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Phenological stages of development of *Cornus* L. S. str. species (Cornaceae) according to BBCH scale

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Under conditions of pronounced dynamic climate change, the scope of phenological data is constantly expanding and increasingly extends beyond local regions. For the international integration of phenological research, a standardized description of the stages of plant development and their identical coding is used – the BBCH scale (Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie). Phenophases of seasonal development, according to BBCH, are already unified for many different in origin, nature of ecology, and economic use of plants of common and little-known species and crops, including fruit. According to the BBCH scale, we described the seasonal stages of development of 23 cultivars of *Cornus mas* L. selection gene pool of the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine, genotypes of *C. officinalis* Siebold & Zucc., nine genotypes of *C. sessilis* Torr. ex Durand, as well as three genotypes of the artificial hybrid from crossing *C. officinalis* × *C. mas.* Phenological monitoring was carried out in NBG (Ukraine) two or three times a week for three seasons (2018–2020) from the beginning of vegetation (bud development) to November and the beginning of winter dormancy. In the studied species of the subgenus *Cornus*, as in some other stone fruit plants, there are eight of the ten main stages of seasonal development. In all studied species and cultivars of dogwood at the beginning of the growing season generative buds in their development significantly ahead of vegetative and plants begin seasonal development from the development of inflorescences and flowering (principal growth stage 5 and principal growth stage 6, respectively). Different species and varieties differ in the calendar dates of onset and duration of certain major stages of development. The obtained data are important for further studies of adaptive capabilities of *Cornus* species and cultivars in different climatic conditions, for practical use of genetic resources of studied *Cornus* species and cultivars, as well as for the introduction of little-known *Cornus* species and their use in agricultural production, pharmacology, ornamental and landscape gardens.

Keywords: *Cornus* spp., cultivars, phenology, BBCH-scale

Introduction

Seasonal reactions of plants – bud development, flowering, fruiting, dormancy, due to the hereditary genetic basis formed in the process of evolution, on the one hand, and on the other hand, largely depend on their sensitivity to environmental factors, including photoperiod, temperature, humidity, etc. (Parmesan, 2006; Wilczek et al., 2010; Zettlemoyer and Peterson, 2021). Under conditions of pronounced dynamic climate change, the scope of phenological data is

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constantly expanding and increasingly extends beyond local regions (Walther et al., 2002; Donnelly and Yu, 2017; Saxena and Rao, 2020).

The term "phenology" was used to describe the science that studies the periodic events of nature, proposed by Charles Morren. He first used it in a public lecture at the Royal Academy of Sciences in Brussels on December 16, 1849 (Demarée and Rutishauser, 2011), and in 1853 he used it in the title of an article on the observation of plants during the winter of 1852–1853 (Morren, 1853; Demarée and Rutishauser, 2011). However, accounting for phenological observations has a very long history. Perhaps the first documented phenological data were records of sakura blossoms in Kyoto, found in many diaries and chronicles from 812 to 1864 (Aono & Kazui, 2008). In Europe, some phenological observations began to be recorded in the early twelfth century. In particular, Ch. Morren, quoting information from Gabriel Peignot, said: "En 1172, l'hiver fut si doux que les arbres se couvrirent de verdure, et tout fut en pleine vegetation" (in 1172 the winter was so mild that the trees were covered greens, and everything was growing). For nearly five centuries, data on seasonal plant development have been fragmented or private (Sparks and Menzel, 2002). For example, the Marsham family of Norfolk (UK) recorded the flowering date of nearly 20 plant species for 154 years (1736–1958), including *Anemone nemorosa* L. (Sparks and Menzel, 2002). Phenology as a science that studies and systematizes seasonal events in plant life was substantiated by Carl Linnaeus. He organized a network of observation centers in Sweden, in "Philosophia botanica" (1751) set out the purpose and methods of phenological research, as an example, cited the results of his observations of many Uppsala plants during 1748–1749. Linnaeus identified the main phenophases of plant development: «Tempus Vigendi, Germinandi, Frondescendi, Efflorescendi, Vigilandi, Fructescendi, Defoliandi indicat Clima» (1751, p. 270) and even then he was convinced that the development of plants during the season is determined by the climate, and phenological calendars should be drawn up in each region in order to see the differences between them depending on the climate: «Calendaria Florae quotannis conficienda sunt in quavis Provincia, secundum Frondescentiam, Efflorescentiam, Fructescentiam, Defoliationem, observato simul Climate, ut inde constet diversitas Regionum inter se» (1751, p. 276). Later, phenological studies gained general recognition and in the early 19th century the period of flowering and fruiting was given for each species in many floristic publications (Bieberstein, 1808a, b; Rogovich, 1855).

For nearly 200 years (1751–1950) phenology developed in many countries and was usually coordinated with meteorological services (Schnelle, 1955). In Ukraine, instrumental meteorological and phenological observations were one of the first to be started by military doctor Lerhe in Kyiv in 1771. He reported, for example, that "on April 18, 1771, the trees began to bloom, but after three days snow fell, which did a lot of harm" (Lipinsky, 2011). Somewhat later, in the late 18th – early 19th centuries, the geographer, historian, and prominent public figure M.F. Berlinsky and the founder and rector of Kharkiv University V.N. Karazin began systematic hydrometeorological observations, an integral part of which were reports on the course of seasonal development of plants (Lipinsky, 2011).

Local phenological observations were carried out mainly according to various schemes, in which only the most important phases of development for plants of a particular species were most often described. For example, in Ukraine, in the vicinity of the city of Poltava, and other regions, S. Ilyichevsky conducted long-term observations of the flowering of more than 700 plant species since 1917 (Ilyichevsky, 1924a, 1934; Illichevs'kyy 1924b; Lipshits, 1950). The author emphasized that the dates of the beginning of flowering from year to year are very changeable, and the sums of the average daily temperatures, upon reaching which flowering begins, change much less. By analogy with the basic biogenetic law of E. Haeckel, S. Ilyichevsky (in parallel with Minio), employing statistical analysis of the number of flowering species during spring and summer, found that the general course of flowering of plants in its main features repeats the history of their development: at the beginning of the growing season, flowering begins predominantly species with primitively built flowers, and in the middle of summer, mainly those species that have a specialized flower structure bloom. This generalization in botanical literature is called the Minio-Ilyichevsky law (Lipshits, 1950; Samorodov and Khalimon, 2020).

In the middle of the 20th century, it was stated that the phenological scales used in some regions were not always suitable for use in others, and the phenological phases developed for some groups of plants did not correspond to the stages of development of other groups of them. As a result, standardized phenological scales began to be developed that reflected the stages of plant development, regardless of their taxonomic status or region of observation (Cautín and Agustí, 2005).

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In Eastern Europe in 1972, at a session of the Council of Botanical Gardens of the former USSR, a commission was created to develop a method of phenological research in botanical gardens, and in 1975 the Main Botanical Garden (GBS, Moscow), edited by P. Lapin, published a unified program of phenological observations of conifers, herbaceous and woody deciduous plants (1975). The developers separately considered the development of vegetative and generative organs of plants, used alphanumeric coding of the phenophase, and indicated the diagnostic features of each of them. This technique was applied by Zaitsev (1978, 1981) for statistical processing of data from long-term phenological observations, first for herbal perennials, and later for woody plants. Both techniques are popular and widely used in Eastern Europe.

In Western Europe, almost simultaneously, Zadoks et al. (1974) were among the first to propose 10 fundamental principles for constructing an integrated scale for determining the phenophases of plants, in particular, they emphasized that the phenophases should be recorded in the order of their ontogenetic manifestation, the main stages of plant growth should be indicated by symbols (for example, coded with numbers) so that they are available on all languages, the main phenophases must have unambiguous, and the secondary – two-digit codes and the like. Based on these principles, the authors developed a standardized phenological scale for cereals, in which they identified 10 coded numbers (from 0 to 9, respectively), the main phenological phases of development. Each such phase could include 10 or fewer secondary stages of development, which they also ciphered with numbers from 0 to 9. Principles of phenophase fixation, initiated by Zadoks et al. (1974), became more and more widespread and unified, in accordance with the consideration of certain groups of plants. In 1986–1987, in the Notes (Merkblatt) of the Federal Biological Institute for Agriculture and Forestry of Germany (Biologische Bundesanstalt für Land- und Forstwirtschaft, Bundesrepublik Deutschland), several articles were published, which described the development stages (BBA-scheme) of first weeds, and then pome and stone fruit plants and strawberries using digital coding of the phenophases (Bleiholder et al., 1986; Berning et al., 1987a, b, c). The authors identified 10 macro- and 10 micro-stages of plant development, described the characteristic visual morphological features of each of them, and emphasized that in certain species different phenophases can be observed simultaneously, or e.g. in different stone fruits, the blooming of vegetative buds occurs before, during or after flowering.

Further development of the BBA-scheme was the BBCH scale (BBCH = Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie), proposed by Bleiholder et al. (1989), and the extended BBCH scale recommended by Hack et al. (1992) for the same encryption of phenological stages of development of monocotyledonous and dicotyledonous plants. The extended BBCH scale is the development of a joint project team of scientists from three institutions: the Federal Biological Institute for Agriculture and Forestry (der Biologischen Bundesanstalt für Land- und Forstwirtschaft (BBA), the Federal Bureau of Plant Varieties (des Bundessortenamtes (BSA) and the Association of Agricultural Industries (des Industrieverbandes Agrar (IV A).

The expanded BBCH scale is growing in popularity. Now it has become international and has already been adapted for many different in origin, ecology, and economic use of plants of common and little-known species and agricultural crops, including fruit crops (Danner et al., 2019; Vaidya, 2019; Liu et al., 2021).

According to the BBCH scale, unified stages of development of pome and stone fruits, currants and strawberries (Meier et al., 1994), *Punica granatum* L. (Melgarejo et al., 1997), *Olea europaea* L. (Sanz-Cortés et al., 2002), *Rosa* sp. (Meier et al., 2009), *Actinidia deliciosa* C.F.Liang & A.R.Ferguson (Salinero et al., 2009), *Diospyros virginiana* L. (Grygorieva et al., 2010), *Theobroma* sp. (Niemenak et al., 2010), *Mangifera indica* L. (Delgado et al., 2011), *Persea americana* Mill. (Alcaraz et al., 2013), *Mespilus germanica* L. (Atay, 2013), *Ziziphus jujuba* Mill. (Hernández et al., 2015), *Morus* sp. (Sánchez-Salcedo et al., 2017), *Pseudocydonia sinensis* C.K. Schneid. (Grygorieva et al., 2018), cultivar "Pero de Cehegín" *Malus domestica* Borkh (Martínez et al., 2019), *Diospyros kaki* Thunb. (García-Carbonell et al., 2001; Guan et al., 2021), *Juglans neotropica* Diels (Ramírez and Kallarackal, 2021) etc.

The genus *Cornus* L. (Cornaceae Bercht. Ex J. Presl) – dogwood, includes about 60 species of deciduous trees and shrubs, most common in the cold and temperate zones of Europe, North America, Asia, and Africa (Xiang et al., 2006; Murrell and Poindexter, 2016). All Dogwoods are characterized by opposite solid leaves, four-membered flowers, and drupes of different shapes and colors. Their generative structures are highly variable (Murrell, 1993; Xiang et al., 2006; Feng et al., 2011). According to the results of molecular studies, four clades are distinguished in the genus, which includes nine subgenera, including the subgenus *Cornus* or *Cornus* s. str. (Xiang et al., 2006, 2008; Murrell and Poindexter, 2016).

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Some species of the subgenus *Cornus* belong to ancient fruit and medicinal plants. In the northern Black Sea region (Moldova), the fruits of *C. mas* were used even in the Neolithic period (Yanushevich, 1986). In Ukraine, *C. mas* plants were cultivated already in Kievan Rus (Klymenko, 1990). Almost 2000 years old, the fruits of *C. officinalis* are used in traditional and official Chinese medicine for liver and kidney health, as well as for the treatment of diabetes and other diseases (Huang et al., 2018). *Cornus sessilis* has an edible fruit. According to Klymenko et al. (2021), they contain almost 6.3 % sugars, 66.0 mg/% ascorbic acid, 0.6 % tannins. In the United States, the plants of this California's endemic are grown mainly for use in horticulture, garden design, and landscaping (https://calscape.org/Cornus-sessilis-(Miner's-ogwwod)?srchcr=sc5f3b85d0f226d). *Cornus* species, especially *C. mas* (subgenus *Cornus*), have been the objects of phenological observations. Usually, attention was paid to the beginning of the flowering of plants of this species. For the first time, perhaps, data on the flowering of *C. mas* (= *C. mas*cula L.) were given by Ch. Morren (1853), describing the vegetation of plants in Liege, Kingdom of Belgium during the unusually warm winter of 1852–1853. The author noted that the plants in the hedge bloomed on January 12, while before that time the beginning of flowering came on January 31, later on April 2, and most often on March 4. In the Netherlands, in the period 1901–1968 average flowering date of *C. mas* fell on March 13, and during 2001–2005 – on February 15 (van Vliet, 2014). In the climatic conditions of Ukraine, S. Klymenko studied in detail all the main phases of the seasonal development of *C. mas* in the period 1976–1987, according to the GBS method (1990). Our study aims to describe, according to the BBCH scale, the phenological stages of development of species of the genus *Cornus* s. str. (subgenus *Cornus*), in particular *C. mas* (cultivars), *C. officinalis*, and *C. sessilis*, presented in the collection of the M.M. Gryshko National Botanical Garden of NAS of Ukraine (NBG).

Material and methods

Study region

The research was carried out in the NBG (southeastern part of Kyiv, the low Pechersk slopes of the Kyiv Upland, the Zverinets tract, coordinates 50° 22' N and 30° 33' E). The climate is moderately continental, winters are mild, summers are warm. The average monthly temperature in January is -3.5 °C, in July +20.5 °C. The average annual temperature is +7.7 °C. The average annual precipitation is 640 mm; fall out throughout the year.

Research objects

Genotypes of 23 cultivars of *C. mas* of the breeding gene pool of the NBG; genotypes *C. officinalis* (26-year-old maternal plant obtained in 1993). As biennial plant from "Northwoods Wholesale Nursery" Mollala (Oregon, USA), 8- and 16-year-old seedlings of the maternal plant), nine genotypes of *C. sessilis*, grown in NBG from seeds obtained from California (Sierra Seed Supply, USA), three hybrid genotypes from the crossing of *C. officinalis* and *C. mas* (cultivar Etude).

Phenological monitoring

The observation was carried out two to three times a week for three seasons (2018-2020) from the beginning of the growing season (bud development) to November and the beginning of winter dormancy. To fix and describe the phenological stages of growth, the extended BBCH scale for mono- and dicotyledonous plants (Hack et al., 1992), the adapted BBCH scale for pome and stone fruits, currants, and strawberries (Meier et al., 1994), as well as data on the seasonal development of *C. mas* in Ukraine, obtained by S. Klymenko in 1976–1987 (1990).

Results and discussion

In the climatic conditions of Ukraine (NBG) species and cultivars of dogwood (subgenus *Cornus*) go through a full development cycle. In accordance with the BBCH scale, eight of the ten main stages of seasonal development are clearly distinguished in them (Table 1, Figure 1A–C), in particular: development of buds (Principal growth stage 0), leaves (Principal growth stage 1), shoots (Principal growth stage 3), inflorescences (Principal growth stage 5), flowering (Principal growth stage 6), fruit development (Principal growth stage 7), ripening of fruits (Principal growth stage 8) and ageing and the beginning of dormancy (Principal growth stage 9). For dogwood, like other fruit plants (Meier et al., 1994), tillering (Principal growth stage 2, observed in cereals) and the development of organs of vegetative reproduction (Principal growth stage 4, characteristic, for example, of strawberries), are not characteristic. Plants begin their growing season by developing inflorescences and flowering (the fifth and sixth Principal growth stage of the BBCH scale, respectively).

Principal growth stage 5: inflorescence development. The buds of umbellate inflorescences are formed on dicyclic, usually shortened generative shoots, which during the first year form several metameres with opposite leaves (vegetative phase of development), including one or two elongated, others are shortened. On the generative shoots in mid-June,

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Table 1 Phenological stages of development of the species and the cultivars *Cornus* L. s. st. according to the BBCH scale

Scale	Characteristics
	Principal growth stage 5: inflorescence emergence
50	the buds of the inflorescence are closed and covered by brown bracts
51	rounded generative buds swelling, closed, surrounded by slightly isolated greyish-brown bracts
53	the buds of the inflorescence burst: the bracts are slightly separated; the top of a few flower buds is visible
55	all light brown-green bracts are separated and deviated from each other; flower buds are clearly visible, pressed against each other; pedicels are short
57	pedicels elongated, flower buds separated from each other, part of the buds raised above the bracts
59	the bracts are rejected almost at an angle of 45 °; a significant part of the flower buds rised above the bracts and form umbellate inflorescences
	Principal growth stage 6: flowering
60	first flower revealed
61	beginning of flowering: opened about 10 % of flowers
65	full flowering: at least 50 % of the flowers are open, the petals of the first flowers fall off
67	withering of most flowers: fertilization occurs; petals and stamens fall off
69	end of flowering: petals and stamens of all flowers fell off
	Principal growth stage 0: bud development
00	rest period: acute elongated and thin vegetative buds closed and covered with dark brown or reddish scales
01	the beginning of swelling of the buds: buds (vegetative) noticeably elongated and enlarged, scales with a light border
03	end of swelling of the buds: the scales are separated, visible light green areas of the buds
07	the beginning of bud burst: noticeable green first leaves tips
09	the green leaves tips are about 5 mm long
	Principal growth stage 1: leaf development
10	green leaf tips 10 mm above the bud scales; first leaves separating
11	the first leaves are unfolded; others are still unfolding
15	more leaves unfolded, but not yet at full size
19	the first leaves are fully developed: have reached the typical size for the species/cultivars size
	Principal growth stage 3: shoot development
31	beginning of shoot growth: axes of developing shoots visible; about 10% of the expected length
32	shoots (annuals) reached about 20 % of the expected length
35	shoots (annuals) reached about 50 % of the expected length
39	shoots (annuals) reached about 90 % of the expected length
	Principal growth stage 7: fruit development
71	fruit set: the ovaries increase in size; the beginning of the ovary falling off
72	the ovaries are green, surrounded by a dying crown of the calyx
73	the second fall of the ovaries
75	the fruits have reached half of the final size
77	the fruits are about 70 % of the final size
79	the fruits have reached the final size, green
	Principal growth stage 8: maturity of fruit
81	the beginning of fruit ripening: change of color from green to light green
85	fruit color is progressing; the intensity of the color increases
87	the fruits acquire a color characteristic of the species or variety; 80 % of fruits have reached technical maturity
89	almost all fruits are ripe for consumption: they have a typical taste and hardness

Continuation of table 1

	Principal growth stage 9: senescence, beginning of dormancy
91	shoot growth completed; terminal bud developed; foliage still fully green
92	leaves begin to discolour
93	the beginning of leaf fall
95	half of the leaves discoloured or fell off
97	all the leaves fell
99	the beginning of winter dormancy

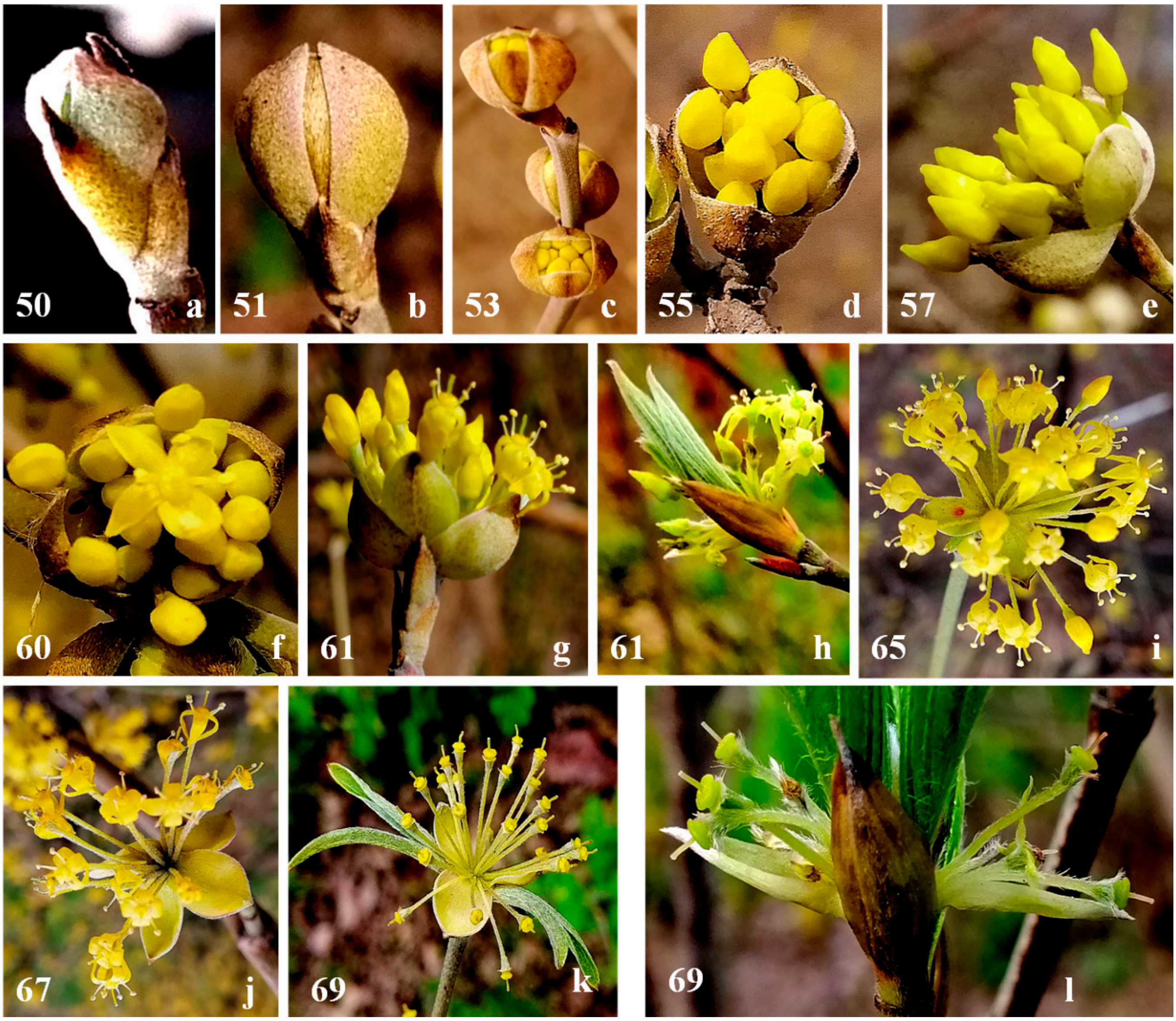

Figure 1A Phenological stages of *Cornus* species (subgenus *Cornus*)
a, ag – *C. mas*; b – *C. mas* 'Eugenia'; c – *C. mas* 'Alyosha'; d – *C. mas* 'Ekzotychnyy'; e, g, s, u, y, ae – *C. officinalis* × *C. mas* (cv. Etude); f – *C. mas* 'Nizhnyy'; h, l, m – *C. sessilis*; i, o, ab, ad, af – *C. officinalis*; j, k – *C. mas* 'Yuvileynyy Klymenko'; n, p, q, z – *C. mas* 'Kostya'; r, t – *C. mas* 'Starokyyivs'kyy'; v, ah – *C. mas* 'Elehantnyy'; w – *C. mas* 'Koralovyy'; x – *C. mas* 'Koralovyy Marka'; ac – *C. mas* 'Samofetyl'nyy'

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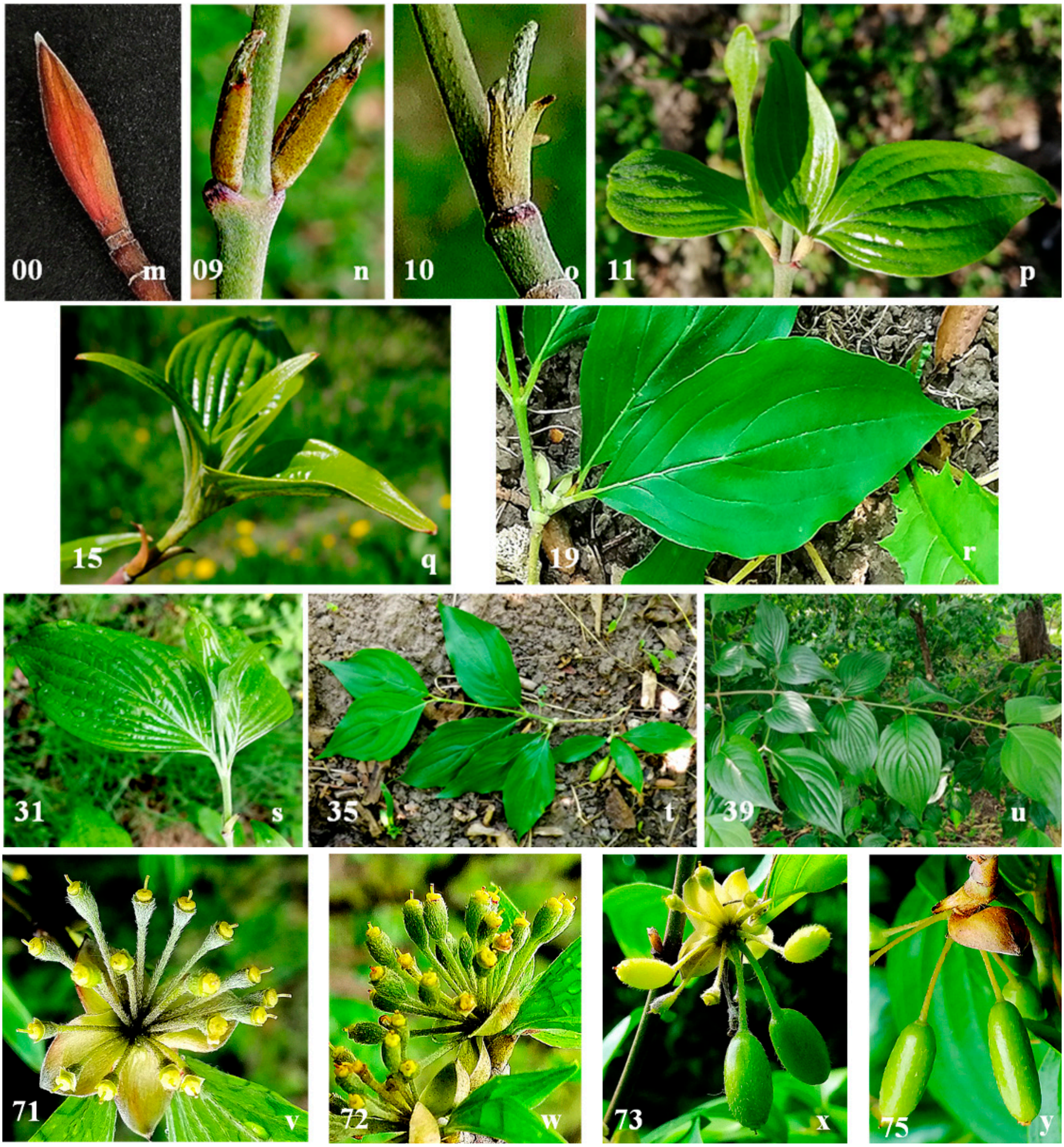

Figure 1B Phenological stages of *Cornus* species (subgenus *Cornus*)
a, ag – *C. mas*; b – *C. mas* 'Eugenia'; c – *C. mas* 'Alyosha'; d – *C. mas* 'Ekzotychnyy'; e, g, s, u, y, ae – *C. officinalis* × *C. mas* (cv. Etude); f – *C. mas* 'Nizhnyy'; h, l, m – *C. sessilis*; i, o, ab, ad, af – *C. officinalis*; j, k – *C. mas* 'Yuvileynyy Klymenko'; n, p, q, z – *C. mas* 'Kostya'; r, t – *C. mas* 'Starokyyivs'kyy'; v, ah – *C. mas* 'Elehantnyy'; w – *C. mas* 'Koralovyy'; x – *C. mas* 'Koralovyy Marka'; ac – *C. mas* 'Samofetyl'nyy'

Figure 1C Phenological stages of *Cornus* species (subgenus *Cornus*)
a, ag – *C. mas*; b – *C. mas* 'Eugenia'; c – *C. mas* 'Alyosha'; d – *C. mas* 'Ekzotychnyy'; e, g, s, u, y, ae – *C. officinalis* × *C. mas* (cv. Etude); f – *C. mas* 'Nizhnyy'; h, l, m – *C. sessilis*; i, o, ab, ad, af – *C. officinalis*; j, k – *C. mas* 'Yuvileynyy Klymenko'; n, p, q, z – *C. mas* 'Kostya'; r, t – *C. mas* 'Starokyyivs'kyy'; v, ah – *C. mas* 'Elehantnyy'; w – *C. mas* 'Koralovyy'; x – *C. mas* 'Koralovyy Marka'; ac – *C. mas* 'Samofetyl'nyy'

the apical complex bud of the next year is already clearly visible. In the second year of development (generative phase of development), it consists of an inflorescence bud surrounded by four bracts, and two oppositely located vegetative buds, each of which has its cataphil. Almost half of the complex bud is wrapped by two buds scales fused at the base.

Principal growth stage 6: flowering. The flowers of the studied genotypes *C. sessilis*, *C. mas*, *C. officinalis*, and their hybrid (usually 15–27 in one inflorescence) are very small, actinomorphic, four-membered, bisexual; the calyx is very reduced, consists of four small teeth, the petals are yellow, lanceolate, about 4 mm long; stamens attached to the nectar disc, alternating with

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petals; gynoecium formed by two carpels, a simple column, and a cabbage stigma; the ovary is inferior, two-celled. After pollination, the petals are bent downward. The flowering of individual dogwood flowers occurs simultaneously. In umbrellas, it starts in the direction from its periphery to the center. The central flowers often remain underdeveloped and die off. Within the framework of the skeletal branch, flowering spreads from its base to the top, and on one plant, flowers are the first to open in its middle part – well lit and better protected from the north wind. Simultaneously, at least three secondary phenophases of flowering can be observed on the plant: 60, 61, and 65. The beginning and duration of the flowering period largely depend on weather conditions. Under favorable conditions, flowering lasts 10–14 days.

Principal growth stage 0: buds development. The development of vegetative buds begins when the plants reach the flowering phenophase (stage 61). Green leaf tips about 5 mm long (stage 09) can be observed during the full flowering of the plants (stage 65).

Principal growth stage 1: leaf development. Leaves begin to form with the deployment of the first pair of leaves. The unfolded the first pair of leaves (stage 11) is observed approximately four weeks after the end of flowering. These leaves reach their final development (stage 19) after a few weeks. New leaves on vegetative shoots form during a significant part of the growing season, and old ones can die off even before the beginning of November.

Principal growth stage 3: shoot development. Simultaneously with the deployment of the leaves of the first pair, the formation of vegetative shoots begins. The beginning of their growth (the axes of the shoots of stage 31 are visually noticeable), is observed after the complete deployment of the first pair of leaves. The studied species are characterized by monopodial continuation. Under optimal weather conditions, vegetative shoots at the end of their development form 4-8 elongated metameres with opposite leaves. The studied species are also characterized by the development of sylleptic shoots, which, in *C. sessilis*, for example, are formed in the leaf axils of the third node. In June, vegetative buds of the next year begin to form in the axils of mature leaves.

Principal growth stage 7: fruit development. In parallel with the growth of vegetative shoots, the development of fruits begins. In the first stages (stages 71, 72 and 73), the ovaries, surrounded by a dying crown of the calyx, increase in size and turn green. A significant part of the ovaries, and later of the fruits, albeit a smaller amount, fall off. The long process of fruit shedding is due to the extended period of flowering of the dogwood. Fruit growth is at first intense (stages 75, 77), and later – slower. Upon reaching the final size (stage 79), usually from one to two, to six, to seven fruits remain in one inflorescence.

Principal growth stage 8: fruit ripening. The onset of fruit ripening begins with a color change (stage 81). In all studied species, they first turn light green, and then gradually acquire a color characteristic of each species or cultivar. In the same inflorescence, as well as on the same tree, the fruits do not ripen simultaneously, which corresponds to a long flowering period of dogwood. The fruits are harvested for processing at the stage of technical ripeness (stage 87).

Principal growth stage 9: senescence, beginning of dormancy. The stage of ageing and the beginning of dormancy in the studied dogwood genotypes is extended in time and begins at the end of the period of mass ripening of fruits. First, the old leaves of the first and second metameres change colour and fall off (stages 92, 93); later, other leaves die off. As a result, under optimal weather conditions, leaf abscission (stages 93 and 95) in the genotypes of *C. sessilis*, *C. mas*, *C. officinalis*, and their hybrid is rather long and is not intense. Rapid, within a few days, leaf fall may be due to significant night frosts. All leaves (stage 97) in the studied species fall off infrequently. Usually, one or two pairs of them remain on the tops of the shoots for a very long time, sometimes until spring.

Conclusions

In this work, the phenological stages of development of genotypes of three species of the genus *Cornus* (*C. mas*, *C. officinalis*, *C. sessilis*), 23 cultivars of *C. mas* of the NBG breeding gene pool, and a hybrid from the crossing of *C. officinalis* and *C. mas* (cultivar Etude) are described for the first time according to the extended BBCH scale. In the studied species of the subgenus *Cornus*, as in some other stone fruit plants, there are eight out of ten main stages of seasonal development, in particular: development of buds (principal growth stage 0), leaves (principal growth stage 1), shoots (principal growth stage 3), inflorescences (principal growth stage 5), flowering (principal growth stage 6), fruit development (principal growth stage 7), ripening of fruits (principal growth stage 8) and senescence, beginning of dormancy (principal growth stage 9). In all studied species and cultivars of dogwood at the beginning of the growing season, generative buds in their development outstrip vegetative ones and plants begin seasonal development from the deployment of inflorescences and flowering (principal growth stage 5 and principal growth stage 6, respectively). Various species and cultivars differ among themselves in the calendar dates of the beginning and duration of specific principal growth stages of development. The data obtained are important for further studies of the adaptive capabilities of dogwood species and cultivars under different climatic conditions, for the practical use of the complex of genetic resources of the studied dogwood species and cultivars, as well as for the introduction of little-known species and their use in agricultural production, pharmacology, ornamental and landscape gardening.

Conflicts of interest

The authors declare no conflict of interest.

Ethical statement

This article does not contain any studies that would require an ethical statement.

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