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Characterization of the species *Chrysanthemum coronarium* in North-West Algeria

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Abstract

Many aromatic plants, sometimes considered adventitious, have very interesting biological properties whose application extends to various fields such as medicine, pharmacy, cosmetology and agriculture. Our work focuses on the study of a medicinal plant *chrysanthemum coronarium*, it is widespread in Algeria, of the family Asteraceae are known in the world for their therapeutic properties (antiseptic, antineuralgic, analgesic...) and the economic interest of their essential oils. has for objectives the morpho-metric characterization of 05 different regions at the level of the wilaya of Tlemcen (Rachgoun, Chlaida, Sabra, Maghia, Hennaya), using 13 quantitative and qualitative traits were the subject of a statistical study by R software. The estimated H' showed wide phenotypic variability for the different traits with an average H' of 0.55. The results of the Multiple Match Analysis (PCA) and Hierarchical Classification (HFA) showed a clear distinction between accessions.

Keywords: *chrysanthemum coronarium*/ genetic diversity/ morphometric characterization/ physico-chemical characterization / west Algeria.

الملخص

تتمتع العديد من النباتات العطرية التي تعتبر أحياناً نباتات عطرية عرضية بخصائص بيولوجية مثيرة للاهتمام، وتمتد تطبيقاتها إلى مجالات مختلفة مثل الطب والصيدلة والتجميل والزراعة. يركز عملنا على دراسة نبتة الأقحوان الطبية، وهي منتشرة في الجزائر، من فصيلة الأقحوان العطرية المعروفة في العالم بخصائصها العلاجية (مطهر، مضاد للأعصاب، مسكن...) والفائدة الاقتصادية لزيوتها الأساسية. ولتحقيق هذه الأهداف، تم إجراء دراسة إحصائية بواسطة برنامجR ، حيث تم توصيف مورفولوجي متري ل 05 مناطق مختلفة على مستوى ولاية تلمسان (رشقون، شلايدة، صبرة، مغنية، حنايا)، باستخدام 13 سمة كمية ونوعية .أظهر H' التقديري تباينًا ظاهريًا واسعًا للصفات المختلفة بمتوسط .H' 0.55 أظهرت نتائج تحليل التطابق المتعدد (PCA) والتصنيف الهرمي (HFA) تمييزًا واضحًا بين الوصولات.

الكلمات المفتاحية: أقحوان كوروناريوم/ توصيف مورفومتري/ التنوع الوراثي/ غرب الجزائر/ توصيف فيزيائي كيميائي

Introduction

Chrysanthemum coronarium is an annual herbaceous weed widely distributed in the Mediterranean region, Japan, China and the Philippines. sins this species is rarely studied in our country the aim of our work is to identify and morphometrically characterize the species *Chrysanthemum coronarium* in five wilayas and to chemically analyses leaves from different regions. This plant belongs to the Asteraceae family, which are dicotyledonous flowering plants belonging to the Asteraceae order. Annuals or perennials, herbaceous to shrubby, they are present everywhere in human life: plants grown in fields or gardens, industrial, consumed or ornamental, they are also sometimes plants with medicinal effects or crop weeds. In natural environments, from rare to frequent, from miniature to giant, the Asteraceae present an extraordinary diversity and an impressive abundance of species. Curiously, this very large group of plants is both relatively homogeneous and yet isolated from the other families in the phylogenetic tree. They are melliferous and very useful for maintaining insect biodiversity. Their flowers are often visited by generalist insects. A bed of flowering asters in the garden, for example, is a good way of monitoring the health and diversity of the insect population in your region: it should be buzzing all the time and be surrounded by many species of butterfly. Chamomile and Chrysanthemum are also found in many beauty products, from shampoos to make your hair blonde to face creams, masks and lotions. Chamomile could improve skin quality, erasing redness and imperfections. It can even out the complexion, making it more radiant.

Materials and Methods

Presentation of the study areas:

This study was conducted in the West Algerian region.

Western Algeria:

Its total surface area exceeds 63,000 km². It is bordered to the north by the Mediterranean, to the west by Morocco, to the south-west by the Chott Chergui, to the south by the high plains of the Sersou and to the east by the Ouarsenis mountains and the Lower Chélif valley. It is made up of eight wilayas and appears to be representative of the disparities between the coast and the hinterland (Daniel Benazzouz; 2012) (Figure 01).

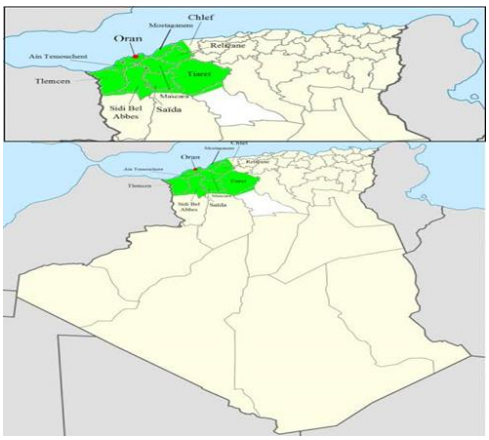

Figure 01. Geographical delimitation of western Algeria.

Field investigations were carried out in nine regions in five wilayas: Tlemcen (Hennaya, Maghnia, Sabra, Chlaida) Ain Temouchent (Ain Tolba, Rechgoun), Mascara, Oran, Sidi Belabbas. During (February-March 2020 and February-April 2022), (figure 02).

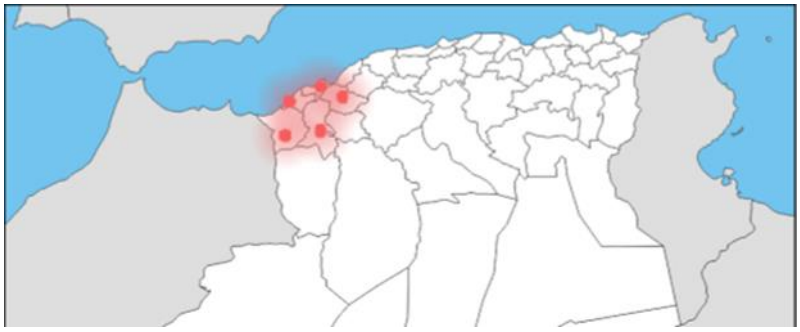

Figure 02. Sampling region.

Tlemcen:

It is located on the north-western coast of the country and borders Morocco. The Wilaya of Tlemcen has a Mediterranean climate**.** (Jean-Claude Piguet; 2010). The average annual temperature is 15.4°C. Average rainfall over the year is 454 mm.

Hennaya:

Located at the north-western tip of Algeria, between 34° and 35° 40'north latitude and 0° 30' and 2° 30' west longitude. It has a semi-arid Mediterranean climate. Average annual rainfall is 351mm. The average annual temperature is 17.7°C. The commune of Hennaya is divided into three types of soil texture (Sandy loam, Sandy loam, Clay) (Institut National de la Météorologie; 2020).

Sabra:

Located in the extreme west of Algeria close to the Algerian Moroccan borders to the west of the wilaya of Tlemcen. It has a warm Mediterranean climate with dry summers. The average annual rainfall is 351 mm and the average annual temperature 19.7°C. (Khaled Ben Amar; 2013). Sabra's soils are of two main types: Mediterranean red soils and leached and podzolic soils (Mohamed Seddik Ben Yahia; 2018).

Maghnia:

The commune of Maghnia covers an area of 294, 00 km2 (29,400 hectares) at a minimum altitude of 310m and a maximum altitude of 680 m. (Mohamed Seddik Ben Yahia; 2018). The best extension area

is located to the west of the plain, on either side of the Maghnia-Oujda road. It is made up of deep, silty soils that are suitable for growing fine irrigated crops. The other soils all have disadvantages that are more or less restrictive for agriculture. (Institut National de Recherche Agronomique 2019)

Chlaida:

Our main study area is Chlaida, but since we can't find strings on Chlaida, we took the territory of the commune of Amieur as a reference. Amieur is located in the north-east of the wilaya of Tlemcen, approximately 18 km north-east of Tlemcen as the crow flies. 35° 2′ 7″ North 1° 14′ 24″ West (Mohamed Seddik Ben Yahia; 2018). Has a warm Mediterranean climate with dry summers. Rainfall averages 351 mm and the average temperature is 17.7°C. (Institut National de la Météorologie; 2020).

Ain-Temouchent:

The wilaya is located on the country's western coastline and has an 80 km seafront. (Administrative division of Algeria & Monographie 2014). It has a warm Mediterranean climate with dry summers. The average temperature is 19.1°C and rainfall averages 316.2 mm (Khaled Ben Amar; 2014). The soil types are brown calcareous soil, input soil (browned colluvial soil). (Jean-Claude Piguet; 2010).

Rechgoun:

This station is located on a latitude of 35°18‘North and a longitude of 01°21’West. Rainfall averages 316.2 mm and the average temperature at Rechgoun is 19.1°C (Planificateur.a-contresens 2022).

Ain Tolba:

Aïn Tolba has a warm Mediterranean climate with dry summers. Over the year, the average temperature is 19.1°C and rainfall averages 316.2 mm (Planificateur.a-contresens 2022).

The geographical coordinates of Aïn Tolba are Latitude: 35.2483, Longitude: -1.24889 35° 14′ 54″ North, 1° 14′ 56″ West (Db-city 2013).

Mascara:

It has a warm Mediterranean climate with dry summers. The average temperature in Mascara is 17.2°C and rainfall averages 393.2 mm (Planificateur.a-contresens 2022). Soils are poor and rainfall varies from 30 to 350 minutes per year. (Wilaya mascara 2022). The dominant soils are solontchaks or white saline soils with the sodium ion in the form of chloride in the solutions, influencing the composition and development of the vegetation. (Insist, 2022)

Oran

The wilaya of Oran is located on Algeria's north-west coast, offering a varied geological setting and a Mediterranean climate. The region is characterized by a variety of geological formations. Oran has a Mediterranean climate, with hot, dry summers and mild, wet winters. Summer temperatures can reach around 30°C, while winter temperatures are moderate, around 10-15°C (Moulin, 2006). Precipitation is mainly concentrated in winter, with an annual average of around 400-600 mm. The driest months are from May to October (Hacini and Boudiaf, 2015).

Sidi Belabbas

The wilaya of Sidi Bel Abbès, located in western Algeria, has a geological and climatic diversity influenced by its geographical position. The wilaya of Sidi Bel Abbès is partly covered by the Tellian Atlas Mountains, a folded mountain range composed mainly of sedimentary rocks such as limestone, sandstone and clay. These formations are the result of the collision between the African and Eurasian tectonic plates (Raimondi, 1994). The Sidi Bel Abbès region includes alluvial plains formed by river deposits. These plains are made up of sediments such as sand, silt and clay brought by the region's rivers (Boudouma and Ouali, 2002). Sidi Bel Abbès enjoys a Mediterranean climate, with hot, dry summers and mild, wet winters. Summer temperatures generally vary around 30°C, while winter temperatures are moderate, between 10°C and 15°C (Moulin, 2006). Precipitation is concentrated mainly in winter, with an annual average of around 400-600 mm. The driest months are from May to October (Hacini and Boudiaf, 2015).

Morphometric study

Plant material

In order to carry out the study on the plant *Chrysanthemum coronarium* several field trips were carried out and this in nine regions, during February - March 2020 and February - April 2021.

Samples were collected at random (20 plants from each region; mature, fresh and labelled). Morphometric measurements were taken on leaves, flowers, stems and roots (Figure 03).

Figure 03. Original photo of the field trip (2020)

Morphometric measurements:
Morphometric characterization was carried out on 11 quantitative and 2 qualitative characteristics of 180 plants from different regions. The parameters were measured using a tape measure, a calipers and a measuring ruler. The parameters studied were:

a) Number of petals: Each plant has a specific number of petals (figure 04).

Figure 04. Petals of a study plant

b) Length of petals, Width of petals, Diameter (figure 05)

Figure 05. D: diameter; Lrg p: width of petals; Lp: length of petals

c) Petal colors (figure 06)

a-yellow and white b-yellow

Figure 06. Chromatographic polymorphism in the study populations

d) Petal shape

There is only one form of petal, the lobed and sessile form.

e) Number of sepals (figure 07)

We counted the number of sepals on 20 different plants.

f) Number of primary shoots
g) Number of branches
h) Number of leaves
i) Number of buds
j) Number of flowers
k) Length of plant **(figure 08)**

Figure 08. Measuring the length of the plant

Physical and chemical analysis

Material: plant:

The plant material consisted of the leaves of the *Chrysanthemum coronarium* plant. This biochemical characterization involved 30 accessions, including 02 varieties.

Preparation of the sample (figure 09)

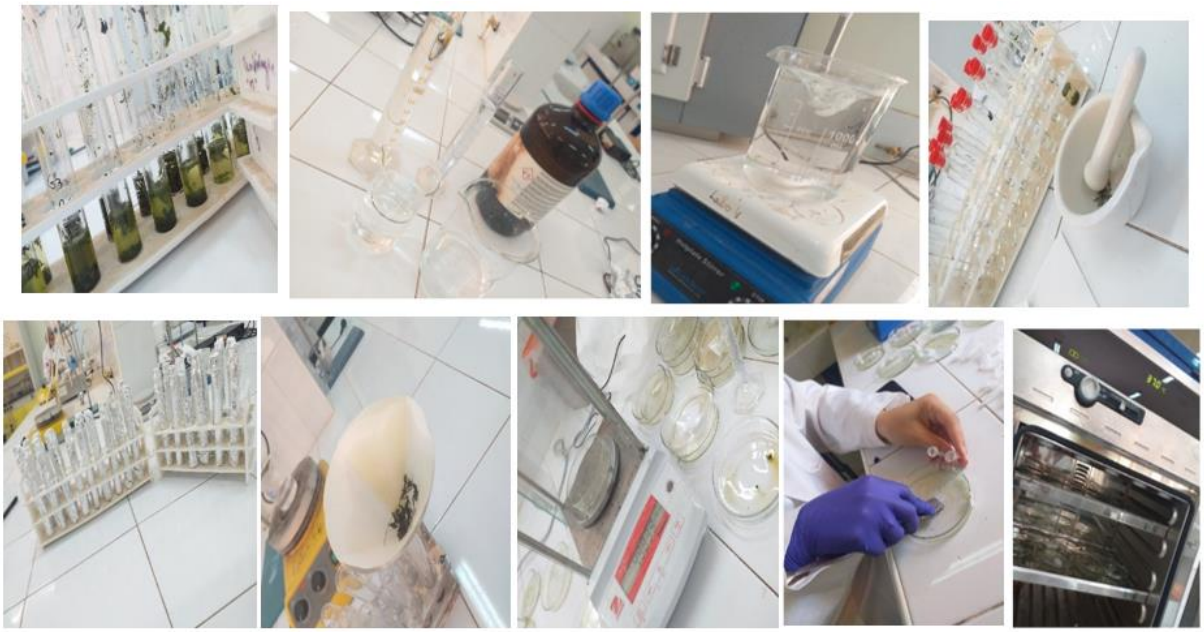

Figure 09. Original photos of sample preparation

In order to carry out the phytochemical screening, fresh leaves were sampled from 30 plants at the beginning of May. They were then washed and dried in a dry, ventilated place away from light, until the leaves were completely dehydrated and their mass stabilized in order to preserve as many molecules as possible. The leaves were then cut into small pieces to prepare the extract.

The preparation of the crude extract was based on the solid-liquid extraction method (Maceration), since it allows the extraction of the product richest in families of secondary metabolites according to A. M. Smith 2018. This method is proposed by Benettayeb, 2019 and A. M. Smith 2018. This method was performed with some modifications as follows:

1g of plant material macerated in 25 ml of distilled water/methanol mixture (30/70: v/v) for 48H at room temperature, protected from light, with a little manual agitation, finalized by filtration of the mixture; using filter paper. The methanol was evaporated in a rotary evaporator under reduced pressure at 40°C.

The crude extract was dehydrated in an oven at 37°C for 2 days. The extract was then weighed to make dilutions according to each protocol.

Phytochemical screening

Phytochemical screening has made it possible to set up calibration or so-called phytochemical tests; these are qualitative tests which do not provide information on the structure of a specific molecule, but which do highlight the presence of substances with great therapeutic value (flavonoids, tannins, etc.). (Springer link 2022). These tests are marked by the formation of a precipitate, a change in color or by direct observation under ultra-violet light, using standard procedures.

Flavonoid test

Flavonoids are phenolic or aromatic compounds responsible for the yellow and orange colorations of many flowers, fruits and sometimes senescent young leaves. (Ouahiba 2013). In a tube, 1 ml of the extract was taken, 1 ml of concentrated hydrochloric acid (HCl) was added, followed by a few small cuts of magnesium (Mg2+). The formation of a pink, red or yellow coloration after five minutes incubation at room temperature indicates the presence of flavonoids in solution.

Alkaloids

Alkaloids are nitrogenous organic compounds virtually all of therapeutic interest (Ouahiba 2013). They were characterized using Mayer and Wagner reagents. In two tubes, 0.5 ml of the extract to be analyzed was introduced, to which 0.25 ml of hydrochloric acid (HCL 1%) was added, followed by stirring of the acid solution, adding the Mayer reagent in the first tube and 1 to 2 drops of the Wagner reagent in the second tube. The appearance of a yellowish-white or brown precipitate, respectively, reveals the presence of alkaloids (Figure 10).

Figure 10. Alkaloids detected in the substance analyzed (Original photo)

Free quinones:

Quinones are organic compounds, some of which are yellow, orange, violet and red pigments found in plants (Ouahiba 2013**).** In a tube, 1 ml of leaf extract was introduced and 0.1 ml of sodium hydroxide NaOH (1%) was added. The appearance of a color that turns yellow, red or purple indicates the presence of free quinones.

Anthraquinones

In a glass tube, 1 ml of the extract to be analyzed was introduced, then 1 ml of NH4OH (10%) was added. Observation is made after a few seconds of shaking. The appearance of a violet coloration indicates the presence of anthraquinones.

Saponins or foam test

To detect saponins, we introduced 10 ml of the extract to be analyzed into a test tube, then shook vigorously for 30 seconds and left the mixture to stand for 15 to 20 minutes. The thickness of the persistent foam was measured using a graduated ruler. A foam height greater than 1 cm indicates the presence of saponins.

Terpenoids or Slakowski test

To 1 ml of the extract to be analyzed, add 1 ml of chloroform and 0.6 ml of concentrated sulphuric acid; the formation of two phases and a brown color at the interphase indicate the presence of terpenoids.

Statistical analysis

Statistical analyses were carried out using SPSS (Statistical Package for Social Sciences), a data processing software package for statistical analyses.

Descriptive analysis

Descriptive data analysis is used to summarize a set of raw data using statistical techniques. The main purpose of this type of analysis is to describe the characteristics of a sample (Rajotte, T. 2019) and to group together homogeneous individuals. We calculated the arithmetic mean (M) and the standard deviation, which measures the dispersion of the data around the mean. The minimum (Min) and maximum (Max) values, which both give an idea of the extent of the data. For qualitative characteristics, we estimated the percentage according to each modality.

Shannon-Weaver diversity index

The index is calculated as follows:

H = - $\Sigma_{i=1}^{N} Pi \ln Pi$ With:

H: Shannon and Weaver diversity index

Pi: Frequency of each phenotypic class i of a given trait

N: Number of phenotypic classes for each trait

The index (H) is converted to the relative phenotypic diversity index (H′) by dividing it by its maximum value H max (LN(n)) in order to obtain values between 0 and 1.

H′= - $\Sigma_{i=1}^{N} Pi \ln Pi$/ Ln (n)

Principal Component Analysis (PCA)

This method of analysis groups correlated variables into a reduced number of principal factors.

Ascending hierarchical classification (AHC)

The ascending hierarchical classification of genotypes is carried out using the aggregation method: Unweighted averages of associated genotypes.

Results and discussion

Morphometric characterization

Descriptive analysis

In order to achieve our objective of characterizing *Chrysanthemum Coronarium*, we began with a description based on 11 quantitative and 2 qualitative characteristics.

Descriptive analysis of qualitative characteristics

Table 1 shows the color of the petals found in the different regions. The description at the level of the regions of Oran, Chlaida, Maghnia shows us that the white yellow color is in the majority; this can be due to the influence of the climate or the soil on the color of the petals of the *Chrysanthemum coronarium* plant.

Table 01. Descriptive analysis for the color of *Chrysanthemum coronarium*

Regions	Frequency	Percentage
Hennaya	YELLOW	20
	WHITE- YELLOW	80
	Total	100
Sidi Bel Abbès	YELLOW	4,8
	WHITE- YELLOW	95,2
	Total	100
Oran	YELLOW	0
	WHITE- YELLOW	100
	Total	100
Aïn Temouchent	YELLOW	5
	WHITE- YELLOW	95
	Total	100
Mascara	YELLOW	30
	WHITE- YELLOW	70
	Total	100
Chlaida	YELLOW	0
	WHITE- YELLOW	100
	Total	100
Maghnia	YELLOW	0
	WHITE- YELLOW	100
	Total	100
Rechgoun	YELLOW	20
	WHITE- YELLOW	80
	Total	100
Sabra	YELLOW	20
	WHITE- YELLOW	80
	Total	100

Chi2 test

In order to see if there is a relationship between the region and the petal colour, we carried out the chi2 test, which is based on two hypotheses: the first is that there is a relationship between the colour and the region, and the second is that there is no relationship between the colour and the region **(table 02).**

Table 02. Chi2 test on petal colour and region of origin.

	Ddl	Asymptotic significance (bilateral)
Pearson chi-square	16	,012

From this result in Table 02 we can see that the result is significant (p = 0.12); this means that there is a relationship between color and region. This relationship can be explained by the influence of climate and/or soil on petal color.

Descriptive analysis of quantitative characteristics (Table 3-11)
Plant length shows high averages ranging from a value of 47cm in the Mascara region to 129cm in the Sidi Bel Abbes region. The average number of flowers in the Chlaida region is low compared with Ain Temouchent, which has a value of 18.6500 flowers.

The length of the petals varies between a minimum of 1cm for the population of the Rechgoun region and a maximum of 5cm for the Sidi Bel Abes region and an average of 1.55cm and 1.724cm respectively.

The diameter of the flowers in all regions ranged between 1cm and 2cm. All length in the table below are in (cm).

Table 03. Descriptive analysis of the Hennaya region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	15,65	1,640	1,410	26,45	127,100	2,15	24,25	22,10	,430	3,50	3,7500
Standard deviation	2,134	,1789	,1410	1,701	12,3795	1,461	8,608	4,587	,1261	1,192	1,51744
Minimum	12	1,3	1,2	24	105,0	0	13	15	,2	2	1,00
Maximum	19	1,9	1,6	29	150,0	6	43	29	,6	6	7,00

Table 04. Descriptive analysis of the Oran region.

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	13,70	1,890	1,430	22,45	107,200	2,60	17,20	19,50	,625	38,30	6,8000
Standard deviation	,923	,2693	,1750	2,164	18,0543	2,891	7,367	3,791	,1713	18,111	5,64381
Minimum	13	1,2	1,1	19	72,0	0	6	10	,3	8	1,00
Maximum	16	2,2	1,8	26	139,0	8	35	25	,9	65	23,00

Table 05. Descriptive analysis

Number of petals	Petal length	Diametre	Number of _Sepal	Longeur de la plante	Rameau Primary	Secondary branch	Number of leaves	Largeur de petale	Number of buds	Number of flowers
12,72	1,724	1,262	22,48	129,667	1,67	31,24	15,00	,614	5,48	3,8000
3,124	,7861	,1117	2,943	8,6679	1,426	7,327	4,123	,1459	1,289	1,57614
0	1,3	1,1	16	120,0	0	20	10	,4	3	1,00
16	5,0	1,5	26	149,0	5	45	25	,9	8	6,00

Table 06. Descriptive analysis of the Ain Temouchent region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal length	Nombre de bourgeon	Number of flowers
Mean	14,20	1,790	1,380	23,90	122,850	1,30	26,65	24,40	,645	17,25	18,6500
Standard deviation	1,473	,3144	,1361	3,093	10,6142	1,490	12,807	5,826	,1146	7,268	10,62903
Minimum	13	1,2	1,2	19	107,0	0	7	14	,5	6	8,00
Maximum	19	2,5	1,6	30	148,0	3	64	39	,8	33	52,00

Table 07. Descriptive analysis of the Mascara region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal widths	Number of buds	Number of flowers
Mean	12,45	1,915	,970	16,70	47,80	0,95	18,25	15,90	,335	6,35	12,0000

Standard deviation	1,468	2,6164	,1658	2,430	8,6912	1,731	9,358	3,553	,1040	4,184	9,12262
Minimum	8	,9	,7	13	32,0	0	3	10	,2	1	2,00
Maximum	16	13,0	1,3	23	71,0	6	47	22	,6	17	42,00

Table 08. Descriptive analysis of the Chlaida region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	12,10	1,255	1,350	12,05	52,330	,00	4,90	19,85	,660	4,70	2,4000
Standard deviation	1,619	,3517	,1792	1,877	16,8272	,000	2,553	8,946	,3267	2,658	1,50088
Minimum	9	,7	1,0	7	32,2	0	0	12	,3	1	1,00
Maximum	16	2,1	1,6	16	90,0	0	9	50	1,9	10	5,00

Table 09. Descriptive analysis of the Maghnia region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	13,95	1,770	1,335	20,70	77,500	,00	5,75	17,65	,520	6,95	4,3500
Standard deviation	1,317	,3326	,2007	3,164	23,8758	,000	3,385	3,731	,1361	5,472	4,01674
Minimum	12	1,1	,9	15	38,0	0	0	11	,2	1	1,00
Maximum	17	2,3	1,6	27	116,0	0	14	24	,7	23	15,00

Table 10. Descriptive analysis of the Rechgoun region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	12,55	1,550	1,285	13,05	54,250	,00	8,60	30,65	,710	3,85	8,5500
Standard deviation	1,731	,2856	,1814	3,410	20,2715	,000	3,648	7,443	,1447	1,565	5,20602
Minimum	9	1,0	1,0	9	25,0	0	4	20	,4	1	1,00
Maximum	16	2,2	1,6	26	100,0	0	16	45	,9	8	22,00

Table 11. Descriptive analysis of the sabra region

	Number of petals	Petal length	Diameter	Number of _Sepal	Length of plant	Rameau Primary	Secondary branch	Number of leaves	Petal width	Number of buds	Number of flowers
Mean	14,10	1,750	1,285	23,75	52,895	2,60	13,55	12,80	,715	11,10	8,5500
Standard deviation	1,861	,3678	,1814	1,446	5,5287	1,698	8,069	2,587	,1599	5,902	5,20602
Minimum	12	1,1	1,0	22	44,5	1	4	8	,2	3	1,00
Maximum	20	2,3	1,6	26	61,5	5	32	17	,9	29	22,00

Number of flowers (NF), number of buds (Nb), primary shoot (RP), number of secondary shoots (NRS), plant length (LONP), number of sepals (NS) Secondary (NRS), plant length (LONP), number of sepals (NS), number of petals (NP), NFL diameter (D) (number of flowers).

The results showed that the Rechgoun region has higher values (number of leaves) than the Sabra region; this may be due to the influence of the climate in the Rechgoun region, which is more humid, whereas the Sabra region has a drier climate. The Ain Temouchent region has a plant length value of 120cm compared with the other regions, which can also be explained by the influence of the more humid coastal climate.

Analysis of variance (ANOVA):

To analyse the variance of these characteristics, we began by testing the normality of the data. We compared the quantitative parameters, i.e. petal length, number of flowers, number of leaves, plant length, number of secondary and primary branches, flower diameter, number of petals and number of buds, with environmental factors, i.e. the regions (table 12).

Table 12. ANOVA test

		Sum of squares	Ddl	Medium square	F	Sig.
Number of petals	Intergroups	193,378	8	24,172	9,819	0,000
	Intragroup	420,950	171	2,462		
	Total	614,328	179			
length of petals	Intergroups	6,759	8	0,845	1,006	0,433
	Intragroup	143,589	171	0,840		
	Total	150,348	179			
The diameter	Intergroups	2,987	8	0,373	13,635	0,000
	Intragroup	4,683	171	0,027		
	Total	7,670	179			
Number of sepals	Intergroups	4144,444	8	518,056	81,651	0,000
	Intragroup	1084,950	171	6,345		
	Total	5229,394	179			
length of plant	Intergroups	204290,914	8	25536,364	112,880	0,000
	Intragroup	38684,742	171	226,227		
	Total	242975,655	179			
Number of primary branches	Intergroups	189,678	8	23,710	10,368	0,000
	Intragroup	391,050	171	2,287		
	Total	580,728	179			
Number of secondary branches	Intergroups	14336,144	8	1792,018	30,482	0,000
	Intragroup	10053,100	171	58,790		
	Total	24389,244	179			
Number of leaves	Intergroups	4722,478	8	590,310	20,761	0,000
	Intragroup	4862,250	171	28,434		
	Total	9584,728	179			
Petal width	Intergroups	2,706	8	0,338	11,593	0,000
	Intragroup	4,990	171	0,029		
	Total	7,696	179			
Number of buds	Intergroups	19989,000	8	2498,625	47,264	0,000
	Intragroup	9040,000	171	52,865		
	Total	29029,000	179			
Number of flowers	Intergroups	4180,911	8	522,614	15,582	0,000
	Intragroup	5735,150	171	33,539		
	Total	9916,061	179			

Table 12 shows a very highly significant result (p value less than 0.001) for all the quantitative variables which means that there is a big divercity present in *chrysanthemum coronarium*, except for the petal length characteristic, where there was no significant difference (p = 0.433).

Pearson correlation

This correlation allows us to study the links between the different quantitative parameters (Table 13).

Table 13. Correlation matrix

	Number of petals	length of petals	diameter	Number of sepals	length of plant	Number of primary branches	Number of secondary branches	Number of leaves	Petal width	Number of buds	Number of flowers
Number of petals	1,000	-,048	,323	,505	,307	,198	,122	,022	-,009	,093	-,034
length of petals	-,048	1,000	,122	,055	,047	,019	,004	-,094	,024	,125	,054
diameter	,323	,122	1,000	,259	,363	,007	-,032	,187	,251	,156	-,160
Number of sepals	,505	,055	,259	1,000	,608	,396	,413	-,186	-,052	,197	,017
length of plant	,307	,047	,363	,608	1,000	,209	,575	,105	-,050	,219	,015
Number of primary branches	,198	,019	,007	,396	,209	1,000	,423	-,168	,113	,447	,234
Number of secondary branches	,122	,004	-,032	,413	,575	,423	1,000	-,022	-,098	,242	,378
Number of leaves	,022	-,094	,187	-,186	,105	-,168	-,022	1,000	,274	-,029	,107
Petal width	-,009	,024	,251	-,052	-,050	,113	-,098	,274	1,000	,136	,022
Number of buds	,093	,125	,156	,197	,219	,447	,242	-,029	,136	1,000	,252
Number of flowers	-,034	,054	-,160	,017	,015	,234	,378	,107	,022	,252	1,000

After processing the statistical data using a Pearson correlation test, it was noted that there were mainly average links between the parameters (LP, NS) (NP, NS) which means there is a correlation between them, but it is not that strong. However, the correlation percentages of the characters (LP, NP) (LP, NF) with the other characters were low (negative) so we can conclude that there is a negative correlation between them.

Individual variation

Principal component analysis (PCA) (Figure 11) was performed on the variables studied. The results of this analysis showed that 56.64% of the total inertia on the two axes was maintained, which is statistically representative.

Number of flowers (NF), number of buds (Nb), primary shoot (RP), number of secondary shoots (NRS), plant length (LONP), number of sepals (NS), number of petals (NP), diameter (D).

The characters were well presented on the 2 axes, with a positive correlation between the number of buds and the primary shoot. This is most likely due to common coding by a number of plant genes, but the number of flowers and the diameter did not correlate with the other characters.

The characters (petal length and petal width, number of leaves and plant width) are not presented graphically in view of their low contributions on the 2 axes.

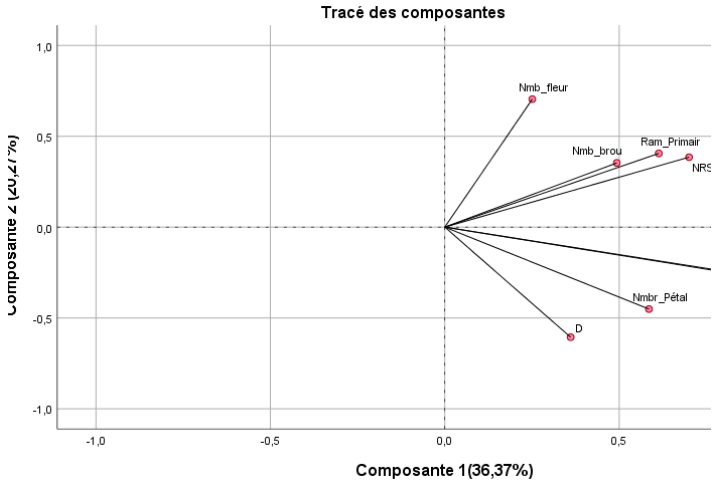

Figure 11. Correlation circle for morphometric measurements by PCA.

Hierarchical classification

The dendrogram of the hierarchical tree allows us to visualise 2 large classes, the first of which is divided into 2 groups and 2 sub-groups, 1 group includes plants originating from Sidi bel Abes and Ain Temouchant and the second sub-group includes plants originating from El Hennaya.

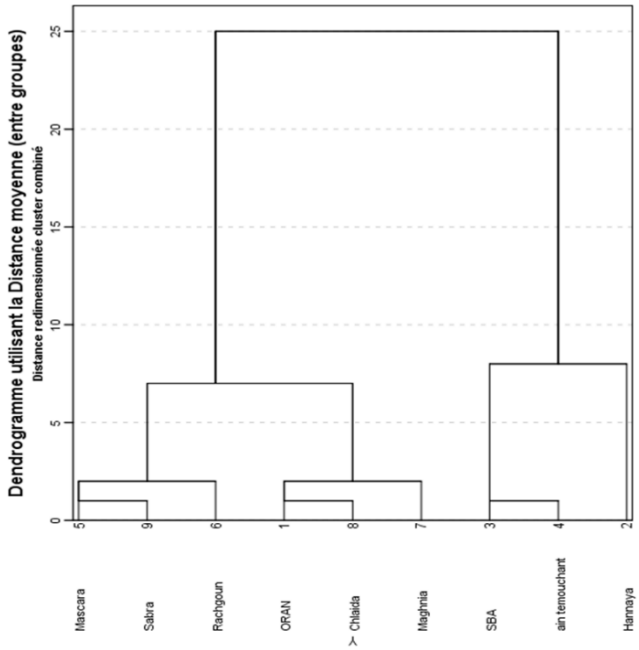

Figure 12. Hierarchical tree using the average distance between classes.

The 2nd class is divided into 2 sub-groups; the first sub-group (Oran, Chlaida, Maghnia) and the 2nd sub-group (Mascara, Sabra, Rachgoun). The 1st sub-group (Oran, Chlaida) and the 2nd sub-group (Mascara, Sabra). This can be explained by the existence of water in the places where these samples were taken.

Shannon index for quantitative traits :

The eleven traits studied showed similar levels of diversity. We also note that this index expresses a high level of diversity in the populations studied, which can be explained by the effect of climate or water availability (table 14).

Table 14. Shannon diversity index for the study sample.

Trait	**SI**	**H= Sum (pi*ln (pi))**
Number of petals	0,76421067	1,059420939
length of petals	0,99461499	1,378829157
diameter	0,96444427	1,337003655
Number of sepals	0,95524621	1,324252435
length of plant	0,99753997	1,382884033
Number of primary branches	0,63059299	0,874187501
Number of secondary branches	0,99836259	1,384024433
Number of leaves	0,99642811	1,381342664
Petal width	0,9835746	1,36352392
Number of buds	0,99764392	1,383028144
Number of flowers	0,99600474	1,380755756

(SI): Shannon index.

Physicochemical characterization

Phytochemical screening

Phytochemical screening is a means of highlighting the presence of groups of chemical families present in a given solution (table 15).

Table 15. Phytochemical screening of *Chrysanthemum coronarium* leaves of the two varieties studied

	Alkaloids	Alkaloids	Free quinones	Anthraquinones	Moss	Terpenoids	Tannins	Flavonoids
	Mayer	Wagner						
G1HJ	+	++	+	-	-	++	++	+
G2HJ	+	++	+	-	-	+		+
G3HJ	-	+	+	-	-	+		+
G4HJ	++	-	+	-	-	+		+
G5HJ	+	+	+	-	-	+		+
G1HJB	-	-	+	-	-	++		+
G2HJB	-	-	+	-	-	+++		+
G3HJB	-	-	+	-	-	+		+
G4HJB	-	-	+	-	-	+	+	+
G5HJB	-	-	+	-	-	+		+
G1RJ	+	++	+	-	-	+		+
G2RJ	+	++	+	-	-	+		+
G3RJ	-	++	+	-	-	+		+
G4RJ	+	++	+	-	-	++		+
G5RJ	+	-	+	-	-	+	+++	+
G1RJB	+	++	+	-	-	++		+
G2RJB	-	++	+	-	-	++	++	+
G3RJB	+	++	+	-	-	++		++
G4RJB	+	++	+	-	-	+	+	++
G5RJB	+	++	+	-	-	+		++
G1OJ	++	++	+	-	-	+	+	++
G2OJ	++	++	+	-	-	++		+
G3OJ	++	+	+	-	-	+		+
G4OJ	+	++	+	-	-	+++		+
G5OJ	+	+	+	-	-	++		++
G1OJB	+	++	+	-	-	+		+
G2OJB	+	+	+	-	-	+		+
G3OJB	+	++	+	-	-	+		+
G4OJB	+	-	+	-	-	+		+
G5OJB	+	++	+	-	-	++	+	+

- absent / + present / ++ strong present / +++ very strong present Alc: Alcohol/ Tan: Tannin/ Flavo: Flavonoid/ Anthr: Anthraquinone/ Quin : Quinone Sapon: Saponin.

Table 15 shows the absence of a result in the mouse test, which indicates the absence of saponins, and the absence of a violet coloration in the anthraquinone test, which indicates the absence of anthraquinones. For the other tests, the results obtained vary between positive and negative for each sample from the different regions.

Conclusion and outlook

The present work was launched with the aim of studying the morphometric and biochemical characterisation of the *Chrysanthemum coronarium* plant (Glebioniscoronaria) in 09 different regions, in 05 wilayas; Tlemcen (Hennaya, Maghnia, Sabra and Chlaida), Ain Temouchent (Rechgoun and Ain Tolba), Oran, Sidi Belabas and Mascara. This work was carried out on a wide range of phenotypic markers. Morpho-metric measurements showed that the population is homogeneous. The relative Shannon-Weaver diversity index (average H') for all the varieties studied was around 0.93 (showing that there is great diversity and very high genetic variability in the populations studied).

Biochemical characterisation was carried out on 29 samples (leaves), including 02 varieties from 03 regions. The tests applied made it possible to identify the various chemical groups present in the leaves of this plant which are of pharmaceutical interest.

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