 DOI: 10.19601/j.cnki.issn1943 - 9903.2022.08.010

Advances in Origin, Evolution and Classification of *Pyrus* L.

Weishuang TONG, Zhanbo GUAN, Huashan GAO*

College of Chemical and Environmental Engineering, Pingdingshan University, Pingdingshan 467000, China

Abstract China is not only one of the origin centers of *Pyrus* L., but also the earliest birthplace of *Pyrus* L. in the world. This paper reviews the evolution of *Pyrus* L. from the aspects of leaf edge morphology, inflorescence and fruit type, and summarizes the research progress of classification and species distribution of *Pyrus* L., which is of great significance for the protection, evaluation and utilization of germplasm resources.

Key words *Pyrus* L., Origin, Evolution, Classification, Species distribution, Germplasm resources conservation

1 Introduction

Pyrus L., as deciduous trees or shrubs, falls within dicotyledonous class, Rosales order, Rosaceae family. The fruit is sour, sweet and delicious, and its nutritional value is high. It has been one of the favorite fruits since ancient times. Because of the white and beautiful pear flowers, *Pyrus* L. is often used in garden cultivation. The fruits of *Pyrus* L. can also be used as medicine, which can clear the lungs and resolve phlegm, invigorate the body and quench thirst, help digestion, nourish yin and moisten the lungs, relieve sore poison, alcohol poison and so on. There are about 25 species of *Pyrus* L. in the world, which are distributed in Asia, Europe and North Africa. There are 14 species in China, 8 of which are endemic to China. China is not only one of the origin centers of *Pyrus* L., but also the earliest birthplace of *Pyrus* L. in the world. The study on the origin, evolution, classification and species distribution of *Pyrus* L. is of great significance to the protection, evaluation and utilization of germplasm resources.

2 Study on the origin

China is not only one of the origin centers of *Pyrus* L., but also the earliest birthplace of *Pyrus* L. in the world. It is reported that *Pyrus* L. originated in the mountains of western China in the Cenozoic era. Due to the geographical isolation of *Pyrus* L. community and its adaptability to cold and dry conditions, it developed to both sides along the mountain range, which promoted its evolution. The westward evolution of *Pyrus* L. is mainly in the European direction, forming western pears, while the other side is mainly in eastern Asia, especially in China, forming oriental pears. At the same time, it has also formed the three origin centers of cultivated pears in the world, namely, the center of China, the center of Central Asia and the center of the near East. Yu Dejun, a plant taxonomist at the Institute of Botany of the Chinese Academy of Sciences, believes that western pears originated in central and southeastern Europe, as well as in Asia minor and Central Asia, and were cultivated as early as 2 000 years ago in Roman times.

In addition, American scholars combined 29 chemical substances with 22 botanical characteristics to build a classification chart composed of computer quantitative analysis methods, and listed *P. calleryana* as the most primitive species in the evolutionary classification diagram. According to the characteristics of pollen and the results of karyotype research on *P. calleryana*, some scholars also listed *P. calleryana* as the most primitive species.

3 Evolution

3.1 Evolution of leaf edge morphology For the *Pyrus* L. in China, the primitive type is often serrated round or obtuse or entire, while the evolutionary type is prickly at the serrated apex of the leaf margin. Western *Pyrus* L. is a special type. The leaf edges of most species of *Pyrus* L. in China are serrated, but the types of serration are different. The common leaf edge serration types are shown in Table 1. The upper leaf edge of *P. xerophila* has a few fine and sharp edges, the lower leaf edge of *P. sinkiangensis Yu* is not serrated or has shallow obtuse edges, and the upper leaf edge is mostly fine and sharp. The results show that *P. xerophila* and *P. sinkiangensis* Yu evolved from east to north in the transitional stage of evolution.

3.2 Evolution of inflorescences The evolution trend of inflorescences of *Pyrus* L. in China is as follows: from raceme or racemose-corymbose to corymbose and then to subumbellate, as shown in Table 2. In terms of the number of flowers per inflorescence, it decreases gradually in the above order. The diameter of each flower tends to increase gradually, for example, the diameter of *P. betulacfolia* and *P. calleryana* flower is generally less than 3 cm, while that of *P. ussuriensis* and *P. bretachneideri* flower is more than 3 cm, a maximum of 4 cm. The east-west succession and north-south succession of *Pyrus* L. appeared.

Received: May 19, 2022 Accepted: July 29, 2022

Supported by the Natural Science Foundation of Henan Provincial Department of Science and Technology (222300420508); Henan Provincial Key Science and Technology Research Project (202102310478); the PhD Research Fund of Pingdingshan University (PXY-BSQD-2012009); Training Program for Young Backbone Teachers in Higher Education Institutions in Henan Province (2021GGJS147).

Weishun TONG, lecturer, research direction: resource botany and molecular biology.

* Corresponding author. Huashan GAO, PhD., lecturer, research direction: microbial and biochemical pharmaceutical research.

Table 1 Leaf margin serration types of *Pyrus* L. in China

Leaf margin serration types	Variety	Distribution
Round, obtuse apex	*P. pashia*, *P. calleryana*, *P. communis*, *P. armeniacaifolia*, *P. pseudopashia*, *P. xerophila*	Southwest Yunnan and Himalayan region
Thick, sharp apex	*P. betulaefolia*, *P. serrulata*, *P. sinkiangensis*, *P. phaeocarpa*	East China, South China and Northwest China

Table 2 Inflorescence types of *Pyrus* L. in China

Inflorescence type	Variety	Distribution
Racemose or racemose-corymbose	*P. calleryana*, *P. betulaefolia*, *P. pashia*, *P. pseudopashia*	To the south of the Yangtze River in China, including South Asia
Corymbose-umbellate or subumbellate	*P. bretachneideri*, *P. ussuriensis*, *P. pyrifolia*, *P. hopeiensis*	To the north of China's Yangtze River, to Japan and North Korea to the east, and to Inner Mongolia and Russia to the north

3.3 Evolution of fruit type In the types of *Pyrus* L. in China, those with a fruit diameter of less than 2 cm are called small fruit type, and those with a fruit diameter of more than 2 cm are called large fruit type. The research data show that the small fruit type is more primitive than the large fruit type, the ovaries or fruits with 2 – 3 locules are more primitive than those with 4 – 5 locules, and those with brown pericarp are more primitive than those with yellow-green pericarp. The fruit type characteristics of *Pyrus* L. in China are shown in Table 3.

The pericarp of large fruit type with 2 – 3 locules is mostly yellow or green, brown, and most of them are cultivars with 5 locules. It is obvious that there is a trend of eastward and northward succession from the Pearl River and the Yangtze River basin and the Himalayas to North China and the Yellow River Basin.

Table 3 Fruit types of *Pyrus* L. in China

Fruit type	Variety	Distribution
Small fruit	*P. calleryana*, *P. betulaefolia*, *P. xerophila*, *P. pashia*	Himalayas, East China, Southwest Yunnan, South Asia
Large fruit	*P. pyrifolia*, *P. ussuriensis*, *P. bretachneideri*, *P. sinkiangensis*	To the north of the Yellow River basin, a trend of continuous development to the north and east
Medium fruit	*P. serrulata*, *P. armeniacaifolia*, *P. hopeiensis*, *P. phaeocarpa*, *P. pseudopashia*	North China, Yellow River basin, Northwest, Southwest Yunnan, South China

4 Classification study

According to different classification basis, different countries and scholars have made different classifications of *Pyrus* L., as shown in Table 4.

Table 4 Classification of *Pyrus* L.

Classification system		Year	Classification basis	Classification
Classification by foreign scholars	Classification by E. Koehne	1890	Whether the sepals on the fruit remain or not	*Achras*, *Pashia*
	Classification by Kikuchi	1951	The number of locules in *Pyrus* L.	*Eupyrus*, *Micropyrus Kikuchi*, *Inetrmedia Kikuchi*
	Classification by AH. A. ФегороВ	1954	Comprehensive morphology, biological characteristics and eco-geographical conditions of *Pyrus* L.	*Pashia Fed*, *Xeropyrenia Fed*, *Eupyrus Fed*, *Argyromalon Fed*
Classification by Chinese scholars	Yu Dejun	1960	Leaf edge serration condition	The *Pyrus* L. native to China was divided into 14 species
	Pu Fushen	1993	Evolution and eco-geographical conditions of *Pyrus* L.	Among the more than 30 species of *Pyrus* L. in the world, 28 were divided into 2 families and 4 populations, namely the western pear line and the oriental pear line

5 Species distribution

There are about 25 species of *Pyrus* L. in the world, which are distributed in Asia, Europe and North Africa. There are 14 species in China, 8 of which are endemic to China. They are widely cultivated in the north and south of China.

5.1 Distribution in the world According to the research of American scholar Westwood, *Pyrus* L. in the world can be divided into four major populations, as detailed in Table 5.

5.2 Distribution in China The species distribution of *Pyrus* L. in China is shown in Table 6.

Table 5 Distribution of *Pyrus* L. populations in the world

Population	Distribution	Variety
Europe	Western Europe, Southeast Europe, Central Europe, Turkey, France, Spain, *etc.*	*P. communis*, *P. coucasica*, *P. nivelie*, *etc.*
Mediterranean Sea	Greece, Turkey, Yugoslavia, Sardinia, Soviet Union, Israel, Algeria, Tunisia, Libya, Lebanon, Southeast Europe, Morocco, *etc.*	*P. amygdalifarmis*, *P. elaegrifofia*, *P. syriaea*, *P. longipes*, *P. gharbianh*, *P. mamorensis*, *etc.*
Central Asia	Iran, Soviet Union, Afghanistan, Pakistan, India, Nepal, China	*P. salicifolia*, *P. regelii*, *P. pashia*, *etc.*
East Asia	China, Japan, Korea, Siberia of the Soviet Union, *etc.*	*P. pyrifolia*, *P. ussuriensis*, *P. handoensis*, *P. calleryana*, *P. betulacfolia*, *P. fauiei*, *P. dimorphopyll*, *P. koehnei*, *etc.*

Table 6 Distribution of *Pyrus* L. populations in China

Population		Distribution in China	Distribution abroad
Endemic species	*P. hopeiensis*	Shandong, Hebei	
	P. sinkiangensis	Xinjiang	
	P. serrulata	Hubei, Hunan, Fujian, Guizhou, Jiangxi, Zhejiang, Sichuan, Guangdong, Guangxi	
	P. armeniacaifolia	Xinjiang	
	P. pseudopashia	Yunnan, Guizhou	
	P. xerophila	Shanxi, Shaanxi, Henan, Gansu, Xinjiang, Tibet	
	P. bretachneideri	Hebei, Henan, Shandong, Shanxi, Shaanxi, Gansu, Qinghai, Xinjiang	
	P. phaeocarpa	Hebei, Shandong, Shanxi, Shaanxi, Gansu, Xinjiang	
Non-endemic species	*P. ussuriensis*	Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Shandong, Shanxi, Shaanxi, Gansu	Northeast Asia, Russia and North Korea, *etc.*
	P. communis	Southwest to southern China	Bhutan, Russia, Sikkim, Vietnam, Western Asia and Europe
	P. pyrifolia	Anhui, Zhejiang, Jiangsu, Hubei, Jiangxi, Hunan, Sichuan, Guangdong, Yunnan, Guangxi, Guizhou, Fujian	Laos, Vietnam
	P. betulaefolia	Liaoning, Shandong, Hebei, Henan, Guizhou, Shanxi, Shaanxi, Jiangsu, Gansu, Hubei, Jiangxi, Anhui, Inner Mongolia, Tibet, Zhejiang	Laos
	P. calleryana	Shandong, Zhejiang, Henan, Jiangsu, Anhui, Jiangxi, Hubei, Guangdong, Fujian, Guangxi, Hunan, Taiwan	Japan, northern Vietnam
	P. pashia	Sichuan, Tibet, Yunnan, Guizhou	India, Bhutan, Myanmar, Nepal, Laos, Thailand, Vietnam, Sikkim, Pakistan, *etc.*

6 Conclusions

Pyrus L. is widely distributed and adaptable in China, and China is also one of its origin centers. The study on the origin, evolution, classification and species distribution of *Pyrus* L. is of great significance for the protection, evaluation and utilization of *Pyrus* L. germplasm resources.

References

[1] YU Y. Studies on the morphological evolution and geographical distribution of *Pyrus*[J]. Journal of Graduate Students of Sun Yat-sen University (Natural Science and Medicine Edition), 2009,30(2): 26 – 33. (in Chinese).

[2] RUBZOV, GA. Geographical distribution of the genus *Pyrus* and trends and factors in its evolution[J]. American Naturalist,1944(78): 358 – 366.

[3] OZAKI K. On urticales, ranales and rosales of the late miocene tatsumitogc Florida[J]. Bulletin of the National Science Museum Series C (Geol),1980: 6 – 12.

[4] PU FS. Chinese pear germplasm resources and pear breeding[J]. Journal of Horticulture, 1979,6(2): 69 – 75. (in Chinese).

[5] YU DJ. Taxonomy of Chinese fruit trees[M]. Beijing: Agricultural Publishing House, 1979: 22. (in Chinese).

[6] CHALLICE JS, WESTWOOD MN. Numerical taxonomic studies of the genus *Pyrus* using both chemical and botanical characters[J]. Botanical Journal of the Linnean Society,1973(67): 121 – 148.

[7] PU FS, CHEN RY. Studies on the karyotype of *Pyrus* in China(2)[J]. Journal of Horticulture, 1986,13(2): 87 – 90. (in Chinese).

[8] YAO YX, XU F. Observation on pollen morphology of *Pyrus* in China[J]. Journal of Caiyang Agricultural College, 1990,7(1): 1 – 8. (in Chinese).

[9] JIANG XF, CHU QG, ZHANG CS. Classification and evolution of the genus *Pyrus* in China[J]. Journal of Laiyang Agricultural College, 1992(1): 18 – 21. (in Chinese).

[10] TIAN LM, DONG XG, CAO YF, *et al.* Advances in taxonomy of *Pyrus*[J]. Chinese Fruit trees, 2021(9): 5 – 10. (in Chinese).

[11] QU ZZ, WANG YH, LI SL. Advances in taxonomy of fruit tree varieties[J]. Journal of Hebei Agricultural University, 1986, 9(2): 95 – 99. (in Chinese).

[12] HAN ZH. Germplasm Resources of deciduous Fruit trees[M]. Beijing: China Agricultural Publishing House, 1994: 239 – 266. (in Chinese).

(To page 54)

soil management in the southern United States[J]. HortScience: A Publication of the American Society for Horticultural Science, 1986, 21(3): 397 - 402.
[4] CAO Q, SHEN YY, WANG ZK, *et al.* Effects of living mulch on soil physical and chemical properties in orchards: A review[J]. Acta Prataculturae Sinica, 2016, 25(8): 180 - 188. (in Chinese).
[5] MERWIN IA, STILES WC. Orchard groundcover management impacts on apple tree growth and yield, and nutrient availability and uptake[J]. Journal of the American Society for Horticultural Science, 1994, 119(2): 209 - 215.
[6] LI TC. Study on the characteristics of soil water change of interplanting different herbages for a long time in apple orchard in the area of Weibei plateau[D]. Yangling: Northwest A&F University, 2014. (in Chinese).
[7] LI XG, SHAO MC, YANG QS, *et al.* Inhibitory effect of white clover cultivation on weeds in pear orchard and its influence on soil physical and chemical properties[J]. Shanghai Agricultural Science and Technology, 2017(2): 106 - 107. (in Chinese).
[8] WEI YN. Effect of different mulching methods on soil moisture and yield of dryland apple orchard[J]. China Fruit & Vegetable, 2020, 40(12): 42 - 45. (in Chinese).
[9] YANG JF, DING ZW, ZHANG XF. Study on comprehensive effect of grass-proof cloth mulching technology in mulberry orchard[J]. Yunnan Agricultural Science and Technology, 2019(5): 38 - 39. (in Chinese).
[10] LI FK, XIE YQ, XUE YY, *et al.* Response of physical and chemical properties of soil in apple root-zone to black ground fabric mulching[J]. Agricultural Research in the Arid Areas, 2020, 38(5): 123 - 129. (in Chinese).
[11] LIU W, LUO L, ZHONG Q, *et al.* Effects of grass planting and ground fabric mulching on soil properties and fruit quality in mango orchards in Panzhihua, China[J]. Chinese Journal of Applied & Environmental Biology, 2021, 27(2): 261 - 270. (in Chinese).
[12] ZENG M, MA GH, YU D, *et al.* Effects of grass cultivation on arbuscular root formation and fruit quality of citrus[J]. Chinese Agricultural Science Bulletin, 2005, 21(9): 304 - 306, 309. (in Chinese).
[13] ZHANG CB, LI YF, LI SJ, *et al.* Effects of different soil managements on soil temperature, moisture and citrus growth during summer drought season[J]. Journal of South China Agricultural University, 2019, 40(3): 45 - 52. (in Chinese).
[14] GAN L, PENG XH, PETH S, *et al.* Effects of grazing intensity on soil water regime and flux in Inner Mongolia Grassland, China[J]. Pedosphere, 2012, 22(2): 165 - 177.
[15] LIU H, LEI TW, ZHAO J, *et al.* Effects of rainfall intensity and antecedent soil water content on soil infiltrability under rainfall conditions using the run off-on-out method[J]. Journal of Hydrology, 2011, 396(1 - 2): 24 - 32.
[16] CHEN ML, ZHANG BW, REN TT, *et al.* Responses of soil moisture to precipitation pattern change in semiarid grasslands in Nei Mongol, China[J]. Acta Phytoecologica Sinica, 2016, 40(7): 658 - 668. (in Chinese).
[17] LIU JL, ZHANG SK, REN GQ, *et al.* Influence of rainfall on spatial variability of soil moisture in corn farmland under straw return condition[J]. Journal of Basic Science and Engineering, 2019, 27(4): 67 - 78. (in Chinese).
[18] CHEN WL, WANG SX, QI TX, *et al.* Spatiotemporal dynamics and temporal stability of soil moisture at black locust plantations with different restoration years on hilly region of the loess plateau, China[J]. Acta Ecologica Sinica, 2021, 41(14): 5643 - 5657. (in Chinese).
[19] FU X, WANG J, SAINJU UM, *et al.* Aggregate size distribution and associated carbon and nitrogen in mulched winter wheat and spring corn[J]. Canadian Journal of Soil Science, 2020, 99(4): 367 - 379.
[20] YUAN MM, ZHAO Q, TIAN XP, *et al.* Effects of spring *Brassica campestris* L. rolling on the soil aggregates and humus combined form[J]. Acta Agriculturae Boreali-Sinica, 2021, 36(4): 147 - 154. (in Chinese).
[21] WANG SJ, JIANG DH, ZHU WG, *et al.* Effect of deep vertical rotary tillage on aggregate structure in farmland of lateritic red soil[J]. Acta Pedologica Sinica, 2020, 57(2): 326 - 335.
[22] YANG QH, HUANG J, HU GC, *et al.* Preliminary report on the application of grass-proof cloth in different orange orchards[J]. South China Fruits, 2019, 48(3): 37 - 40. (in Chinese).
[23] LI FL, ZHUANG ML, QIAN XJ, *et al.* Effects of soil remediation and mulching with grass-proof cloth on soil nitrogen and phosphorus loss in tableland pomelo orchard[J]. Chinese Agricultural Science Bulletin, 2021, 37(10): 94 - 100. (in Chinese).
[24] BAI GS, ZOU CY, DU SN. Effects of self-sown grass on soil moisture and tree growth in apple orchard on Weibei dry plateau[J]. Transactions of the Chinese Society of Agricultural Engineering, 2018, 34(3): 151 - 158. (in Chinese).
[25] TANG YF, ZHANG XH, ZHANG XC. Effects of different mulching methods on water consumption and yield of pea in rain-fed semiarid area[J]. Agricultural Research in the Arid Areas, 2015(5): 6 - 10, 180. (in Chinese).
[26] LI H, HAO SP, GUO SP, *et al.* Effects of ground cloth mulching on soil physical and chemical properties and weed growth in apple orchard[J]. Forestry and Ecological Sciences, 2018, 33(4): 402 - 407. (in Chinese).
[27] KADER MA, NAKAMURA K, SENGE M, *et al.* Numerical simulation of water- and heat-flow regimes of mulched soil in rain-fed soybean field in central Japan[J]. Soil & Tillage Research, 2019(191): 142 - 155.
[28] ZHOU YJ, PU XK, WU CH, *et al.* Effects of different degradable plastic film with furrow mulch under ridge-furrow planting on farmland potato yield and soil water and heat[J]. Journal of Nuclear Agricultural Sciences, 2021, 35(11): 2664 - 2673. (in Chinese).

(From page 48)

[13] TENG YW, CHAI ML, LI XG. Historical review and new progress in taxonomy of *Pyrus*[J]. Journal of Fruit trees, 2004, (3): 252 - 257. (in Chinese).
[14] ZHANG P. Advances in the classification of species and varieties of *Pyrus* in China[J]. Fruit Trees in Shanxi, 1991(2): 2 - 5. (in Chinese).
[15] YU DJ. Taxonomy of Chinese fruit trees[M]. Beijing: Agricultural Publishing House, 1979: 122 - 146. (in Chinese).
[16] JIANG XF, CHU QG, ZHANG CS. Classification and evolution of the genus *Pyrus* in China[J]. Journal of Laiyang Agricultural College, 1992(1): 18 - 21. (in Chinese).
[17] MABBERLEY DJ. The Plant-Book (second edition)[M]. Cambridge: Cambridge University Press, 1997: 601.
[18] HOU KZ. Dictionary of families and genera of seed plants in China[M]. Beijing: Science Publishing House, 1984: 310. (in Chinese).
[19] WANG F, JIANG SL, OU CQ *et al.* Selection and analysis of backbone parents of pear breeding parents in China[J]. Fruit in South China, 2015, 44(5): 106 - 111. (in Chinese).
[20] LU M, TANG HR, LUO Y, *et al.* Application of SSR markers in the study of genetic relationship of *Pyrus*[J]. Horticulture in North China, 2012(23): 193 - 196. (in Chinese).
[21] ZHANG BB. Study on genetic diversity of cold-resistant apple and pear germplasm resources[D]. Changchun: Jilin Agricultural University, 2008. (in Chinese).
[22] MA YZ. Establishment and application of RAPD reaction system in *Pyrus* L.[D]. Baoding: Hebei Agricultural University, 2003. (in Chinese).
[23] PU FS. Pear germplasm resources and their studies[J]. Chinese Fruit, 1988(2): 42 - 46. (in Chinese).