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Phenological scale for the mortiño or agraz (*Vaccinium meridionale* Swartz) in the high Colombian Andean area

Escala fenológica para el mortiño o agraz (*Vaccinium meridionale* Swartz) en la zona altoandina colombiana

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ABSTRACT

Keywords:
Andean blueberry
Branching
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Promising species
Sprouting

Mortiño, *Vaccinium meridionale* Swartz, represents a viable alternative for fruit growing because of the presence of appropriate ecological niches and spontaneous populations in the Colombian Andean zone. The knowledge of plants' phenology is useful to identify the response to critical periods (stages and phases) to different biotic or abiotic factors and to define agronomic practices adjusted to their requirements. Only the different phenological stages have been recognized in the mortiño; therefore, it is necessary to detail the phases within each one of them. The identification of the phenological stages and phases of the mortiño's canopy evolution was based on the scale of the blueberries *Vaccinium corymbosum*. It was adjusted between 2008 and 2011 to describe in detail the phenological stages of mortiño through monthly photographic records in five natural populations of three Colombian departments; where 48 individuals were randomly identified in each one. The purpose of the elaboration of this scale was to describe and visually identify the phenological phases of natural populations in similar climatic conditions. Four stages were found, the first one comprised the vegetative button formation (VB) with 5 phases, which ends with the formation of shoots. The second stage was the development of the inflorescence (ID) distributed in 5 phases as well, from floral bud to floral anthesis. In the third stage, the floral development (FD) took place, also with 5 phases, from flowering to the beginning of berry formation. The last stage, the berries were developed (BD) through 4 phases, from fruit formation until harvest maturity.

RESUMEN

Palabras clave:
Arándano andino
Ramificación
Floración
Fructificación
Especie promisoria
Brotación

El mortiño, *Vaccinium meridionale* Swartz es una alternativa frutícola viable por la presencia de nichos ecológicos apropiados y poblaciones espontáneas en la zona andina colombiana. El conocimiento de la fenología de las plantas es útil para identificar la respuesta a épocas críticas (etapas y fases) a distintos factores bióticos o abióticos y definir prácticas agronómicas ajustadas a sus requerimientos. En el mortiño solo se reconocen las distintas etapas fenológicas; por tanto, se requiere detallar las fases de cada una de aquellas. La identificación de las etapas y fases fenológicas de evolución del dosel del mortiño se fundamentó en la escala de los arándanos, *Vaccinium corymbosum*; la que se ajustó entre 2008 y 2011 para describir, detalladamente, los estados fenológicos del mortiño, a través de un registro fotográfico, con observaciones mensuales, en cinco poblaciones naturales de cuatro departamentos colombianos; donde se identificaron, al azar, 48 individuos en cada una. La elaboración de esta escala tuvo como objetivo describir e identificar, visualmente, las fases fenológicas de poblaciones naturales, en condiciones climáticas similares. Se encontraron 4 etapas: la primera comprendió formación del botón vegetativo (VB) con 5 fases, la que finaliza con la formación de brotes; la segunda fue el desarrollo de la inflorescencia (ID) distribuida en 5 fases, de botón floral hasta antesis floral; en la tercera sucedió el desarrollo floral (FD), con 5 fases, desde florescencia hasta inicio de formación de bayas; en la última se desarrollaron las bayas (BD), a través de 4 fases, de formación de frutos hasta madurez de cosecha.

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The word *mortiño* is described by Castilian language as a term applied to plants of the genus *Vaccinium*, name imposed by the Spanish in America; the first reference of the expression *mortiño* dates from 1548, which was used in the region of Guaca, current province of Carchi, Ecuador, a village inhabited by the "Pastos" indigenous(Patiño, 2002).

The agraz, mortiño or vichachá, *Vaccinium meridionale* Swartz, is a clonal plant belonging to the tribe Vaccinieae Rehb. and Ericaceae Juss. family; it comprises about 35 genera and more than 1000 species. Also, the genus *Vaccinium* has registered between 400 and 450 species, distributed in the northern hemisphere and in the mountains of the tropical regions of the Andes, South Africa and Madagascar (Luteyn, 2002; Smith *et al*., 2004). On the other hand, the mountains of northwestern South America and especially on the Pacific slope are rich in this group of plants (Salinas and Betancur, 2007). In the High Andean Area, there is information available on five species: *V. corymbodendrom* Klotzsch, *V. floribundum* Kunth, *V. meridionale* Swartz, *V. euryanthum* A.C. Smith, and *V. singularis* Salinas & Betancur; the last mentioned is only known in the Pacific slope of the department of Nariño (Salinas and Betancur, 2007). According to Ligarreto (2009), the species of the genus *Vaccinium* are distributed in the Departments of Antioquia, Boyacá, Cauca, Chocó, Cundinamarca, Magdalena, Meta, Nariño, Norte de Santander, Putumayo, Quindío, Santander, and Tolima; with the highest number of reports in Antioquia, Boyacá and Cundinamarca.

The mortiño represents a viable alternative for fruit growing with possibilities of development in the country in similar climatic conditions. This is based on a series of aspects such as international and national demand for berries, the presence of ecological niches suitable for their production, spontaneous populations in the Andean area with various forms of agro-industrial use. It is also a plant of great agro-industrial interest for the antioxidant activity of its berries, which includes this species in the category of nutraceutical products. Additionally, the taxon provides ecosystem services in wild environments (Medina *et al*., 2005; Zapata *et al*., 2015).

Secondary metabolites, including flavonoids, play an important role in the physiology of these plants because they are synthesized in response to stress to defend against biotic and abiotic agents (Zakaryan *et al*., 2017). Dróżdż *et al.* (2017) found different phenolic compounds in the diversity of species of the genus *Vaccinium*, as well as in the different varieties, phenological stages and in the post-harvest of the berries. *Vaccinium* species are recognized as a functional food because its high content and structural diversity of secondary metabolites. They have an important content of phenolic compounds, flavonoids, and anthocyanins (Gaviria *et al*., 2012; Lopera *et al*., 2013; Maldonado *et.al*., 2018; Tian *et al*., 2017). Likewise, the previous authors, with Krikorian *et al.* (2010) and Liu *et al.* (2011), stated that these substances have beneficial effects on health; for their action at ocular level, against degenerative diseases; certain types of cancer; memory impairment; and protection of the cardiovascular system. Additionally, they act as reducing agents for donating hydrogen that inhibits *singlet* oxygen, metal ion chelators; preventing the formation of free radicals (Galleano *et al*., 2010; Ghasemzadeh and Ghasemzadeh, 2011).

Phenology is defined as the study of the periodic and repetitive phases or activities of the life cycle of plants, both in their development and in their growth, due to the diurnal and annual temporal variations (Cook *et al*., 2012). The knowledge of the phenology of plants is useful to identify critical periods where plants develop appropriate strategies to face the effect of biotic or abiotic factors, stressors or not (Valbuena *et al.,* 2009). Phenology is useful to know the differences among plant's genotypes and develop agronomic practices adjusted to plant's requirements (Martínez-Adriano *et al*., 2016). Additionally, it helps to recognize the plasticity between plants and identify the different environments to which they have adapted (Harder and Johnson, 2005).

It must be considered that climate is the main factor controlling and regulating phenological events (Menzel *et al*., 2006) since plants are affected by environmental changes, within and between years, such as temperature, relative and soil humidity, nutrient availability, light and CO_2 increase (Nord and Lynch, 2009; Nijlanda *et al*., 2014; Martínez-Adriano *et al*., 2016). The phenology responds to the climate for the following reasons: for gene flow to occur between individuals for the same population and to avoid damage due to unfavorable changes over time (Jianwu *et al*., 2016). Besides, to face this climatic and genetic variability, plants adopt different phenological strategies (Körner *et al.*, 2016). Rainfall is generally considered as an environmental signal for the variation of phenological events in tropical regions (Morellato *et al.*, 2013, 2006). It is also related to the interpretation of the variability of these phases and their events, which originates the adaptation of plants to diverse environments (Martínez-Adriano *et al.*, 2013, 2016).

For certain species of the *Vaccinium* group, Antunes *et al.* (2008) suggested that the choice of cultivars is based on the identification of the species' phenological phases. This description can allow obtaining a staggering production and an increase of the same in strategic periods of supply and demand of the fruit. Also, Kron *et al.* (2002), in a study of the phylogenetic relationships carried out with the tribe of blueberry species (Vaccineae, Ericaceae) concluded that in the genus *Vaccinium* there is not a very clear grouping among taxa from different continents, or between those of tropical and temperate climate origin. Also, these authors tend to recognize several small groups (clades), rather than a large set of *Vaccinium* species, which would be essentially redundant to the Vaccinieae tribe.

Studies carried out by Ligarreto *et al.* (2011) revealed a wide morphological variation in the metapopulation of *V. meridionale* by quantitative and qualitative factors of the species, highly influenced by the environment. There is also an important wild genetic resource for *V. meridionale* that could cement the introduction of this species in the agricultural world. In a commercial cultivation of blueberries in Guasca (Colombia), with the Biloxi and Sharpblue cultivars, follow-ups were advanced in batches of 20 and 36 months, where it was identified that this last clone presented a superior yield because of a greater number of fruits and an increase in total soluble solids (Cortés-Rojas *et al.*, 2014).

For this species, information on phenological studies has been obtained, such as the one described by Gómez (2004), where certain development events are detailed; among them, the sprouting of leaves, floral button, open flower, flowering, fruiting, and green and ripe fruits. Other works describe six stages of maturity of the berries (Buitrago *et al.*, 2015). The peasant communities of Guarne, Antioquia, have expressed that there occurs biannual fruiting, which is a product of the bimodal rainfall of this area. For the area of the Antilles, Berazaín (2006) has identified that flowering occurs from the beginning of winter in the Ericaceae family. This phenological phase extends throughout the spring, until the beginning of summer; likewise, fruiting lasts from the beginning of autumn, continues throughout the winter, with a maximum in the spring-summer period. These are plants with abundant flowering and fruiting throughout the year.

Consequently, because the mortiño belongs to a group of species of the genus *Vaccinium*, it presents phenological stages and phases similar to blueberries, but not evaluated in conditions of the high Andean zone. Therefore, the objective of developing this scale was designed to describe and visually identify in the stages already known, the phenological phases that natural populations present in climatic conditions similar to the high Andean area studied.

MATERIALS AND METHODS

Locality

The monitoring in the different phenological stages of the mortiño was carried out between 2008 - 2011, in five natural populations selected in the Departments of Antioquia (Santa Rosa de Osos and Medellín, township of Santa Elena), Cundinamarca (Guachetá) and Santander (California), whose geographic coordinates and climatic characteristics are detailed in Table 1. It should be noted that precipitation is bimodal in all locations, and they are located between 2400 and 2900 masl, except California (Santander), where a natural population was identified at almost 3500 m of altitude. These locations are characterized by fluctuating minimum temperatures between 7.0 and 13.2 °C, maximum temperature from 20 to 25 °C, and relative humidity between 43 and 91%.

Identification of the phases and phenological phases of the canopy

The categorization of the growth states of *Vaccinium meridionale* was based on the phenological scale of blueberries, *Vaccinium corymbosum* (Michigan State University, 2003), which describes and includes graphs on the development of foliar, floral, flower and fruit buttons. Additionally, a scale was constructed with the description of the phenological stages of this Andean species, through a photographic record and monthly observations for 26 months in the five natural populations previously described, and on 48 individuals, between 100 to 150 buds were marked randomly. The phases of development of the berries were identified based on the photographic scale achieved by Hernández *et al*. (2012).

Table 1. Geographic location and climatic conditions of the natural populations of mortiño *Vaccinium meridionale* evaluated in Antioquia, Cundinamarca, and Santander.

Locality		Geographic location	Altitude (masl)	Temperature (°C)		Relative Humidity (%)	
Department	**Town**			**Mín.**	**Máx.**	**Mín.**	**Máx.**
Antioquia	Medellín (Santa Elena)	6°15'57''N, 75°29'47'' W	2.475	11.5	24.7	53.0	86.5
	Santa Rosa de Osos	6°4'30''N, 75°25'22''W	2.555	13.2	22.9	63.5	85.8
Cundinamarca	Guachetá	5°27'47''N, 73°39'52''W	2.872	8.75	20.5	48.8	89.9
Santander	California	7°22'39''N, 72°54'49''W	2.737	7.70	22.8	42.6	90.7
		7°23'16''N, 72°53'22''W	3.439				

RESULTS AND DISCUSSION

According to Halle *et al*. (1978), the mortiño presents a simplified branch, by abortion of the terminal buds at the end of each growth period. This model was called George Mangenot, which is initially orthotropic. Then, it leads to a plagiotropic development of the branches by replacing the lateral buds, which simultaneously show different phenological stages (Medina, 2010). Consequently, in this set of taxa, during the growth periods, reproductive and vegetative stems are observed simultaneously (Kawamura and Takeda, 2002).

The growth periods were continuous; so that in the dry season 75% of the structures were in the vegetative stage (VB), and the rainy season they increased up to 80% (Figure 1). On the other hand, in the dry season,

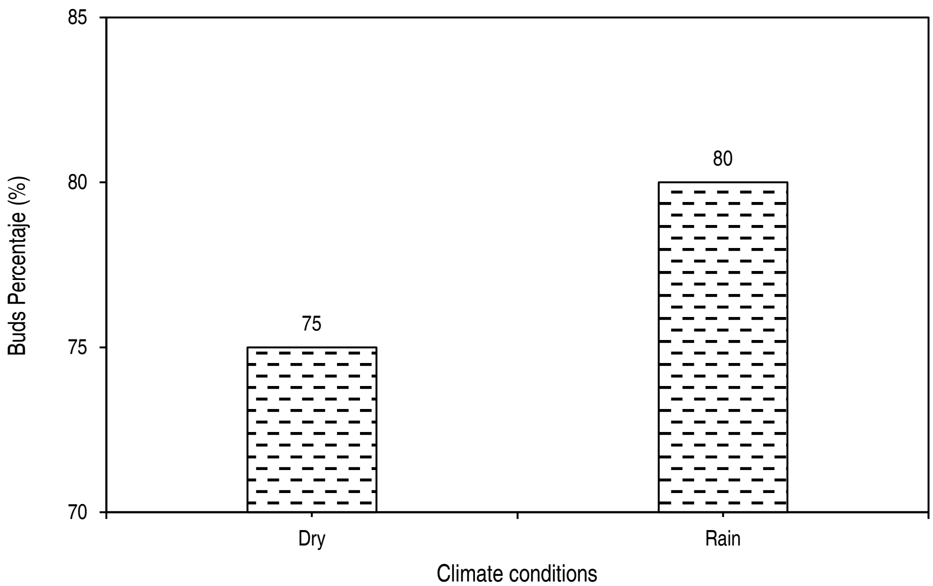

Figure 1. Percentage of mortiño's structures in vegetative stage (VB) according to both dry and rainy seasons.

25% were reproductive structures, of which 15% were in the development of the inflorescence (ID), 7% were floral development (FD), and 8% were the development of the berries (BD). Besides, in the rainy season, the proportion of these was 20%, of which 6% was DI, 7% FD and 7% BD (Figure 2).

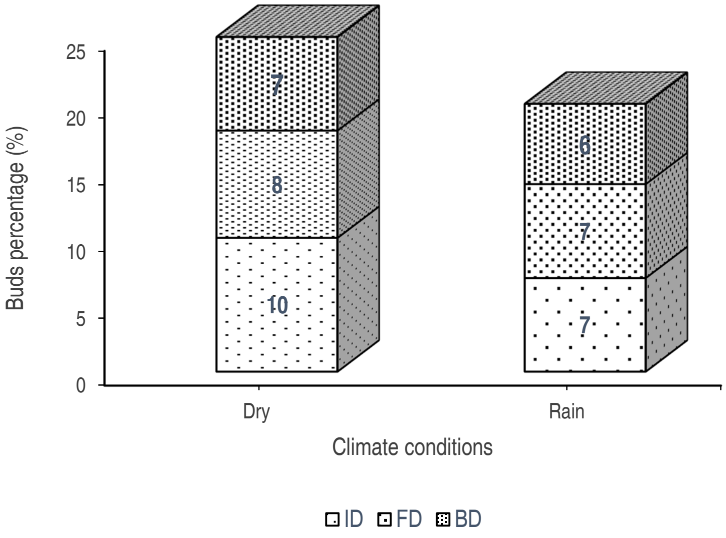

Figure 2. Percentage of moritño's reproductive structures according to both dry and rainy seasons. BD: development of the berries; FD: floral development; ID: inflorescence.

The canopy of the *Vaccinium* has the property of being evergreen (Kawamura and Takeda, 2002), and to last all year long (Gómez, 2004); as foliage, its main characteristic is the predominance of mature leaves in all phases of tree development, which last around one to four years in tropical forests (Coley, 1988).

On the other hand, the role of leaves, besides carrying out the photosynthetic process, is the storage of nutrients and photo-assimilates and as a source of nutrients in the process of remobilization during senescence (Severino and Auld, 2013). It is also important to identify the period of foliage formation since this process has consequences in the interactions between plants and herbivores (Novotny *et al*., 2006); it is the case between the natural populations and the phytophagous insects where the present study was carried out.

For the mortiño, a detailed description of the evolution of the canopy is not known. In research carried out in the municipality of Guarne, Antioquia, it was found that the growth and development of the foliage are permanent. However, it increases up to a maximum in the rainy season and high relative humidity, which coincides with the decrease in flowering and the formation of new berries (Gómez, 2004); unlike the mortiño, cranberry in Chile has two marked periods in leaf development, one for induction of leaf shoots and another for vegetative development (Bañados *et al*., 2007).

Stages and phases of canopy development

Under the climatic conditions of this study (Table 1), the phenological development of mortiño's canopy extended from the sprouting of the meristems, with the later formation of the vegetative structures until the maturity of the fruits. The first stage included the development of vegetative bud (VB) or foliar shoots and the formation of leaves and branches, which was subdivided into 5 phases. The second was related to the evolution of the inflorescence (ID), also distributed in 5 phases. In the third, floral development (FD) occurred, which extended into 5 phases. Finally, the berries were formed through 4 phases (BD).

Vegetative bud (VB) or foliar sprouts. The development phases of the vegetative buds originated from the point of non-visible growth (VB0), which is characterized by being dormant axillary buds (meristems) and ended with the formation of young buds (YB), not lignified, located in the terminal part of the branches (Figure 3). They do not possess dominant apical bud, with anthocyanin pigments in the leaves, very sensitive to the attack of foliage-eating insects and the damage caused by frost; from these young buds, reproductive shoots will be formed (Medina, 2010).

VB0 Point of non-visible growth	**VB1 Lateral buds in development**	**VB2 Late green buds**	**VB3 Expanding buds**	**YB Young buds**

Axillary foliar buds not sprouted	Sprouting of the leaf bud, between 1 and 5 mm	Expansion of the leaf buds (between 6 and 13 mm), with the beginning of the separation of the leaf blades that make up the bud	Complete development of the leaves and separation of the leaf blades present in the axil	Leaves not leathery, elongation of the branch, with senescence of the apical meristem and formation of axillary buds; in some cases, presence of anthocyanins in leaf blades

Figure 3. Stage of development of vegetative bud (VB) or foliar sprouts, where the leaves and branches are formed subdivided into 5 phases.

The growth phases of the VB were characterized by the budding of the lateral buds (VB1), which can reach up to 5 mm in length. The late green buds (VB2) expanded with the corresponding separation of the leaf blades that formed the buds. It continues with the bud's expansion (VB3), leaves development, and the separation of the leaf blades present in the axils. Finally, they became young buds (YB), characterized by having non-leathery leaves, prominent elongation of the branch and leaves, and formation of other axillary buds that can be differentiated into vegetative or reproductive. YB leads to the senescence of the apical meristem; in some cases, anthocyanin pigments were present in the leaf blades from the VB3. Feng *et al*. (2017) and Mazza and Miniati (1993) stated that these secondary metabolites are important in plants because they serve as attractants, protect against ultraviolet rays. They are correlated with an increase in the concentration of them regarding altitude, are associated with resistance of pathogens, are enhancers of photosynthesis in plants of tropical forests, and they regulate gas exchange in woody plants.

In the southern hemisphere, in *Vaccinium corymbosum* L., Rivadeneira and Carlazara (2011) described four stages of growth of the vegetative buds: One with short internodes, later the lengthening of these and leaf expansion occurs. Finally, the branches are fully formed. The vegetative growth is usually by periods, and it stops to start the development of inflorescences and subsequently, the flowers (Bañados *et al*., 2007).

In other evergreen *Vaccinium* spp., as in the case of *V. bracteatum*, the branches do not necessarily grow every year (Kawamura and Takeda, 2002), an aspect that also occurs in *V. meridionale*. It may be affected by climatic events such as the global warming that has affected both the distribution of species and leaf senescence and reproduction (Menzel *et al*., 2006). The most critical factor that affects plant cycles for high-latitude areas is temperature. However, in the tropics, it is the periodicity between dry and rainy seasons (Mendoza *et al*., 2017).

Development of the inflorescence (ID). As seen in Figure 4, in this stage, the inflorescence develops. It extends from the budding of the floral bud (ID1) to a fully developed elongated structure (ID5), to start flowering later.

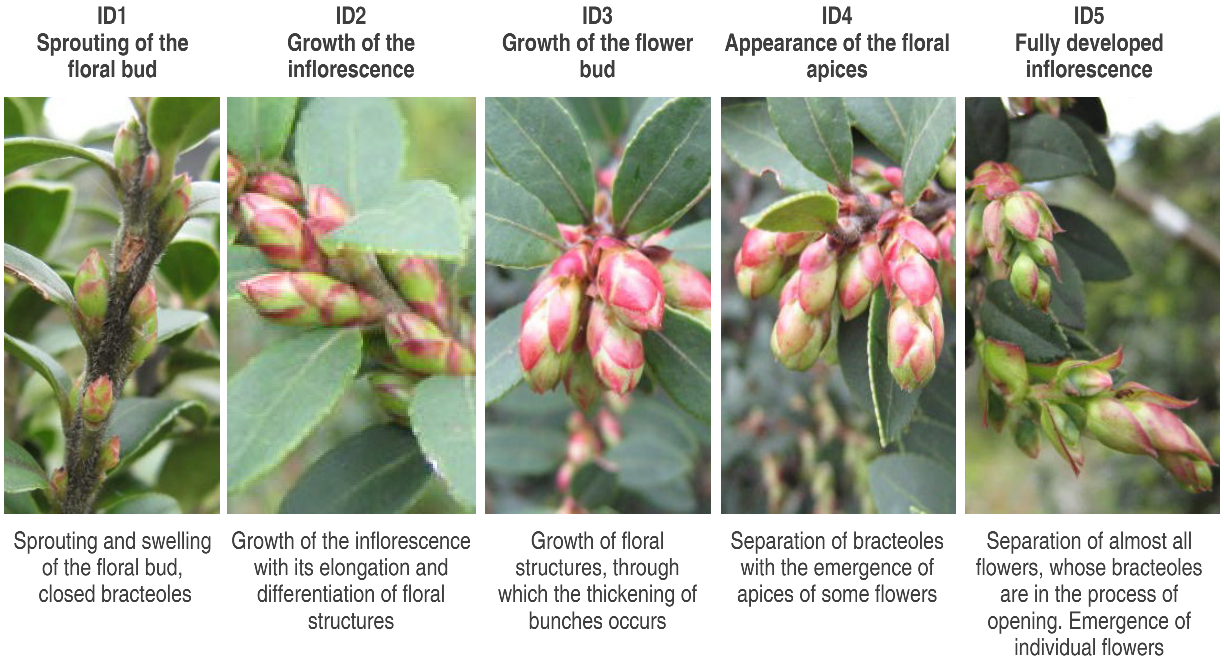

Figure 4. Stage of development of the inflorescence (ID) where the emergence of individual flowers occurs subdivided into 5 phases.

During inflorescence's growth and development, the budding of the floral bud (ID1) occurred because of its hydration and swelling. Subsequently, the elongated and differentiated inflorescence was observed in the different floral structures (ID2); after which, the development of the buds (ID3) and all floral structures was triggered, causing the thickening of the bunches. Once this happened, the floral apices emerged (ID4), with the separation of the bracteoles and emergence of some flowers. In the fully developed inflorescence (ID5) appeared the separated flowers, whose bracteoles were in the process of opening with the corresponding emergence of individual flowers.

In other *Vaccinium*, it has been expressed that the periods of flowering and ripening of fruits may vary according to the year and the location (Antunes *et al*., 2008). In the zone of San Miguel de Sema (Boyacá), there are two periods of flowering, the first from February to April and the second from July to September; likewise, the individuals that bloom in each period are different (Chamorro, 2014). In *V. corymbosum* a swollen bud that will give rise to the flowers was described as the beginning of the inflorescence formation (Meyer and Prinsloo, 2003). These structures are bunches of simple lateral buds that are found in the ending part of the branch; an inflorescence is formed by a knot, but in thick buds, it can be up to two (Gil, 2006).

Floral development (FD). In this stage, the evolution of flower development was described. It elapses from florescence (FD1) to corollas fall, and the beginning of the berries formation (FD5).

During the floral development (FD) (Figure 5), the closed corollas were observed white with slight reddish tints and grouped in bunches (FD1). Later, the flowers separated from the main axis, and reddish tones appeared on the upper half of the floral apices (FD2). Then, the opening of some flowers of the bunches (FD3) began; followed by a number of open flowers in most of the inflorescences, whose apices are curved upwards (FD4). In the last phase, the fall of the senescent corollas was observed, whose rudimentary pistils remained adhered to the pedicel, and the green fruit exhibition occurred (FD5). Although, Chamorro (2014) described ten floral states that range from its opening to floral senescence, under the conditions of this research, only 5 phases were seen in the FD.

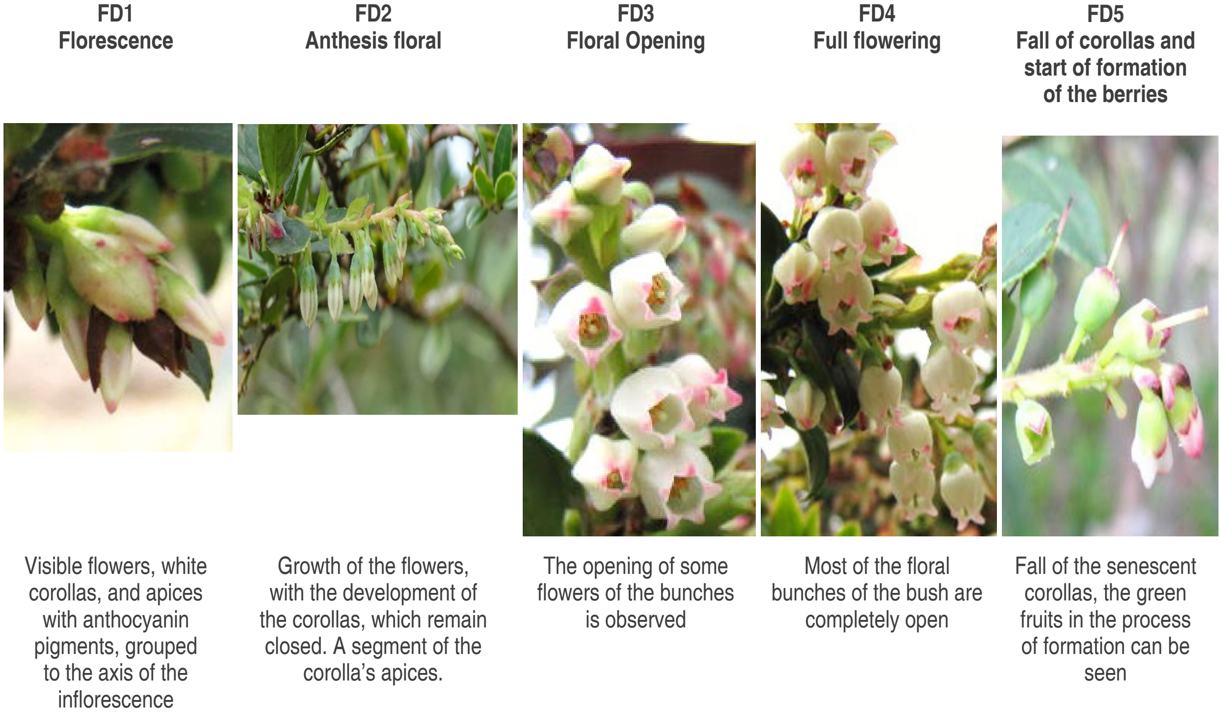

Figure 5. Stage of floral development (FD) subdivided into 5 phases, which end with the formation of the berries.

The flowers' colors are signals given by plants to interact with pollinators and seed dispersers. In addition, another of these colors functions is the protection against abiotic stressors that could interfere with their signaling function to pollinate and disperse animals (Stournaras and Schaefer, 2017).

For the area of eastern Antioquia, Corantioquia (2003) reported that the mortiño flowers twice a year, from February to May and from August to November, which coincides with what was found in this research. According to Gómez (2004), the flowering coincides with the dry seasons and is inversely related to the foliage sprouting and expansion in this region. In San Miguel de Sema (Boyacá) and Guachetá (Cundinamarca), the presence of mortino's blooms is identified between January to March and June to August (Chamorro and Nates-Parra, 2015). Studies conducted in Japan suggested that individuals with early blooms are disadvantaged by the availability of pollinators (Suzuki, 2002).

Regarding the flowering registered in the present study, it was observed that it occurred between February to May and August to November in Santa Elena (Antioquia), and from November to January and April to June in Santa Rosa de Osos (Antioquia). Likewise, from January to April and from June to August in Guachetá (Cundinamarca), and from March to May in California (Santander).

Development of berries (BD). The phases of this stage (Figure 6) were exhibited from the beginning of the fructification (BD1) to the harvest maturity of the berries (BD4). It began with the elongation of the green fruits (BD1) of variable size. Later, the berries began to develop anthocyanins (BD2), which were identified by their reddish coloration from the apical to the basal part of the fruit. They reached their physiological maturity when 25% of the bunch berries had developed reddish, anthocyanin colorations; covering 75 to 100% of the epicarp (BD3).

BD1 Beginning of fruiting	BD2 Berry development	BD3 Physiological maturity of the fruits	BD4 Harvest maturity of the fruits

The berries are in elongation; they are green fruits of variable size.	Berries in the process of development, they begin to form anthocyanin pigments	25% of the bunch berries have reddish anthocyanin colorations, covering 50 to 75% of the epicarp of the fruit	100% of the epicarp of the bunch of berries is purple, as a result of the content of anthocyanin pigments that make them up; In addition, they can be harvested periodically.

Figure 6. Stage of development of the berries (BD) subdivided into 4 phases, from the beginning of the fructification to the harvest. Adjusted by Hernández *et al.* (2012).

This phase is considered by Hernández *et al.* (2012) as the state III of fruit development.

The last phenological phase is harvest maturity of the fruits (BD4), which is characterized by the purple color throughout the epicarp and indicates the appropriate time for collection and consumption. The harvest is carried out periodically in the months of production because of formation of the reproductive structures of this perennial plant. According to these ripeness states of the berry, Hernández *et al*. (2012) identified that the seeds increase their weight as they develop, and the BD4 phase is the most appropriate time for their extraction.

According to Maldonado *et al*. (2018) and Gaviria *et al*. (2012), the berries in BD4 have high anthocyanin content and antioxidant activity. They also have a content of total phenols and natural colors comparable or superior to other *Vaccinium*; therefore, it is a promising fruit for its production and sale as a nutraceutical source to develop functional foods, or for the fresh fruit market.

The fruit is a rounded-shape and fleshy berry of 8-14 mm, with peduncle of 1 cm long. The fruits are green in the immature state (BD1) and purple or black when ripe (BD4). In certain occasions, they are covered by a waxy layer, they conserve rudiments of the calyx in the apex, and they possess numerous small seeds (Toro, 2012). The size of the berries is also related to the increase of seeds per fruit (Retamales and Hancock, 2012). Fruiting occurs in eastern Antioquia in two main periods, from April to June and September to December (Corantioquia, 2003); however, Gómez (2004) found that in natural populations, fruiting occurred throughout the year, with percentages ranging from 17% to 39%.

Regarding the reproductive phase of this plant (FD and BD), Chamorro and Nates-Parra (2015), in Guachetá (Cundinamarca) and San Miguel de Sema (Boyacá), found that a bud develops completely when its flowers bloom, 18 days after beginning its formation and six days later the senescence of this organ occurs. However, Chamorro (2014) stated that the flowers' duration was only six to ten days, which it is considered a long floral longevity characteristic of the Ericaceae family (Primack, 1985), and these are mechanisms to increase the attraction of pollinators. Rathcke (2003), Torres-Díaz *et al*. (2011), Chamorro (2014) and Chamorro and Nates-Parra (2015) found that the species produces a high quantity of flowers and low fruit production, which has been evidenced by selective abortion of self-pollinated fruits.

The growth stages in *V. corymbosum* were identified in leaves, inflorescences, flowers, and fruits. Thus, the development of the vegetative or foliar bud presented four phases, the floral button four, flowering five, and the development of the fruits five phases as well (Michigan State University, 2003). This scale served as the basis for the categorization of the growth stages of *Vaccinium meridionale*.

CONCLUSIONS

The growth periods were continuous, such that in the dry season the proportion of vegetative structures was 75% and the other 25% were reproductive organs distributed in the following proportions: 15% ID, 7% FD, 8% BD. In the rainy season, the vegetative organs reached 80% and 20% the reproductive organs, whose proportions were 6% ID, 7% FD and 7% BD. *V. meriodionale* Swartz expressed four phenological stages similar to *V. corymbosum*: development of vegetative buds, basic tissues for the formation of leaves and branches, development of the inflorescence, floral and berry development. Each of these stages was made up of five phases, except the last one that only exhibited four phases. The *V. meridionale* expressed a growth by continuous periods, in such a way that different vegetative and reproductive phases were appreciated, simultaneously. The phenological scale achieved in the five evaluated Colombian high Andean natural populations can be applied to other regions with similar climatic characteristics.

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