Ludmila SASS, Alina DUTA, Iulian POPESCU

NATURE GIVES US BEAUTY, INSPIRING THE TECHNICAL CREATIVITY

Abstract: *A mechanism able to generate rodonee similar to corollas of natural flowers was conceived. It consists of two leading elements and dyade of type RRP. The leading elements movements are correlated by means of a linear relation characterised by a coefficient q. Several pictures, corresponding to different values of q, were obtained. In this paper, different natural corolles are identified with pictures generated by this original mechanism. Dialipetal and gamopetalous corollas were sources of inspiration for the creation of certain extremely beautiful curves. The mechanism can be used as a model or toy able to plot these curves.*

Key words: *nature, corolla, mechanism to generate curves of type rhodonea.*

1. INTRODUCTION

Nature exhibits special development and evolution abilities. Human existence genesis cannot be though in disjunction with Nature. This provides an explanation for the unique characteristics of human intellect, able to coexist in harmony with nature.

This paper represents a tribute brought to flowers beauty by engineers, along with painters, sculptors, musicians, horticulturists and in general by all people loving their shape, color and perfume.

The internal envelope of flower is called corolla and consists in petals, which give everybody the joy of diversity through shape, size, color, configuration, symmetry, number and conformation.

Many references to cyclic curves which generates pictures like corolla with different numbers of petals can be found in literature. These are either of type “rhodonea” or of type “rose”, geometrical descriptions for them being found in [4]. On the other hand, curves like epicycloids do not reach the center of the curve. Instead they stop along a circle, which can be identified as a receptacle of flower. Examples for curves of this type were studied in [1], a generating mechanism being presented.

The paper proposes an original mechanism meant to generate beautiful cyclic curves, with shapes similar to the flowers petals created by Nature which represents sources of inspiration for many engineers.

2. INITIAL DATA

The full flowers gather all elements specific to this vegetative organ (Figure 1).

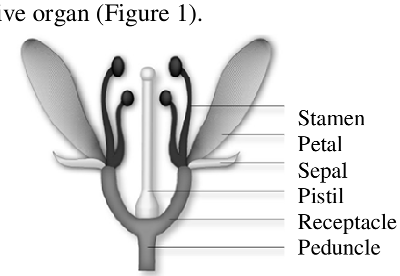


Fig. 1 Elements specific to a full flower [5].

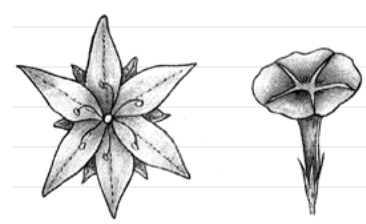
This study is concerned with the corolla – all petals gather across the receptacle and disposed alternatively with the calyx – the ensemble of sepals.

The research starts with the references [6], [7], [8], [16] related to the criteria for petals’ classification, namely: conformation, shape, number of petals, symmetry and respectively properties related to identical petals.

2.1 Conformation of corolla

The paper deals with the generation of two types of corolla, Figure 2 [7]:

- Dialipetal: the petals are not connected
- Gamopetalous: the petals are connected (overgrown).



a. b.

Fig. 2 Types of corolla: a. Dialipetal; b. Gamopetalous.

2.2 Shape of corolla

Petals with a oval-lanceolate shape (Figure 3, position 2) are picked from [6] as a model to trace the contour with the original mechanism.

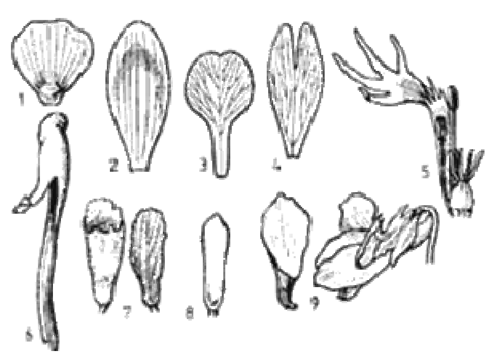


Fig. 3 Petals shape: position 2 presents the oval-lanceolate shape approached in the paper.

2.3 Number of petals

A classification according to the number of floral components from a flower cycle (merosity) [8] includes: flowers with 2 petals (dimery), with 3 petals (trimery), with 4 petals (tetramery), with 5 petals (pentamery), with high number of petals (polymery), with petals covering each other ("involt flower").

Studies presented below will address the corolla with a number of petals denoted by $n_p = 3, 4, 5, 6$, etc.

2.4 Petals' symmetry and equality

- Actinomorphic corolla, the petals are equal, Figure 4.a [7].
- Zigomorphic corolla, the petals are not equal, Figure 4.b [7].

a. b.

Fig. 4 Petals' symmetry and equality.
a. Actinomorphic corolla; b. Zigomorphic corolla.

The proposed mechanism will be used to generate the actinomorphic corolla.

3. GENERATING MECHANISM

Curves of rhodonea (also called rose) type are described in [4] as follows: two points (M and N) are considered as belonging to a circle, their positions being described by the angles θ and $n \cdot \theta$, Figure 5.

The point N is projected on the axis Ox in N'; the points P_1 and P_2, placed on the radius OM, selected such that $OP_1=NN'$ and $OP_2=ON'$, describe the congruent curves called rhodonee (synonymous rose) with the index n.

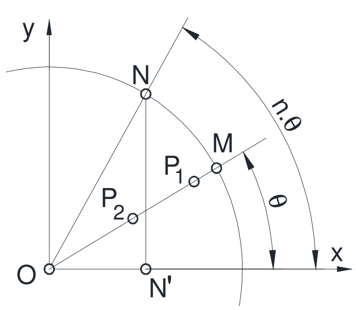


Fig. 5 Geometrical interpretation for the rhodonea generation

This curve is plotted by a point oscillating across a line rotating around a point [4]. The mechanism from Figure 6 [1] was built considering, with program Autocad [19], the above this ascertainment.

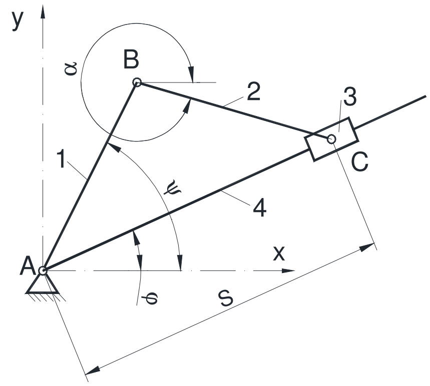


Fig. 6 Mechanism used to generate rhodonea.

The mechanism consists of two leading elements 1 and 4, articulated in the same point A (hosting two couples of rotation, both used for motion) and a dyad of type RRP; the generalized coordinates are the angles φ and ψ; the point C generates the rhodonea in the basis plane.

4. CALCULUS

The following equations rely on Figure 6, where $AB=a$ and $BC=b$:

$$\begin{cases} a \cdot \cos\psi + b \cdot \cos\alpha = S \cdot \cos\varphi \\ a \cdot \sin\psi + b \cdot \sin\alpha = S \cdot \sin\varphi \end{cases} \tag{1}$$

The substitution of α yields the trajectory S:

$$S = a \cdot \cos\,(\psi - \varphi) \pm \sqrt{a^2 \cdot \cos^2(\psi - \varphi) - \left(a^2 - b^2\right)} \tag{2}$$

Finally the coordinates of the point P_1 in fix plane are obtained:

$$\begin{cases} x_C = S \cdot \cos\varphi \\ y_C = S \cdot \sin\varphi \end{cases} \tag{3}$$

The parameters from equations are correlated as follows:

$$\psi = q \cdot \varphi \tag{4}$$

$$b = w \cdot a \tag{5}$$

wher q and w are the coefficients which determine the number of petals and the sizes of rhodoneas.

Several tests were accomplished until formulating the conclusion that the number of petals, denoted by n_p is:

$$n_p = abs(q) - 1 \tag{6}$$

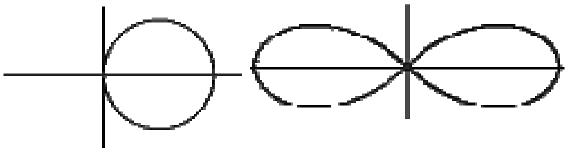
Similar equations and methods were used in [2], [3] to define human bone geometry.

5. GRAPHICAL RESULTS

5.1 Dialipetal corolla with actinomorphic symmetry

For the studied mechanism the parameters a and b were considered as equal to 25. Therefore w=1.

For q=2 and q=3 the tracing point C describes the curves from Figure 7.

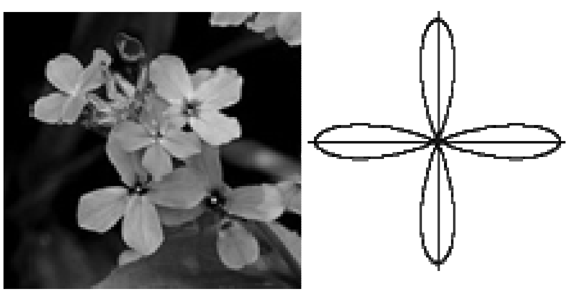


a. b.
Fig. 7 Curves generated by the point C.
a. q=2: circle; b. q=3.

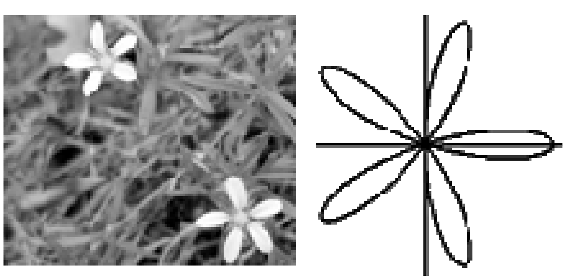
For the rest of the values used for q, other pictures representing rhodonea are obtained. Shapes similar to natural petals of flowers with an oval-lanceolate shape are obtained. The plotted petals are intersecting in the generating system origin.

The following step was to choose parameters for the definition of curves generated for the type of dialipetal actinomorphic corolla with 3, 4, 5, 6 petals, Figure 8 – Figure 11.

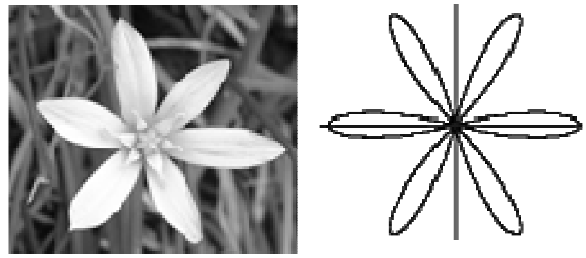
a. b.
Fig. 8 Trimery corolla.
a. Trillium undulatum [9]; b. Curve generated for q=4.



a. b.
Fig. 9 Tetramery corolla.
a. Hesperis matronalis [9]; b. Curve generated for q=5.

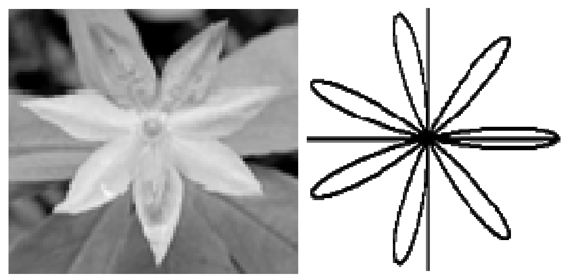


a. b.
Fig. 10 Pentamery corolla.
a. Moehringia pendula [10]; b. Curve generated for q=6.



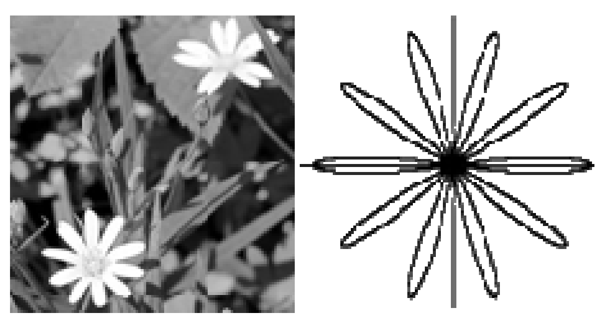
a. b.
Fig. 11 Hexamery corolla.
a. Ornithogalum umbellatum [11]; b. Curve generated for q=7.

Below are presented flowers with multiple petals in the corolla for which rhodonea were generated, Figure 12-Figure 22. Most of them have a variable number of petals.



a. b
Fig. 12 Heptamery corolla
a. Trientalis borealis (5-9 petale) [9]; b. Curve generated for q=8.

a. b.
Fig. 13 Octamery corolla.
a. Sanguinaria Canadensis [12]; b. Curve generated for q=9.



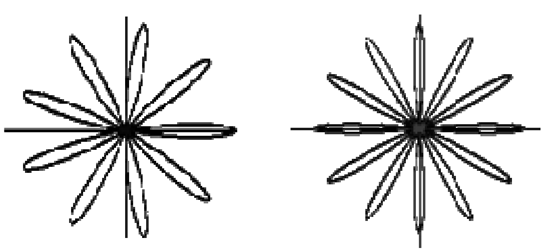
a. b.
Fig. 14 Corolla with 10 petals.
a. Stellaria holostea [10]; b. Curve generated for q=11.

a. b.
Fig. 15 Corolla with multiple petals.
a. Tragopogon orientalis [10]; b. Xeranthemum annuum [10].

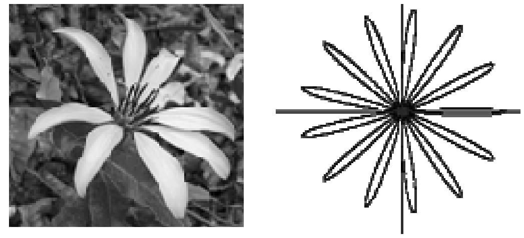
a. b.
Fig. 16 Corolla with multiple petals.
a. Bellis perennis [10]; b. Leucanthemum vulgare [10].

a. b.
Fig. 17 Corolla with multiple petals.
a. Aster alpinus [10]; b. Aster amellus [10].

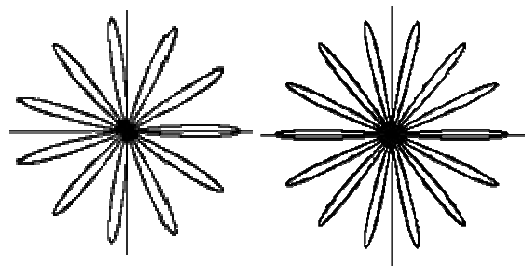
a. b.
Fig. 18 Corolla with multiple petals.
a. Scorzonera rosea [10]; b. Aster patens [10].



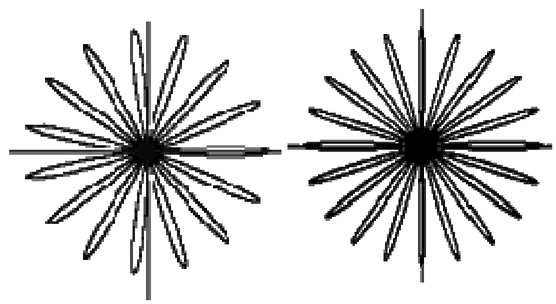
a. b
Fig. 19 Corolla with multiple petals.
a. q=10; b. q=12.



a. b.
Fig. 20 Corolla with multiple petals.
a. q=13; b. q=14.



a. b.
Fig. 21 Corolla with 14 petals.
a. Mutisia spinosa (7-14 petale) [13]; b. Curve generated for q=15.



a. b.
Fig. 22 Curves generated for corolla with multiple petals.
a. q=16; b. q=17.

5.2 Gamopetalous corolla with actinomorphic symmetry

The following step was to choose parameters for the definition of curves generated for the type of gamopetalous actinomorphic corolla.

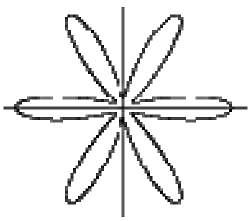
The generated petals are united and do no longer reach the origin of the system of axis – instead beind placed along an internal circle, concentric with the external one.

- For the shape resembling to a campanula, the flower called Campanula medium ”Canterbury Bells” was selected.

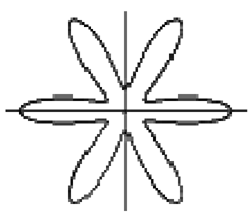
Usually this corolla, Campanula medium ”Canterbury Bells” Figure 23, has 5 divisions, as one can see in the picture (other possibilities being with 6 or 7 divisions). The flower studied in this paper has 6 divisions.

For generation, the following parameters were considered: length of the leading element equal to 1, a=25 and q=7. When increasing the length of the element 2 (more specific, the parameter *b*), the internal diameter on which the petals are reunited is also increased, as in Figure 24.

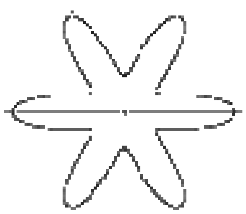
Fig. 23 Campanula medium "Canterbury Bells" [14].



a.



b.

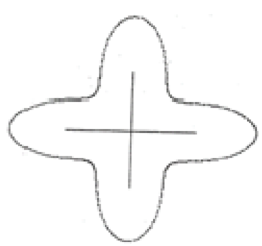


c.

Fig. 24 Curves generated for corolla gamopetalous with actinomorphic symmetry.
a. w=1.2, b=30; b. w=1.5, b=37.5; c. w=2, b=50.

- For the corolla with a campanula shape (4 division), found as similar to the plant Coccocypselum capitatum, (Figure 25.a), the picture from Figure 25.b was generated.

a.



b.

Fig. 25 Gamopetalous corolla.
a. Coccocypselum capitatum [15]; b. Curve generated for q=5, w=2.5, a=25, b=62.5.

The following shapes were selected for generation when approaching the corolla with 5 divisions:

- Rotated shape, similar to Borago officinalis or Echium amoenum, Figure 26.a.
- Star shape, similar to Gentiana verna, Figure 26.b.
- Campanula shape, similar to Campanula latifolia, figure 27.a.
- Verbascum lychnitis, Figure 27.b.

The curve from Figure 28 was generated for this type of corolla.

a.

b.

Fig. 26 Gamopetalous corolla.
a. Borago officinalis [16]; b. Gentiana verna [16].

a.

b.

c.

Fig. 27 Gamopetalous corolla
a. Campanula latifolia [10]; b. Verbascum lychnitis [17]; c. Cucumis sativus L [18].

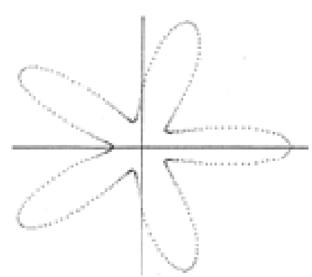


Fig. 28 Curve generated for q =6, w=1.5, a=25, b=37.5.

6. CONCLUSIONS

- A mechanism consisting in two leading elements and a dyad of type RRP was conceived. It can be used to plot different shapes of rhodonea.
- Natural flowers were selected (of type dialipetal and gamopetalous, with petals of shape oval-lanceolate, containing different numbers of (unequal petals). Plane curves were generated for them, of type rhodonea, with similar aesthetical characteristics.
- By varying the coefficient q used for the correlation between the angles of the leading elements and the coefficient w used for the correlation between the elements lengths, flowers with different numbers of petals were generated.
- When the mechanism elements obey the relation b>a, then corollas with a conformation of gamopetalous are obtained.
- The aesthetic properties of the studied natural corolla is beautiful and unique and cannot be copied. Yet they represent a source of inspiration for the generation of some interesting curves.
- There is no technical approach in which a mechanism with a single leading element should be able to generate these curves. The cycloidal mechanisms can be used to generated epicycloids and hipocycloids, normal, elongated or shortened, resembling to certain flowers if considering only the number of petals, but not in what is concerning the shape.

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