the flesh of apples (Ryabov, 1983). Seedlings obtained from pollination of a pear by Japanese quince by Dolmatov (1992) are the result of pseudodiploid apomixis. Seedlings from pollination of Japanese quince with red-leaf paradise apple tree pollen had red pigmentation from the male parent, but proved to be unviable and died during the first year of life (Budagovsky, 1978). The new species *Chaenomeles thibetica*, described by the authors as a putative natural hybrid between *Chaenomeles* and *Docynia* (Yü & Kuan, 1963), is most likely only a form of *Chaenomeles cathayensis* (Mezhenskyj & Mezhenska, 2023).

From 1984 to 1999, we carried out intergeneric crosses, pollinating more than 20 thousand flowers in 768 crossing combinations, mainly Japanese quinces by pear, apple, and quince pollen. To increase the efficiency of crosses a mixture of pollen of different varieties and taxa was used as well as repeated pollination, pollen treatment in the gas phase with chemical mutagens and para-aminobenzoic acid, application of a solution of boric acid on the pistil, pollination on plants grafted into the crown of plants of other taxa and a combination of these methods. The fruit set was 2–10 times less than in intraspecific and interspecific crosses of Japanese quinces. Many seedlings in the sowing boxes were probably of hybrid origin and died in the early stages of development in the phase of cotyledons and the first true leaves. Most surviving seedlings had matroclin-type characteristics, but some seedlings were morphologically different from Japanese quince. The hybrid '9–19' F_1 was developed as a result of crosses in 1988. The seedling was characterized by depressed growth, which did not increase when grafted onto quince, pear, and Japanese quince. The grafted plants have small leaves and do not exceed 0.5 m in height (Mezhenskij, 2003; Mezhenskyj & Mezhenska, 2023). The nothogeneric name ×*Pyromeles* (= *Chaenomeles* × *Pyrus*) was proposed for the putative hybrid (Mezhenskij, 1996).

The origin and the detective story of the preservation of the hybrid

In 1983, while carrying out a breeding program to improve Japanese quince at the former Donetsk branch of the Institute of Horticulture of the Ukrainian Academy of Agrarian Sciences, we treated the seeds of *Chaenomeles japonica* '1–3' growing in the Artemivsk Arboretum with a chemical super-mutagen, N-Nitroso-N-methylurea, at 0.025% concentration. These experimental seedlings were planted in a breeding garden. They were later used in experiments on remote hybridization, including the form '9–19', which belongs to this group of plants. It was used as a mother plant for crossing. In 1988, the castrated flowers of '9–19' were pollinated with a pollen mixture from 20–30 pear and apple cultivars pretreated with para-aminobenzoic acid in the gas phase for 63 hours.

This cross combination resulted in a seedling with intermediate morphological characteristics. A hybrid seedling exhibiting characteristics associated with the pear was propagated through grafting onto quince seedlings. The own-rooted maternal plant together with the nine grafted plants was planted in the breeding site in a row with other Japanese quince seedlings. The plants demonstrated weak growth and exhibited significant developmental deficiencies in comparison to the Japanese quince seedlings. The individual responsible for cultivating the rows in the garden failed to observe the presence of these small plants and, as a result, tilted the cultivator in a manner that caused them to be plowed up. The last plant of a putative hybrid in the row was merely coated with a layer of soil and survived. The plant was subsequently relocated to a private garden for conservation. When the decision was made to transfer the collection of genetic resources of rare fruit crops from Bakhmut to Kyiv, nursery plants of the putative hybrid were propagated through budding on quince seedlings. In the fall, the annual nursery plants were transported to the Agronomic Experimental Station of the National University of Life and Environmental Sciences of Ukraine near Kyiv, where they were scheduled for planting in the collection garden in the spring. However, the plants were stolen while in storage. A subsequent visit to Bakhmut to collect cuttings or rare fruit plants for propagation was unsuccessful in locating the putative hybrid plant in question, which was not observed to be growing in a plot in a private garden that had been left unattended for an extended time. During the final expedition to Bakhmut in 2017, it was discovered that the plant in question was still alive. In the summer, the plant was transplanted into a container with a lump of soil and transported to Kyiv (Fig. 1). However, when stored in the basement, it did not survive the winter. Of the buds that budded on the pear tree, only one survived and exhibited healthy growth in the Educational, Research and Productive Laboratory of Genetic Resources, Introduction and Breeding of Rare Fruits and Ornamentals (Fig. 2). This shoot was used for budding in the crown of pear, quince, and Swedish whitebeam trees. The best growth was observed on the pear and the Swedish whitebeam, while the quince grew less well. In the spring of 2024, flower buds were formed on the branches of the putative hybrid in the crown of the Swedish whitebeam. During the period spanning 1988 to 2024, the hybrid plant was observed to pass through the neck of the bottle on multiple occasions, which could have resulted in its demise. However, it managed to survive. The initial flowering event occurred on branches that were six years old.

Fig. 1. ×*Pyromeles* plant on a quince rootstock just transplanted into a container

Fig. 2. The young shoot of ×*Pyromeles* budded in the tree crown

Flowering of ×*Pyromeles*

According to the observations of the weather station of the Borys Sreznevsky Central Geophysical Observatory, the average temperature over the winter was 0.3 °C, which is 2.8 °C above the climate norm. The calendar winter of 2023–2024 was the third warmest winter in Kyiv since 1881. The much warmer than normal weather caused the onset of meteorological spring much earlier than usual – on January 24, when the air temperature steadily moved above 0 °C, 37 days earlier than the long-term average. The average monthly air temperature in Kyiv in March was 4.8 °C, which is 2.3 °C above the climate norm, and the warmest was March 31, when the maximum temperature rose to +25.3 °C, setting a temperature record. The average monthly air temperature in Kyiv in April was 12.8 °C, which is 2.8 °C above the climate norm. It was the third warmest month on record in 144 years.

Thus, the spring of 2024 had an early onset, and consequently the phenological phases of plant development shifted to earlier dates. Once the flowering cycle of the pear trees and the majority of the Japanese quince bushes had reached its conclusion, the inflorescences of ×*Pyromeles* were observed in the crown of the Swedish whitebeam tree on April 20 (Fig. 3). A total of six inflorescences were noted in the Swedish whitebeam tree crown. At that time, they were at the principal growth stage 5, Inflorescence emergence according to the BBCH scale (Meier, 2018). There were secondary growth stages 56–57. Green bud stage: single flowers separating (stage 56) and pink bud stage: flower petals elongating;

sepals slightly open; petals just visible (stage 57). Additionally, a single inflorescence emerged in the crown of the pear tree a week later (Fig. 4). This is stage 59 when most flowers were with petals forming a hollow ball.

Fig. 3. Inflorescences of ×*Pyromeles* in the crown of the Swedish whitebeam tree

Fig. 4. Inflorescence of ×*Pyromeles* from the crown of the pear tree

Fig. 5. Flowering of ×*Pyromeles* with first flowers open

The principal growth stage 6: flowering is present in Fig. 5 and 6, secondary growth stage 60 when the first flowers open to stage 65 with full flowering when at least 50% of flowers are open and the first petals are falling.

Microsatellite markers are used in genetic genealogy of pome fruits (Vanwynsberghe et al., 2009; Sun et al., 2018), but microsatellites were not used to identify the hybrid nature of this genotype, instead intermediate morphological features provided confirmation. *Chaenomeles ×superba* is characterized by flowers with petals in various shades of red and yellow anthers, while *Pyrus communis* has white petals and purple anthers. ×*Pyromeles* flowers have intermediate features combining the characteristics of both parental species. Consequently, the petals are pink, and the anthers are purple (Fig. 7, 8).

Fig. 6. Full flowering of ×*Pyromeles* with fall of the first petals

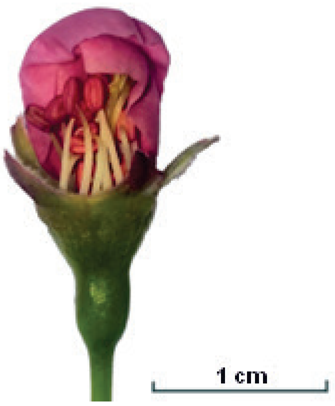

Fig. 7. Flower of ×Pyromeles (some petals are removed)

Fig. 8. Pistils and stamens inside the flower

The pentacarpelar fruit pistil is terminated by a stigma on each style (Fig. 9). The stigma is composed of stigmatic papillae, which serve to interfere with pollen receptivity. Approximately two dozen stamens are arranged around the pistil. The two-lobed anthers are attached to the filament in the middle area of the anther (Fig. 10). The yellow pollen was observed to have been released following the dehiscence of the anther. Pollen viability has not been determined.

The ovules are enclosed by the five-locular ovary (Fig. 11). The longitudinal section reveals the presence of several ovules within each locule.

One fruit set and developed for a month. In late May it fell due to high winds during a thunderstorm. It was sub-stage 72 BBCH scale: green ovary surrounded by dying sepal crown, sepals beginning to fall of principal growth stage 7: development of fruit.

Fig. 9. Pistil stigma

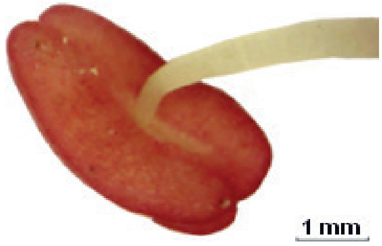

Fig. 10. Anther on the stamen filament

Fig. 11. Transverse section through the ovary

Nomenclature

Mezhenskij (1996) proposed the nothogeneric name ×*Pyromeles* for hybrids between *Chaenomeles* and *Pyrus*. The name meets the criteria outlined in Art. H.6 of the International Code of Nomenclature for algae, fungi, and plants (Turland et al., 2017). Hybrids between representatives of two or more taxa may receive a name (Art. H.3.1). Names of nothotaxa at the rank of species must be validly published (Art. H.10). In the book on plant genetic resources (Mezhenskyj & Mezhenska, 2023), several *nomina nuda* including ×*Pyromeles weberae* were used to designate the accessions of some intergeneric hybrids. The provisional names were assigned to validly publish them in the future. However, according to Hetterscheid & Brandenburg (1995), it seems futile to "invent" a nothospecies for an artificial hybrid. The intricate procedure of establishing a nothospecific name serves no useful purpose.

Thus, in honor of Claude Weber (1922–2011), a monographer of *Chaenomeles*, one can use the cultivar epithet instead of the nothospecies epithet. Plants in cultivation meeting the criteria of being recognized in the categories of cultivars may be given epithets following the International Code of Nomenclature for Cultivated Plants (Brickell et al., 2016). According to Art. 21.1 of this Code, the name of a cultivar is a combination of the correct name of the genus with a cultivar epithet. Therefore, this intergeneric hybrid has been designated by the cultivar name ×*Pyromeles* 'Claude Weber'.

×*Pyromeles* 'Claude Weber': little trees when grafted, 0.3–0.5 m tall. Branchlets brown, pilose when young, later glabrate. Winter buds small, ca. 1 mm long. Stipules lobate, 5–10 mm long, caducous. Leaves simple, alternate, on short shoots fasciculate, glabrous; petiole 1.5–3.0 cm long; leaf blade orbicular, elliptic, or ovate 2.5–4.0 cm long, 2.0–3.5 cm wide, base rounded, oblique or cuneate, apex acute, margin serrate; adaxial surface green, abaxial surface pale green. Inflorescences corymbose 3–5-flowered. Pedicel 2.5–3.0 cm long. Flowers pentamerous, complete, 2.0–2.5 cm in diameter. Hypanthium campanulate, abaxially glabrate, 5 mm long, 3 mm in diameter. Sepals broadly triangular, 5 mm long, apex acute, margin ciliate. Petals pink, ovate, ellipsoidal, suborbicular, concave, ca. 1 cm long, clawed. Stamens ca. 20, shorter than petals; filaments white; anthers violet, ellipsoid, 4 mm long. Ovary green, glabrous, 5-loculed; style as long as stamens. Young fruit pear-shaped.

Conclusions

There is an intergeneric hybrid between *Chaenomeles* ×*superba* and *Pyrus communis* with intermediate traits originating from a cross made in 1988. The first flowering was obtained in 2024 on grafts in Swedish whitebeam and pear crowns made in 2017–2018. It is the first case in the world of the Japanese quince-pear hybrid entering the generative phase. The super dwarf habit and beautiful pink flowers of ×*Pyromeles* 'Claude Weber' make the cultivar suitable for bonsai. Other scientific and economic uses of the cultivar may include the study of phylogenetic relationships within the subtribe Malinae and both pear and Japanese quince breeding.

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The authors declare that they have no personal relationships that could have appeared to influence the work reported in this paper.

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