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Brazilian Amazon Orchids—Part III: Volatile Constituents of Floral Scents from Five *Gongora* Species and Their Chemometric and Chemotaxonomic Analysis

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Abstract

Gongora is a neotropical epiphytic orchid found from Mexico to South America, with 11 species recorded in Brazil. Little is known about the aromas produced by the flowers of these orchid species. This study aimed to identify the volatile constituents of the flowers of *Gongora histrionica* (1), *G. jauariensis* (1), *G. longiracemosa* (2), *G. minax* (1), and *G. pleiochroma* (2), all of which are found in the Amazon. Gas chromatography-mass spectrometry (GC-MS) was used to analyze the volatile constituents of *Gongora*. Additionally, multivariate statistical analysis was employed to evaluate the variability of volatile constituents in their floral aromas. The principal constituents (>25%) of *Gongora* specimens were (*Z*)-α-bisabolene, terpinen-4-ol, *cis*-β-elemenone, (*E*,*E*)-geranyl linalool, β-bisabolene, (*E*,*E*)-α-farnesene, and 1,8-cineole. Based on the identified compounds, the multivariate statistical analysis revealed seven distinct groups for the *Gongora* volatile concentrates, indicating a significant variability between the studied species. These results contribute to a better understanding of the genus *Gongora* chemotaxonomy analysis.

Keywords: *Gongora*; Orchidaceae; floral scents; principal constituents; (*Z*)-β-bisabolene; terpinen-4-ol; (*E*,*E*)-geranyl linalool

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1. Introduction

Plants do not naturally evolve to produce perfumes for the benefit of humanity. However, humans find certain floral scents aesthetically pleasing, leading to the cultivation and propagation of specific plant species. While human scent preferences vary, most prefer the smell of bee-pollinated flowers. Flowers attract pollinators through visual and olfactory stimuli. The volatile compounds in floral scents attract and influence behaviors such as landing, feeding, mating, and oviposition in a diverse range of flowers. The relative importance of different pollinating bees in plant pollination and selective pressure on floral traits, including floral scent chemistry, may vary. It is essential to identify visiting pollinators and the primary floral characteristics that attract them to understand the relationship between floral aroma chemistry and the type of pollinator [1]. Research into the composition of floral aromas has increased in recent decades, primarily due to the use of floral volatiles

in cosmetics. Numerous studies have also been dedicated to examining the biological aspects of floral aroma in plants. However, to date, only a few studies have focused on the biosynthesis of aromatic compounds and the behavioral differences between plants and insect pollinators [2].

More than 1700 floral odoriferous compounds have been identified, spanning 990 taxa [3,4]. The floral perianth in particular emits the aromas in plants, although all other floral parts also contribute to the emission of the fragrance. The floral scents of orchids are stored in the oil glands of insects, such as trichomes, and are later released into the environment. Furthermore, these volatile compounds emitted by other plant organs, in addition to flowers, are also involved in their defense mechanisms. Therefore, floral volatiles play a significant role in the reproductive process of plants, attracting pollinators and acting as repellents and physiological protectors against abiotic stress [4,5]. The volatile compounds emitted by flowers serve as the primary signals for insects to select which flowers to visit. Flower colors also send signals for insect visitation [5,6]. These volatile compounds, predominantly lipophilic and of low molecular weight, include terpenoids, fatty acid derivatives, benzenoids, and phenylpropanoids. They are compounds branched at carbon-5 and may also contain nitrogen and sulfur atoms. The compounds released by plants, especially flowers, and the variety and quantity of these volatile substances are influenced by interactions with herbivores [5,7].

Orchidaceae is one of the world's most influential families of flowering plants. It comprises 736 genera and approximately 28,000 species, featuring a diverse range of epiphytic and terrestrial specimens found in nearly all habitats on Earth. Orchids are renowned for their varied morphological types and stunning variations, and they play a significant role in the floral evolution of monocots [8,9]. Orchids have developed specialized pollination mechanisms to attract insects, resulting in specific floral characteristics and fragrances that are associated with attracting particular pollinators [5,10].

The Orchidaceae family displays a variety of complex animal pollination methods. One specialized form of pollination is performed by male euglossine bees (Apidae, Euglossini) in more than 600 species of Neotropical orchids. The orchids pollinated by euglossine bees produce abundant floral scents, attracting and rewarding male bees. The male euglossine bees collect volatile compounds from floral and non-floral sources using the complex morphology of the orchid flowers and store them in their specialized tibiae. These compounds are released during their courtship display, transferring the orchid's pollinia (pollen masses) to the stigma of the flower [10]. The floral fragrances serve as signals and rewards for the bees, as some of the components in these mixtures become part of their pheromones, which are essential for sexual recognition and selection during mating [1,11].

Gongora Ruiz & Pav. comprises approximately 60–70 species found from Southern Mexico to South America, including the slopes of the Andes and regions of Venezuela, Guianas, and Brazil. There are around eleven *Gongora* species in Brazil, with eight of these species found in the Brazilian Amazon. This orchid is a neotropical, long-lived perennial epiphyte that produces hanging clusters of about 10 to 60 waxy, glossy, and strongly scented flowers. These flowers open simultaneously and emit their most potent scent in the morning, when male Euglossine bees are most active for pollination [10,12].

In previous studies, we analyzed the volatile components responsible for the scents of certain *Encyclia* and *Catasetum* orchid species from the Brazilian Amazon [13,14]. This study aimed to extract the aromas of orchid inflorescences of the genus *Gongora*, identifying the volatile constituents of specimens of *G. histrionica* Rchb.f. (1), *G. jauariensis* Campacci & J.B.F.Silva (1), *G. longiracemosa* G.Gerlach & J.B.F.Silva (2), *G. minax* Rchb.f. (1), and *G. pleiochroma* Rchb.f. (2) existing in the Brazilian Amazon. Furthermore, the chemical compo-

sition data of the floral aromas were analyzed using chemometric and chemotaxonomic parameters to compare them with other previously studied *Gongora* species.

2. Materials and Methods

2.1. Plant Material

The orchid specimens used in this work were Gongora *histrionica* (Figure 1), *G. jauariensis* (Figure 3), *G. longiracemosa* (Figure 5), *G. minax* (Figure 7), and *G. pleiochroma* (Figure 9). These living orchid specimens are grown in pots containing charcoal and wood shavings in the private nursery of botanist Luiz Otávio Adão Teixeira, at Residencial Jardim Amazônia, BR-316, km 6, Ananindeua, PA, Brazil (coordinates 1°22′20.96″ S/48°23′34.14″ W). These orchid specimens were previously collected from various locations and cities in the Brazilian Amazon and are described in Section 3. Exsiccata of the orchids are stored in the Herbarium Murça Pires of Emílio Goeldi Museum, Belém, Pará state, Brazil. Orchid flowers were collected at 6 a.m. to standardize the samples regarding the extraction of their volatile constituents during the daily biosynthetic process influenced by sunlight. For this purpose, we used the flowers of two individuals from two different populations of the same orchid species to obtain their volatile concentrates.

2.2. Obtaining and Analyzing the Volatile Concentrates

The orchid flower samples were subjected to microdistillation-extraction, using a Likens & Nickerson-type apparatus (3 flowers, approximately 15–20 g in total, 2 h, duplicate) to separate their volatile concentrates, using *n*-pentane (99% HPLC grade, 3 mL) as the solvent [15].

The volatile compounds from the orchids were analyzed using GC and GC-MS. The analysis was performed using a GC-MS-QP2010 Ultra system (Shimadzu Corporation, Tokyo, Japan) equipped with an AOC-20 i auto-injector and GC-MS Solution software (version 2.53, Shimadzu Corporation, Kioto, Japan), which included the Adams (2007) and Mondello (2011) libraries [16,17]. A Rxi-5 ms silica capillary column (30 m × 0.25 mm; 0.25 µm film thickness) from Restek Corporation was used. The analysis conditions were as follows: injector temperature at 250 °C, oven temperature programmed from 60 to 240 °C at a rate of 3 °C/min, helium used as the carrier gas at a linear velocity of 36.5 cm/s (1.0 mL/min), split mode injection (split ratio 1:20) of 1.0–2.0 µL of the pentane solution, electron ionization at 70 eV, and ionization source and transfer line temperatures of 200 and 250 °C, respectively. Mass spectra were obtained by scanning every 0.3 s, with mass fragments in the 35–400 m/z range. The retention index for all volatile components was calculated using a homologous series of C8-C40 *n*-alkanes (Sigma-Aldrich, Milwaukee, WI, USA) according to the linear equation of van den Dool and Kratz (1963) [18]. The GC-MS Solution system analyzed the individual components by comparing their retention indices and mass spectra (molecular mass and fragmentation pattern) with those existing in the Adams and Mondello libraries [16,17]. The quantitative data regarding the volatile constituents were obtained using a GC-2010 Series gas chromatograph, operated under conditions similar to those of the GC-MS system. The relative amounts of individual components were calculated by peak-area normalization using a flame ionization detector (GC-FID). Chromatographic analyses were performed in duplicate, and no qualitative differentiation was observed between them.

2.3. Multivariate Statistical Analysis

To examine the relationship between the volatile compounds analyzed by GC-MS and the identified compound classes, the Principal Component Analysis (PCA) was used. These classes included monoterpene hydrocarbons (MH), oxygenated monoterpenes (OM),

sesquiterpene hydrocarbons (SH), oxygenated sesquiterpenes (OS), oxygenated diterpenes (OD), benzenoids/phenylpropanoids, and fatty acids and derivatives. The data matrix was standardized for multivariate analysis by subtracting the mean and dividing by the standard deviation. Furthermore, Hierarchical Cluster Analysis (HCA) using the Euclidean distance and complete linkage was employed to determine sample similarities based on the distribution of the constituents identified in the PCA. The analysis was conducted using Minitab software (free version 390, Minitab Inc., State College, PA, USA).

3. Results and Discussion

3.1. Gongora Ruiz & Pav.

3.1.1. *Gongora histrionica* Rchb.f.

Botanical description: Epiphyte. Pseudobulb conical, ovoid, with longitudinal grooves, apical 3-foliate. Leaves elliptical-lanceolate, varying from 25.0 to 30.0 cm in length and 5.0 to 9.0 cm in width, with an acute apex, attenuated base with a short pseudobulb. The pendant inflorescence is multiflora, with about 15 flowers (see Figure 1). The dorsal sepal is lanceolate, about 1.5 cm long and 0.7 cm wide; the lateral sepals are triangular-asymmetric, about 2.0 cm long, 1.2 cm wide, and 1/3 of the petals are nailed to the column, and the free part is linear-lanceolate. Labellum is based on a swollen hypochilum, forming a right angle in lateral view, with 2 to 3 mm lateral horns flattened and facing downwards. Epichilum is acuminated and smaller than hypochilum. The column is curved and half-welded [19,20]. The botanical identification of the species was conducted at the Emílio Goeldi Museum in Belém, Brazil, by comparing it with an authentic sample of *Gongora histrionica* (MG221267) that was previously registered in the Herbarium João Murça Pires. It flowers in October and November.



Figure 1. *Gongora histrionica* (Source Luiz Otavio Adão).

Synonimy: *Gongora leucochila* Lem., *G. maculata* Lindl. [21].

Geographic distribution: Not endemic in Brazil but found in areas of riparian or gallery, upland, and floodplain forests in the states of Acre, Amazonas, Amapá, Pará, Rondônia, Roraima, and Tocantins [20].

The specimen of *G. histrionica* used in this study was initially sampled in Bujaru, Pará, Brazil. Table 1 lists the constituents of its volatile concentrate, and Figure 2 shows the main compounds.

Table 1. Constituents identified in the volatile concentrate of *G. histrionica* orchids.

Constituents (%)	RI_{Calc}	RI_{Lit}	%
n-Octane	796	800 [a]	0.4
α-Pinene	928	932 [a]	1.9
β-Pinene	970	974 [a]	0.2
Myrcene	989	988 [a]	0.5
n-Octanal	1000	998 [a]	0.2
α-Terpinene	1013	1014 [a]	0.6
1,8-Cineole	1027	1026 [a]	**27.5**
(*E*)-β-Ocimene	1047	1044 [a]	2.9
γ-Terpinene	1056	1054 [a]	1.1
cis-Sabinene hydrate	1063	1065 [a]	0.3
cis-Linalool oxide (furanoid)	1069	1067 [a]	0.5
p-Cresol	1074	1071 [a]	0.3
Terpinolene	1085	1086 [a]	0.3
trans-Sabinene hydrate	1094	1099 [b]	0.2
Linalool	1099	1101 [b]	**9.8**
n-Nonanal	1102	1100 [b]	2.5
cis-p-Menth-2-en-1-ol	1117	1118 [a]	0.1
2-vinyl-Anisole	1128	1135 [b]	0.1
δ-Terpineol	1163	1162 [a]	0.2
Terpinen-4-ol	1174	1174 [a]	3.7
α-Terpineol	1187	1186 [a]	3.1
trans-Carveol	1218	1215 [a]	0.4
Nerol	1226	1227 [a]	0.1
Geraniol	1254	1249 [a]	0.5
(*E*)-Caryophyllene	1418	1417 [a]	0.2
Undeca-2,4-dien-1 ol	1424	1426 [b]	1.0
(*E*)-β-Farnesene	1457	1454 [a]	0.1
α-Zingiberene	1495	1493 [a]	0.2
(*E*,*E*)-α-Farnesene	1511	1505 [a]	**29.3**
(*E*)-Nerolidol	1563	1561 [a]	0.1
trans-β-Elemenone	1598	1602 [a]	0.1
β-Bisabolenol	1788	1789 [a]	**11.3**
Monoterpene hydrocarbons			7.5
Oxygenated monoterpenes			46.4
Sesquiterpene hydrocarbons			29.8
Oxygenated sesquiterpenes			11.5
Benzenoids/Phenylpropanoids			0.4
Fatty acid and derivatives			4.1
Total (%)			**99.7**

RI_{Cal} = Calculated Retention Index; RI_{Lit} = Literature Retention Index; [a] Adams, 2007 [16]; [b] Mondello, 2011 [17]; Bold = main constituents. Unidentified minor constituents were 0.3%.

Oxygenated monoterpenes (46.4%) predominated in the volatile concentrate of *G. histrionica*, followed by sesquiterpene hydrocarbons (29.8%), oxygenated sesquiterpenes (11.5%), and monoterpene hydrocarbons (7.5%). The main constituents were (*E*,*E*)-α-farnesene (29.3%), 1,8-cineole (27.5%), β-bisabolenol (11.3%), and linalool (9.8%) (see Figure 2). The floral scent of *G. histrionica* is being described for the first time.

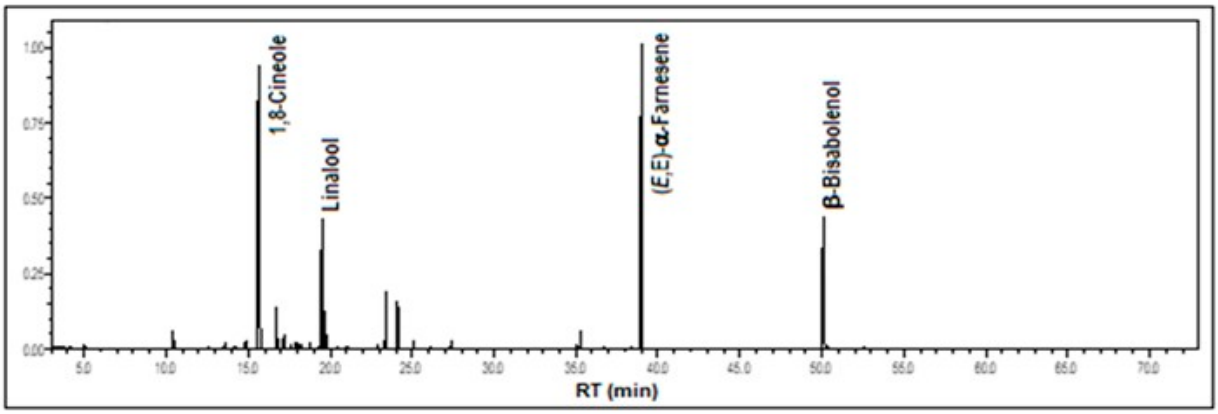


Figure 2. Ion-chromatogram of the *Gongora histrionica* volatile concentrate.

3.1.2. *Gongora jauariensis* Campacci & J.B.F.Silva

Botanical description: Cespitose epiphyte. Inapparent rhizome, white, thin, glabrous roots. Pseudobulbs ovate, deeply concave, 7.0 to 8.0 cm high and 3.5 to 4.0 cm in diameter, yellowish-green, bifoliate. Leaves thin, with strong veins in the abaxial part, elliptical, acute apex, on average 25.0 cm long and up to 8.0 cm wide, green. Inflorescence racemose, yellow, pendant; floral scape on average 50.0 cm long and 2.0 cm in diameter, red, full of amplexicaul bracts 0.6 to 0.8 cm long; rachis with flowers, radially dispersed at 2.5 cm intervals, simultaneous at anthesis; persistent floral bracts, yellow, 7.0 mm long by 2.0 mm broad, triangular, apex acute. Flowers (Figure 3) do not resupinate, are blood red, and have yellow segments at the apex. Dorsal sepal adpressed with column, elliptical, apex acute, margins revolute, 3.0 cm long by 1.2 cm wide; triangular lateral sepals, apex acute, margins revolute, 3.0 cm long by 2.0 cm broad; petals welded with the column at the base and the free part triangular, acute with the apex towards the column, 12.0 to 15.0 mm long by 1.5 to 2.0 mm wide, margins smooth. Lip concrete at the base of the column, fleshy, 18.0 mm long by 6.0 mm wide; hypochilium with a high subtriangular section, equipped with two prominent winged horns with a revolute apex and two other smaller horns close to the base; mesochilium endowed with two long and thin appendages, more than 10.0 mm in length and extending towards the column; triangular epichilium when viewed laterally, with small lobes at base facing downwards, gibbous, acute apex recurved. Thin column, slightly thickened at the apex, 2.2 cm long by 3.0 mm in diameter at the apex, curved from its middle, without lateral wings. The anther is ovoid, 3.0 cm long, yellow; pollinia-2, elongated, typical of the genus [20]. The botanical identification of the species was performed at the Emílio Goeldi Museum in Belém, Brazil, by comparing it with an authentic sample of *Gongora jauariensis* (MG190656) previously registered in the Herbarium João Murça Pires. It flowers from October to December.

Geographic distribution: Endemic in Brazil, occurring in the state of Amazonas in areas of igapó and ombrophylous forests [22].

The specimen of *G. jauariensis* was initially sampled in the Jauari River, municipality of Barcelos, Amazonas state, Brazil. Table 2 lists the constituents of its volatile concentrate, and Figure 4 shows the main compounds.

A previous study of the secretory structures of some *Gongora* species also presented β-bisabolene (39.0%) and (*E*)-β-farnesene (5.1%) as the primary constituents of another *G. jauariensis* specimen collected in Pará state, Brazil [23]. Therefore, it resembles the present specimen described in this manuscript.

Table 2. Constituents identified in the volatile concentrate of *G. jauariensis* orchids.

Constituents (%)	**RI_{Cal}**	**RI_{Lit}**	**%**
2-methyl-3-Buten-2-ol acetate	772	771 [b]	0.3
n-Octane	796	800 [a]	0.7
α-Pinene	928	932 [a]	0.1
β-Pinene	970	974 [a]	0.1
Myrcene	989	988 [a]	0.3
n-Octanal	1000	998 [a]	0.5
p-Cymene	1020	1020 [a]	0.5
1,8-Cineole	1026	1026 [a]	**7.2**
(*E*)-β-Ocimene	1047	1044 [a]	0.2
γ-Terpinene	1056	1054 [a]	0.2
n-Octanol	1070	1063 [a]	0.3
p-Cresol	1071	1072 [a]	0.3
Terpinolene	1085	1086 [a]	0.1
Linalool	1098	1095 [a]	0.1
***n*-Nonanal**	1102	1100 [a]	**4.2**
Ipsdienol	1145	1140 [a]	**4.1**
Terpinen-4-ol	1174	1174 [a]	0.1
Naphthalene	1175	1178 [a]	0.3
Piperitone	1250	1249 [a]	0.1
Safrole	1285	1285 [a]	0.6
α-Copaene	1375	1374 [a]	0.3
β-Elemene	1391	1389 [a]	0.3
Sesquithujene	1405	1405 [a]	0.1
cis-α-Bergamotene	1414	1416 [a]	0.3
(*E*)-Caryophyllene	1418	1417 [a]	0.3
trans-α-Bergamotene	1435	1432 [a]	1.7
(Z)-β-Farnesene	1443	1440 [a]	0.3
(*E*)-β-Farnesene	1445	1452 [a]	0.1
α-Humulene	1452	1452 [a]	0.1
Sesquisabinene	1457	1457 [a]	**4.6**
γ-Curcumene	1479	1481 [a]	0.4
(*E*)-β-Ionone	1485	1487 [a]	**4.5**
α-Zingiberene	1495	1493 [a]	0.6
β-Bisabolene	1512	1508 [a]	**32.1**
(Z)-γ-Bisabolene	1516	1514 [a]	0.1
β-Sesquiphellandrene	1524	1521 [a]	**4.0**
(*E*)-Nerolidol	1554	1561 [a]	0.5
***cis*-β-Elemenone**	1586	1589 [a]	**27.6**
Khusimone	1594	1603 [b]	0.1
1,10-di-*epi*-Cubenol	1613	1618 [a]	0.5
α-Acorenol	1630	1632 [a]	0.3
β-Bisabolol	1670	1674 [a]	0.1
α-Bisabolol	1685	1688 [b]	0.1
(Z)-α-*trans*-Bergamotol	1688	1690 [a]	0.3
Monoterpene hydrocarbons			1.5
Oxygenated monoterpenes			11.9
Sesquiterpene hydrocarbons			45.3
Oxygenated sesquiterpenes			34.0
Benzenoids/Phenylpropanoids			0.6
Fatty acid derivatives			6.3
Total (%)			**99.6**

RI_{Cal} = Calculated Retention Index; RI_{Lit} = Literature Retention Index; [a] Adams, 2007 [16]; [b] Mondello, 2011 [17]; Bold = main constituents. Unidentified minor constituents were 0.4%.



Figure 3. *Gongora jauariensis* (Source Luiz Otavio Adão).

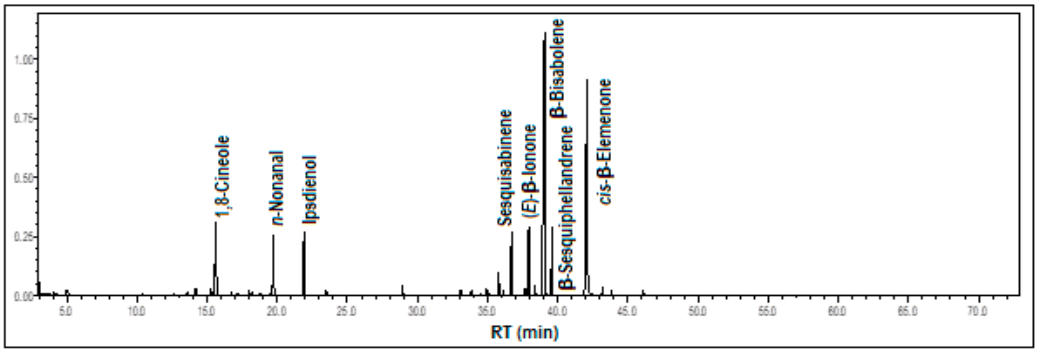


Figure 4. Ion-chromatogram of the *Gongora jauariensis* volatile concentrate.

3.1.3. *Gongora longiracemosa* G.Gerlach & J.B.F.Silva

Botanical description: Epiphyte. Pseudobulbs aggregated, ovoid, longitudinally grooved, 8.0 cm long by 4.0 cm in diameter, bifoliate. Leaves, elliptic-lanceolate, apex acuminate, base attenuated, petiolate; blade with five to seven ribs, 35.0 cm long by 9.0 cm wide. Pendant inflorescence, lax, multiflora, 207.0 cm long, the largest for the genus. Triangular floral bracts, 6.0 cm long. Peduncle and pedicel reddish brown. Flowers (Figure 5) about 60, reddish-brown; sepals (once opened) rapidly curled at lateral margins, dorsal sepals narrowly lanceolate, 2.2 cm long by 0.6 cm wide; oval, triangular lateral sepals, asymmetrical, 2.5 cm long by 0.2 cm wide, welded mainly to the column, curved sigmoid, apex edges; lip with a short isthmus, 2.7 cm long by 0.6 cm wide (less the horns), hypochilium in lateral view with a step at the height of the horns, thin obtuse horns, pronounced and extended horizontally, slightly curved; mesochilium with long bristles, apices curved on ventral side; epichilium very thin and long, with the tip slightly curved upwards. Claviform column, curved, semi-cylindrical in cross-section, 1.7 cm long; stigma slit-shaped, transversely oblong; galled anther; pollinarium 0.35 cm long; stipe relatively short for the genus [24]. The botanical identification of the species was performed at the Emílio Goeldi Museum in Belém, Brazil, by comparing it with an authentic sample of *Gongora longiracemosa* (MG238805) previously registered in the Herbarium João Murça Pires. It is flowering in July.



Figure 5. *Gongora longiracemosa* (Source Luiz Otavio Adão).

Geographic distribution: It is a new species, recently discovered and sampled in the municipalities of Novo Progresso (specimen Glong-1) and Gurupá (specimen Glong-2) in the state of Pará, Brazil [24]. Table 3 lists the constituents identified in their two volatile concentrates, and Figure 6 shows the main compounds.

Table 3. Constituents identified in the volatile concentrate of *G. longiracemosa* orchids.

Constituents (%)	RI_{Cal}	RI_{Lit}	Glon-1	Glon-2
n-Octane	796	800 [a]	2.1	0.9
α-Pinene	928	932 [a]	0.9	-
6-methyl-5-Hepten-2-one	984	981 [a]	-	0.7
2-pentyl-Furan	989	984 [a]	0.3	
n-Octanal	1000	998 [a]	0.5	0.2
1,8-Cineole	1026	1026 [a]	**8.5**	-
Benzene acetaldehyde	1039	1036 [a]	-	0.1
(*E*)-β-Ocimene	1048	1044 [a]	-	**11.4**
n-Octanol	1070	1063 [a]	0.5	0.1
p-Cresol	1074	1071 [a]	2.2	2.0
Camphenilone	1078	1078 [a]	-	0.3
Linalool	1098	1095 [a]	-	1.2
***n*-Nonanal**	1103	1100 [a]	**7.1**	**5.7**
Phenyl ethyl alcohol	1109	1106 [a]	-	**5.7**
α-Terpineol	1187	1186 [a]	0.3	-
p-vinyl-Guaiacol	1311	1309 [a]	-	**7.0**
Eugenol	1355	11,356 [a]	0.4	-
Methyl eugenol	1403	1403 [a]	-	0.1
(*E*)-α-Bergamotene	1428	1432 [a]	1.0	-
(γ)-Elemene	1433	1434 [a]	3.4	-
Geranyl acetone	1452	1453 [a]	-	0.8
α-Cuprenene	1504	1505 [a]	2.2	-
Anisyl acetone	1507	1501 [b]	-	0.3

Table 3. *Cont.*

Constituents (%)	RI_{Cal}	RI_{Lit}	Glon-1	Glon-2
(*Z*)-α-Bisabolene	1509	1506 [a]	2.7	-
δ-Cadinene	1523	1522 [a]	0.9	-
Occidentalol	1545	1548 [b]	0.2	-
β-Vetivenene	1547	1554 [a]	1.0	-
Elemicin	1556	1555 [a]	0.3	-
(*E*)-Nerolidol	1563	1561 [a]	0.1	**4.1**
Spathulenol	1577	1577 [a]	3.0	-
Neryl isovalerate	1580	1582 [a]	-	0.2
Caryophyllene oxide	1583	1582 [a]	1.7	-
Thujopsan-2-α-ol	1586	1586 [a]	1.3	-
Viridiflorol	1591	1592 [a]	1.3	-
Methoxy eugenol	1603	1600 [b]	**27.1**	-
β-Atlantol	1606	1608 [b]	**7.1**	-
Eremoligenol	1626	1627 [b]	3.1	-
Muurola-4,10(14)-dien-1-β-ol	1629	1630 [a]	**7.2**	-
γ-Eudesmol	1632	1632 [b]	0.5	-
Cubenol	1642	1645 [a]	2.7	-
α-Muurolol (=Torreyol)	1646	1651 [b]	1.3	-
Himachalol	1650	1652 [a]	0.5	-
Cadin-4-en-10-ol	1655	1659 [b]	**4.5**	-
Occidentalol acetate	1676	1679 [b]	0.6	-
Eudesm-7(11)-en-4-ol	1695	1700 [a]	1.2	-
γ-Curcumen-12-ol	1718	1727 [b]	1.7	-
(2*Z*,6*E*)-Farnesol	1720	1722 [a]	-	0.3
Benzyl benzoate	1758	1759 [a]	-	2.1
Phenethyl benzoate	1848	1856 [b]	-	2.8
(3*Z*)-Cambrene A	1969	1967 [b]	-	1.0
(*E*,*E*)-Geranyl linalool	2034	2026 [a]	-	**52.1**
Monoterpene hydrocarbons			0.9	11.4
Oxygenated monoterpenes			11.0	4.8
Sesquiterpene hydrocarbons			11.2	-
Oxygenated sesquiterpenes			38.0	4.4
Diterpene hydrocarbons			-	1.0
Oxygenated diterpenes			-	52.1
Benzenoids/Phenylpropanoids			27.8	17.8
Fatty acid and derivatives			10.5	7.6
Total (%)			**99.4**	**99.1**

RI_{Cal} = Calculated Retention Index; RI_{Lit} = Literature Retention Index; [a] Adams, 2007 [16]; [b] Mondello, 2011 [17]; Bold = main constituents. Unidentified minor constituents were 0.6% for Glong-1 and 0.9% for Glong-2.

The specimen Glong-1 was rich in oxygenated sesquiterpenes (38.0%), phenylpropanoids (27.8%), sesquiterpene hydrocarbons (11.2%), oxygenated monoterpenes (11.0%), and fatty acid and derivatives (10.5%), while in the specimen Glong-2 were oxygenated diterpenes (52.1%), benzenoids (17.8%), and fatty acid derivatives (7.6%). The significant constituents of the floral scent of specimen Glon-1 were methoxy eugenol (27.1%), 1,8-cineole (8.5%), muurola-4,10(14)-dien-1-β-ol (7.2%), *n*-nonanal (7.1%), β-atlantol (7.1%), and cadin-4-en-10-ol (4.5%). Likewise, in the specimen Glon-2 were (*E*,*E*)-geranyl linalool (52.1%), (*E*)-β-ocimene (11.4%), *p*-vinyl guaiacol (7.0%), phenyl ethyl alcohol (5.7%), *n*-nonanal (5.7%), and (*E*)-nerolidol (4.1%). Therefore, at least two chemotypes for *G. longiracemosa* can be described (see Figure 6). In the literature, we did not find a previous study on the floral scent of *G. longiracemosa*.

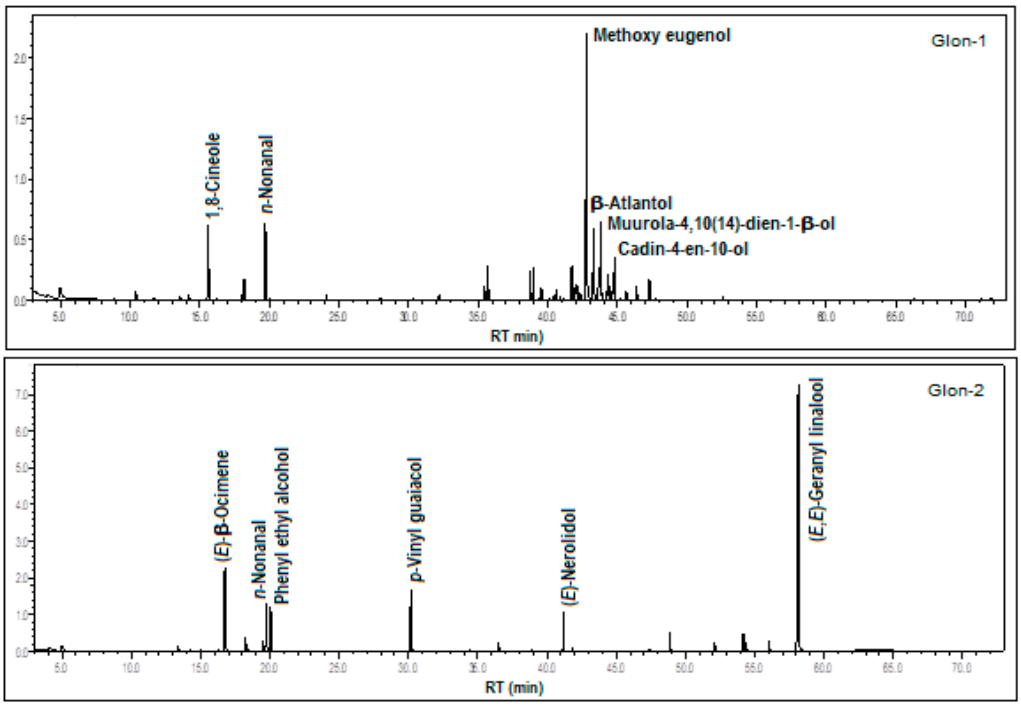


Figure 6. Ion-chromatograms of volatile concentrates of the two *Gongora longiracemosa* specimens.

3.1.4. *Gongora minax* Rchb.f.

Botanical description: Epiphyte. Pseudobulb ovoid, with longitudinal grooves lined by paleous sheaths, apical 2-foliate. Leaves oblong-lanceolate, apex acute, attenuated base in an elongated pseudo-petiole. Pendant inflorescence, pauciflorous, four flowers (Figure 7), elliptical-lanceolate dorsal sepal, asymmetrical triangular lateral sepals, 1/3 of the petals welded to the column, and with the free part linear-lanceolate. A curved lip at the hypochilium base, absence of horns, and an acute indented end; epichilium of the same length as the hypochilium, long, acuminate. A thin column, curved, half-welded [19]. The botanical identification of the species was performed at the Emílio Goeldi Museum in Belém, Brazil, by comparing it with an authentic sample of *Gongora minax* (MG150586) previously registered in the Herbarium João Murça Pires. It flowers in May, September, and October.

Geographic distribution: It is not endemic in Brazil, but instead found in the savanna areas of Amazonas and Pará states [19].

The *G. minax* specimen was collected initially in the municipality of Santarém, Pará state, Brazil. Table 4 lists the constituents identified in its volatile concentrate, and Figure 8 shows the main compounds.

The volatile concentrate of *G. minax* was rich in oxygenated monoterpenes (76.0%) and monoterpene hydrocarbons (23.0%), where terpinen-4-ol (67.2%), γ-terpinene (6.3%), α-terpinene (4.3%), and myrcene (4.0%) predominated as their primary constituents (see Figure 8). In a previous analysis of the volatile concentrate of other *G. minax* specimens, sampled in Pará state, Brazil, the mainly identified constituents were hydrocarbons and fatty acids derivatives, such as 1-docosanol (20.4%), 1-hexadecanol acetate (14.7%), tetracosane (12.0%), (*Z*,*Z*)-9,12-octadecadienoic acid (7.0%), and docosane (5.9%) [23]. Based on these data, at least two phenotypical variations have contributed to the floral aroma of *Gongora minax*, with a different environmental factor as the primary characteristic.

Table 4. Constituents identified in the volatile concentrate of *G. minax* orchids.

Constituents (%)	RI_{Cal}	RI_{Lit}	%
α-Thujene	922	924 [a]	1.0
α-Pinene	928	932 [a]	1.2
Sabinene	968	969 [a]	1.5
Myrcene	989	988 [a]	**4.0**
α-Phellandrene	1000	1002 [a]	0.1
α-Terpinene	1013	1014 [a]	**4.3**
p-Cymene	1020	1020 [a]	0.1
Limonene	1025	1024 [a]	1.6
1,8-Cineole	1026	1026 [a]	1.0
(*Z*)-β-Ocimene	1037	1032	0.4
(*E*)-β-Ocimene	1047	1044 [a]	0.1
γ-Terpinene	1056	1054 [a]	**6.3**
cis-Sabinene hydrate	1063	1065 [a]	2.1
p-Cresol	1079	1071 [a]	0.1
Terpinolene	1085	1086 [a]	2.2
trans-Sabinene hydrate	1094	1098 [a]	1.9
Linalool	1098	1095 [a]	0.7
n-Nonanal	1102	1100 [a]	0.2
cis-*p*-Menth-2-en-1-ol	1118	1118 [a]	1.1
allo-Ocimene	1128	1128 [a]	0.2
trans-p-Menth-2-en-1-ol	1137	1136 [a]	0.3
Terpinen-4-ol	1181	1174 [a]	**67.2**
α-Terpineol	1189	1186 [a]	1.1
cis-Piperitol	1193	1195 [a]	0.2
trans-Piperitol	1205	1207 [a]	0.2
Geraniol	1254	1249 [a]	0.1
(*E*,*E*)-α-Farnesene	1508	1505 [a]	0.4
Monoterpene hydrocarbons			23.0
Oxygenated monoterpenes			76.0
Sesquiterpene hydrocarbons			0.4
Fatty acid and derivatives			0.2
Total (%)			**99.6**

RI_{Cal} = Calculated Retention Index; RI_{Lit} = Literature Retention Index; [a] Adams, 2007 [18]; Bold = main constituents. Unidentified minor constituents were 0.4%.



Figure 7. *Gongora minax* (Source Luiz Otavio Adão).

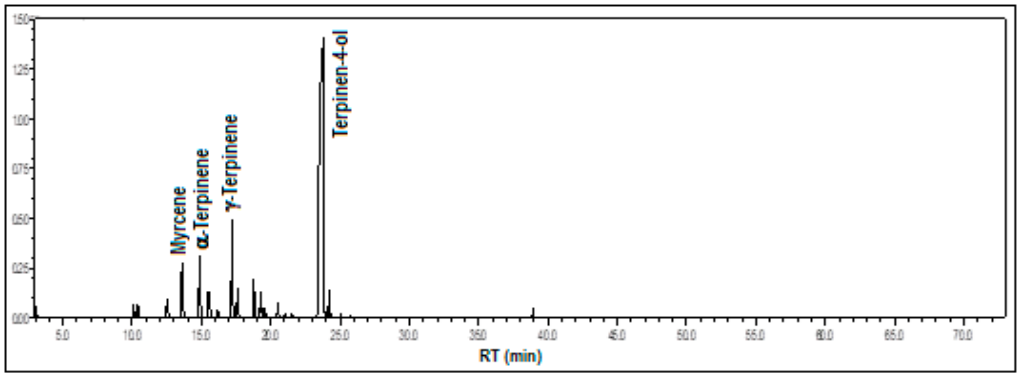


Figure 8. Ion-chromatogram of the *Gongora minax* volatile concentrate.

3.1.5. *Gongora pleiochroma* Rchb.f.

Botanical description: Epiphytic, cespitose, about 25.0 to 32.0 cm long. Short rhizome, less than 1.0 cm between pseudobulbs. Stems thickened into pseudobulbs, aggregated, ovoid, furrowed, with one internode and two leaves. Elliptical, semi-coriaceous leaves with five well-defined veins, apex acute to acuminate, articulated. Inflorescence in a lateral raceme, pendant, with about two to four flowers, varying between 60.0 and 70.0 cm in length. Flowers (Figure 9) leathery, light yellow with reddish-brown spots; dorsal sepal concretized with the dorsum of the column, linear, apex acute, laterals articulated with the dorsum of the column, sub falcate to falcate and apex acute; petals adnate at the base of the gynostemium, linear; Labellum continuous with the column, provided with lateral acicular appendages, 5.0 to 6.0 mm long, less thickened at the base than at the middle and above it, and the anther on the terminal face of the column [25]. The botanical identification of the species was performed at the Emílio Goeldi Museum in Belém, Brazil, by comparing it with an authentic sample of *Gongora pleiochroma* (MG238804) previously registered in the Herbarium João Murça Pires. It flowers from September to December.

Synonimy: *Gongora gracilis* Jenny [26].

Geographic distribution: Colombia, Ecuador, French Guiana, Peru, Suriname, Venezuela, and Brazil [27]. In Brazil, it is found only in the state of Pará, in blackwater forests, flood plains, and dry land.

The study analyzed two floral scents of *G. pleiochroma*. A specimen (Gplei-1) was initially sampled in the municipality of Concórdia do Pará, and another specimen (Gplei-2) in the city of Santa Bárbara do Pará, Pará state, Brazil. The constituents identified in their two volatile concentrates are listed in Table 5, and Figure 10 shows the main compounds.

The specimen Gplei-1 was rich in sesquiterpene hydrocarbons (75.7%), oxygenated sesquiterpenes (14.9%), and oxygenated monoterpenes (7.6%), while in the specimen Gplei-2, the main compound classes were oxygenated sesquiterpenes (62.2%), benzenoids (15.9%), and sesquiterpene hydrocarbons 15.7%). The significant constituents of specimen Gplei-1 were (*Z*)-α-bisabolene (75.6%), β-bisabolenol (14.6%), and 1,8-cineole (5.9%), and in the specimen 2 (Gplei-2) were *cis*-β-elemenone (55.2%), benzyl benzoate (15.6%), β-bisabolene (12.4%), and (*E*)-β-ionone (6.5%) (see Figure 10). In a previous analysis of the volatile concentrate of a specimen of *G. pleiochroma*, also sampled in Pará state, Brazil, the primary identified constituents were benzyl benzoate (60.6%) and eugenol (18.4%) [23]. In addition, the floral scents of specimens of *G. pleiochroma* found in Colombia and Costa Rica were reported to contain (*Z*)-β-ocimene, linalool, and β-sesquiphellandrene as their primary volatile constituents [12].

Table 5. Constituents identified in the volatile concentrates of *G. pleiochroma* orchids.

Constituents	RI_{Cal}	RI_{Lit}	Gple-1	Gple-2
n-Hexanal	796	801 [a]	-	0.4
α-Pinene	928	932 [a]	0.6	-
Myrcene	989	988 [a]	0.1	-
n-Octanal	1000	998 [a]	-	0.3
p-methyl-Anisole	1016	1015 [a]	-	0.2
1,8-Cineole	1027	1026 [a]	**5.9**	-
(*E*)-β-Ocimene	1047	1044 [a]	-	0.9
n-Octanol	1070	1063 [a]	-	0.2
p-Cresol	1074	1071 [b]	-	0.8
Linalool	1098	1095 [a]	1.0	0.1
n-Nonanal	1102	1100 [a]	0.5	2.5
Terpinen-4-ol	1174	1174 [a]	0.1	-
α-Terpineol	1187	1186 [a]	0.3	-
Linalool butanoate	1424	1421 [a]	0.3	-
trans-α-Bergamotene	1433	1432 [a]	-	0.1
Neryl acetone	1436	1434 [a]	-	0.1
dihydro-β-Ionone	1438	1434 [a]	-	0.1
(*E*)-β-Farnesene	1457	1454 [a]	0.1	0.9
γ-Curcumene	1479	1481 [a]	-	0.2
(*E*)-β-Ionone	1485	1487 [a]	-	**6.5**
α-Zingiberene	1495	1493 [a]	-	0.1
β-Bisabolene	1509	1505 [a]	-	**12.4**
(*Z*)-α-Bisabolene	1512	1506 [a]	**75.6**	1.3
β-Sesquiphellandrene	1524	1521 [a]	-	0.8
(*E*)-Nerolidol	1564	1561 [a]	0.1	-
***cis*-β-Elemenone**	1587	1589 [a]	-	**55.2**
Fokienol	1594	1596 [a]	-	0.3
Elemol acetate	1682	1680 [a]	-	0.1
(2*Z*,6*Z*)-Farnesol	1700	1698 [a]	0.2	-
Benzyl benzoate	1759	1759 [a]	-	**15.6**
β-Bisabolenol	1792	1790 [a]	**14.6**	-
Phenyl ethyl octanoate	1848	1846 [a]	0.1	0.3
Tricosane	2300	2300 [a]	-	0.1
Monoterpene hydrocarbons			0.7	0.9
Oxygenated monoterpenes			7.6	1.2
Sesquiterpene hydrocarbons			75.7	15.8
Oxygenated sesquiterpenes			14.9	62.2
Benzenoids/Phenylpropanoids			0.1	15.9
Fatty acid and derivatives			0.5	3.5
Total			**99.5**	**99.5**

RI_{Cal} = Calculated Retention Index; RI_{Lit} = Literature Retention Index; [a] Adams, 2007 [16]; [b] Mondello, 2011 [17]; Bold = main constituents. Unidentified minor constituents were 0.5%.

3.2. Floral Scent Chemistry of Gongora

The *Gongora*-specific floral fragrances enhance pollinator specificity, and this increase reduces the possibility of inappropriate interspecific pollination. High specificity is required in orchids to attract the first visitor, which attaches the pollen mass. The fragrances of euglossophilous orchids are characterized by a small group of constituents (mainly monoterpenes and aromatics) in large quantities, with flowers highly fragrant and detectable from a long distance, as well as significant production over a short time due to the energetic costs of fragrance secretion [12].



Figure 9. *Gongora pleiochroma* (Source Luiz Otavio Adão).

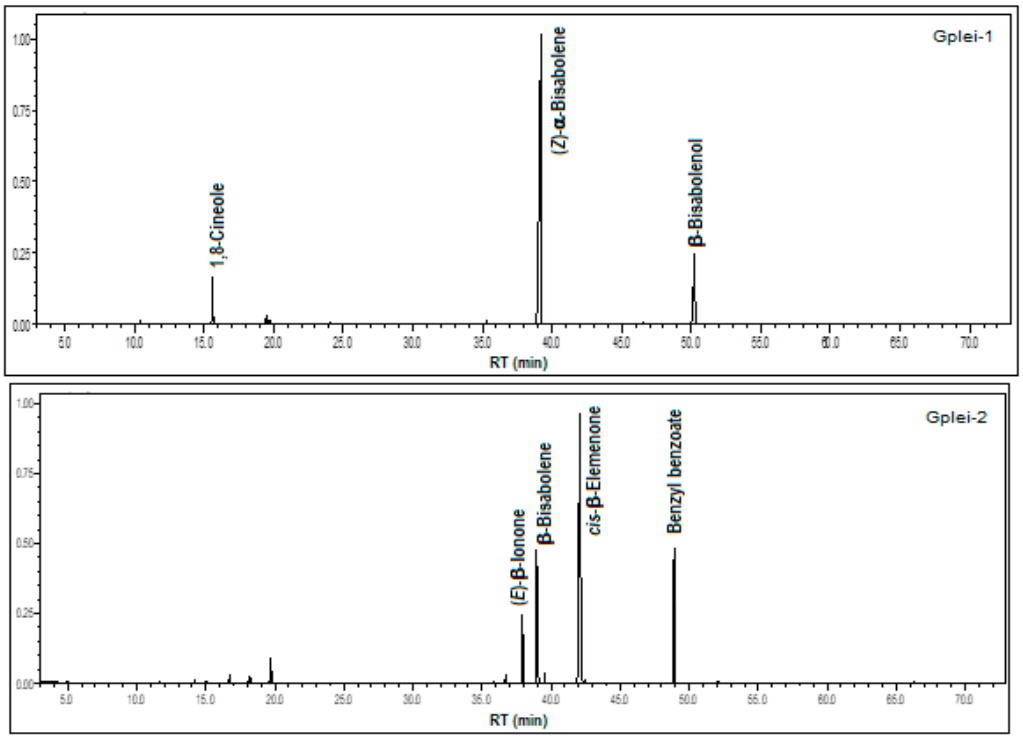


Figure 10. Ion-chromatograms of the volatile concentrates of the two *Gongora pleiochroma* specimens.

In the *Gongora* floral scents analyzed in this work, the main constituents (>4%) in descending order were (*Z*)-α-bisabolene (75.6%), terpinen-4-ol (67.2%), *cis*-β-elemenone (55.2%), (*E*,*E*)-geranyl linalool (52.1%), β-bisabolene (32.1%), 1,8-cineole (27.5%), methoxy eugenol (27.1%), benzyl benzoate (15.6%), β-bisabolenol (14.6%), (*E*)-β-ocimene (11.4%), muurola-4,10(14)-dien-1-β-ol (7.2%), β-atlantol (7.1%), *n*-nonanal (7.1%), *p*-vinyl guaiacol (7.0%), (*E*)-β-ionone (6.5%), γ-terpinene (6.3%), phenyl ethyl alcohol (5.7%), *n*-nonanal (5.7%), sesquisabinene (4.6%), cadin-4-en-10-ol (4.5%), α-terpinene (4.3%), ipsdienol (4.1%), (*E*)-nerolidol (4.1%), myrcene (4.0%), and β-sesquiphellandrene (4.0%) (see Table 6).

Table 6. Volatile constituents (>4.0%) of *Gongora* species/specimens used for the multivariate chemometric analysis (PCA and HCA).

Constituents (%)	Ghis	Gjau	Glon-1	Glon-2	Gmin	Gple-1	Gple-2
1,8-Cineole	27.5	7.2	8.5	-	-	5.9	-
(*E*)-β-Ocimene	-	-	-	11.4	-	-	-
Myrcene	-	-	-	-	4.0	-	-
α-Terpinene	-	-	-	-	4.3	-	-
γ-Terpinene	-	-	-	-	6.3	-	-
Linalool	9.8	-	-	-	-	-	-
n-Nonanal	-	4.2	7.1	5.7	-	-	-
Ipsidienol	-	4.1	-	-	-	-	-
Phenyl ethyl alcohol	-	-	-	5.7	-	-	-
Terpinen-4-ol	-	-	-	-	67.2	-	-
p-Vinyl guaiacol	-	-	-	7.0	-	-	-
Sesquisabinene	-	4.6	-	-	-	-	-
(*E*)-β-Ionone	-	4.5	-	-	-	-	6.5
(*E*,*E*)-α-Farnesene	29.3	-	-	-	-	-	-
β-Bisabolene	-	32.1	-	-	-	-	12.4
β-Sesquiphellandrene	-	4.0	-	-	-	-	-
(*E*)-Nerolidol	-	-	-	4.1	-	-	-
(*Z*)-α-Bisabolene	-	-	-	-	-	75.6	-
cis-β-Elemenone	-	27.6	-	-	-	-	55.2
Methoxy eugenol	-	-	27.1	-	-	-	-
β-Atlantol	-	-	7.1	-	-	-	-
Muurola-4,10(14)-dien-1-β-ol	-	-	7.2	-	-	-	-
Cadin-4-en-10-ol	-	-	4.5	-	-	-	-
Benzyl benzoate	-	-	-	-	-	-	15.6
β-Bisabolenol	11.3	-	-	-	-	14.6	-
(*E*,*E*)-Geranyl linalool	-	-	-	52.1	-	-	-
Monoterpene hydrocarbons (MH)	-	-	-	11.4	14.6	-	-
Oxygenated monoterpenes (OM)	37.3	11.3	8.5	-	67.2	5.9	-
Sesquiterpene hydrocarbons (SH)	29.3	40.7	-	-	-	75.6	12.4
Oxygenated sesquiterpenes (OS)	11.3	32.1	18.8	4.1	-	14.6	61.7
Benzenoids/phenylpropanoids (BP)	-	-	27.1	12.7	-	-	15.6
Fatty acid and derivatives (FA)	-	4.2	7.1	5.7	-	-	-
Oxygenated diterpenes (OD)	-	-	-	52.1	-	-	-
Total (%)	77.9	88.3	61.5	86.0	81.8	96.1	89.7

Some *Gongora* species exhibit non-homogeneous fragrance patterns, with monoterpenes nearly absent, few sesquiterpenes, and, more rarely, cinnamic esters, such as in *G. aff. quinquenervis* Ruiz & Pav. from Cayenne, with anethole, estragole, and α-farnesene; in *G. aff. quinquenervis* from Ecuador, with β-bisabolene, methyl cinnamate, and cinnamyl acetate; in *G. aceras* Dressler from Colombia, with (*E*)-caryophyllene; and in *G. pseudoatropurpurea* Jenny from Colombia, with dihydro-β-ionone and eugenol. However, the volatile composition of populations of *G. aceras* in East Ecuador and West Colombia was quite different, with the predominance of (*E*)-caryophyllene in the first and 1,8-cineole in the second, despite their morphologically indistinguishable flowers. According to the biological species concept, they are treated as two species because different bee species pollinate them [28].

The floral scents of *Gongora armeniaca* (Lindl.) Rchb.f. and *G. cassidea* Rchb.f., found in Mexico, Belize, Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica, were previously reported. The primary volatile constituents of *G. armeniaca* were (*E*)-β-ocimene, germacrene D, germacra-1(10),5-dien-4-ol, and (*E*)-caryophyllene, and in *G. cassidea*, predominate (*E*)-β-ocimene, linalool, (*E*)-α-farnesene epoxide, and (*E*,*E*)-α-farnesene [12,29]. The fragrance of the flowers of *G. galeata* (Lindl. ex-Bosse) Rchb.f., with occurrence in Soconusco, Mexico, showed (*E*)-β-ocimene and linalool as the most abundant constituents [30]. Floral scents of specimens of *G. bufonia* Lindl., occurring in the Atlantic Forest, Serra do Mar, Southeastern Brazil, have also been reported to contain (*E*)-β-ocimene as the main volatile constituent, followed by its oxygenated derivative (*E*)-epoxy-ocimene [31].

A variation from brown to yellow in the flower colors of *G. nigrita* Lindl. was observed in two specimens sampled in Mato Grosso, Brazil, whose main constituents were eugenol (59.0%), 1,8-cineole (23.0%), and (*E*,*E*)-α-farnesene (6.8%) in the first, while eugenol (97.0%) predominated in the second [32]. The *Gongora* spp. emit many diverse and complex volatile

organic compounds, and among them, (*E*)-β-ocimene, linalool, and β-pinene are linked with the attraction of generalist pollinators, including bees, flies, and butterflies [33].

3.3. Gongora Specimens' Multivariate Analysis

The floral variability of the *Gongora* volatile concentrates presented in this work was evaluated using multivariate statistical analyses (PCA, principal component analysis; HCA, hierarchical cluster analysis) based on their main chemical constituents (>4.0%) and respective compound classes, analyzed by GC-MS. The data used as variables are in Table 6.

Based on the identified compound classes, Hierarchical Cluster Analysis (HCA) (Figure 11) revealed the formation of seven groups, with a similarity of 48.52% between the analyzed specimens of *Gongora*. Group I represents the specimen of *Gongora histrionica* (Ghis); Group II the *Gongora jauariensis* (Gjau); Groups III and IV the *Gongora longiracemosa* (Glon-1 and Glon-2); Group V the *Gongora minax* (Gmin); and Groups VI and VII the *Gongora pleiochroma* (Gple-1 and Gple-2).

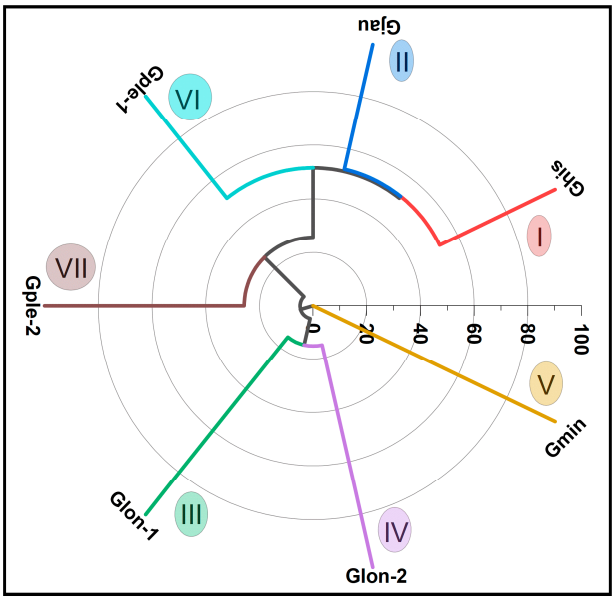


Figure 11. Hierarchical Cluster Analysis (HCA) of the *Gongora* volatile concentrates based on their classes of compounds.

Data variability (87.0%) was also explained by Principal Component Analysis (PCA) (see Figure 12). The PC1 component contributed 36.7% of the data. It showed positive correlations with sesquiterpene hydrocarbons (SH, λ = 1.634) and oxygenated sesquiterpenes (OS, λ = 2.706). In contrast, negative correlations were found with monoterpene hydrocarbons (MH, λ = −1.223), oxygenated monoterpenes (OM, λ = −0.700), benzenoids/phenylpropanoids (BP, λ = −0.244), fatty acid derivatives (FA, λ = −1.791), and oxygenated diterpenes (OD, λ = −0.380). The PC2 component explains 35.0% of the data and has a positive correlation with monoterpene hydrocarbons (MH, λ = 0.628), oxygenated sesquiterpenes (OS, λ = 2.706), and benzenoids/phenylpropanoids (BP, λ = 0.244). It also has a negative correlation with oxygenated monoterpenes (OM, λ = −0.730), sesquiterpene hydrocarbons (SH, λ = −1.302), fatty acids and derivatives (FA, λ = −1.791), and oxygenated diterpenes (OD, λ = −0.380). The PC3 component revealed 15.3% of the data, exhibiting a positive correlation with oxygenated monoterpenes (OM, λ = 0.460), oxygenated sesquiterpenes (OS, λ = 1.227), and fatty acid derivatives (FA, λ = 1.327), and a negative correlation with monoterpene hydrocarbons (MH, λ = −0.067), sesquiterpene hydrocarbons (SH, λ = −0.837), benzenoids/phenylpropanoids (BP, λ = −1.023) and oxy-

genated diterpenes (OD, λ = −1.086). The PCA also confirmed the formation of seven groups, as in the HCA.

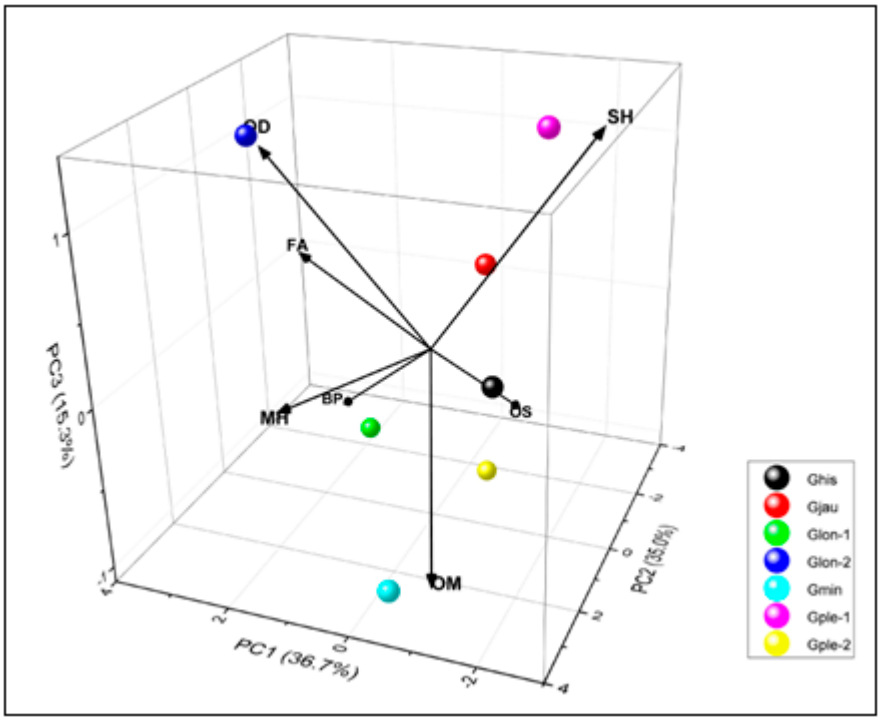


Figure 12. Principal Component Analysis (PCA) of the *Gongora* volatile concentrates based on their classes of compounds.

Group I (Ghis) was characterized by the following classes of compounds: oxygenated monoterpenes (OM: 37.3%), sesquiterpene hydrocarbons (SH: 29.3%), and oxygenated sesquiterpenes (OS: 11.3%). Group II (Gjau) by sesquiterpene hydrocarbons (SH: 40.7%), oxygenated sesquiterpenes (OS: 32.1%), and oxygenated monoterpenes (OM: 11.3%). Group III (Glon-1) by benzenoids/phenylpropanoids (BP: 27.1%), oxygenated sesquiterpenes (OS: 18.8%), and oxygenated monoterpenes (OM: 8.5%). Group IV (Glon-2) by oxygenated diterpenes (OD: 52.1%), benzenoids/phenylpropanoids (BP: 12.7%), and monoterpene hydrocarbons (MH: 11.4%). Group V (Gmin) by oxygenated monoterpenes (OM: 67.2%) and monoterpene hydrocarbons (MH: 14.6%). Group VI (Gple-1) by sesquiterpene hydrocarbons (SH: 75.6%), oxygenated sesquiterpenes (OS: 14.6%), and oxygenated monoterpenes (OM: 5.9%). Group VII (Gple-2) by oxygenated sesquiterpenes (OS: 61.7%), benzenoids/phenylpropanoids (BP: 15.6%), and sesquiterpene hydrocarbons (SH: 12.4%).

Based on their volatile constituents (>4%), the samples of *Gongora longiracemosa* (Glon-1 and Glon-2) and *Gongora pleiochroma* (Gple-1 and Gple-2) presented different chemical profiles. The profiles of volatile concentrates of *G. longiracemosa* were characterized by the specimen Glon-1, rich in methoxy eugenol (27.1%), 1,8-cineole (8.5%), and muurola-4,10(14)-dien-1-β-ol (7.2%), and by the Glon-2 specimen with a predominance of (*E*,*E*)-geranyl linalool (52.1%), (*E*)-β-ocimene (11.4%) and *p*-vinyl guaiacol (7.0%). The profiles of *G. pleiochroma* volatile concentrates were characterized by specimen Gple-1, where (*Z*)-α-bisabolene (75.6%), β-bisabolenol (14.6%), and 1,8-cineole (5.9%) were the main constituents, and by the Gple-2 specimen that exhibited as principal compounds cis-β-elemenone (55.2%), benzyl benzoate (15.6%), and β-bisabolene (12.4%).

4. Conclusions

The analyzed *Gongora* species and specimens were distinct in their volatile compounds and chemical classes. The study included the two chemotypes of *G. longiracemosa* and *G. pleiochroma*. The main constituents identified in *Gongora* species/specimens include (*Z*)-α-bisabolene, terpinen-4-ol, cis-β-elemenone, (*E*,*E*)-geranyl linalool, β-bisabolene, (*E*,*E*)-α-farnesene, and 1,8-cineole. Multivariate statistical analysis of these compounds revealed seven distinct groups of *Gongora* volatile concentrates, highlighting significant variability among the species and specimens studied. These findings enhance our understanding of the chemometric and chemotaxonomic characteristics of the *Gongora* genus.

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