Morphometric Analysis of Datura Plant to Understand Variation and Similarities among Four Major Species

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Abstract

Datura, well known for its poisonous and hallucinogenic properties has great importance in pharmaceuticals. Seeds and leaves are used for treating various ailments. Four commonly occurring Datura species were considered for morphometric analysis to supplement precise variability in statistical terms to taxonomy. For each quantitative trait an analysis of variance (ANOVA) test is conducted to test whether the means of three or more groups are the same. Turkey-Kramer test of individual characteristics provided support to species wise grouping that indicate significant differences among populations. Among fifteen traits measured, at least 13 traits vary between any two species. Cluster analysis reveals that D. metel and D. innoxia has related origin, D. stramonium and D. ferox forms separate group.

Keywords: Datura; Morphometric analysis; ANOVA; Cluster analysis

Introduction

Datura, has been used as a narcotic, since time immemorial. Indians have long been familiar with intoxicating properties of this plant. Its use in Ayurveda has been described by the father of Indian medicine—Shrusrutha. The plant termed as ’Shiva Priya’, ’Maatula’ in Sanskrit has been reportedly used in folk remedies [1-3]. Seeds and leaves of Datura are used for treating various ailments like asthma, rabies, insanity, Parkinsons, leprosy, boils and many other skin related problems. The plant contains hyoscyamine, atropine and norhyoscyamine; its leaves also contains vitamin ‘C’, while seeds contain a fixed oil with a disagreeable odor and taste [4]. Certain varieties are also commercially cultivated for aesthetic and pharmaceutical purposes in South and North American countries [5].

Around 12 to 13 species of Datura are identified across the world, viz., D.ceratocaula, D.candida, D.discolor, D.doliocarpa, D.kymatocarpa, D.leichhardtii, D.metel, D.ruburra, D.wrightii, D.innoxia, D.stramonium and D.ferox. Regarding nomenclature, there are more than one synonymous for single species and certain names are unresolved (the plant list) [6]. Species of Datura occurs in almost all parts of the world except in extreme cold regions [7], and so far, no studies have been undertaken to comprehend species-wise population distribution.

The word ‘Datura’ generally refers to Datura metel [1] any species belonging to the entire genus is referred to as Datura, since the word ‘Datur’ is derived from the Indian word for the seed capsule, ‘Dhatura’ [8]. Through review of literature available over the years [1,3,9-11] and their extensive field experience, the authors conclude that generally four species of Datura can be identified in India. While, D. metel is considered as native to India, the rest were introduced and naturalized [7]. Other species like D. stramonium, D. innoxia and D. ferox also go by the name of ‘dathura’, and are collected for medicinal purposes.

In India, this plant, which is used for medicinal purposes, are collected from road sides or open dumping yards [12]. It’s seeds are commonly used as raw material in pharmaceutical industry. Different species of Datura have different types of seeds; while D. metel and D. innoxia have brown auricular seeds, D. stramonium, and D. ferox have small black seeds. However, due to similarity in appearance of plants, seeds of all species generally get mixed up, when collecting from the wild. In some cases, seeds of another plant known as Argemone mexicana, which also goes by a similar common name ‘datturi’, and having similar seed characteristics, is also sold as ‘Datura’ [13]. In addition, higher concentration of heavy metals were observed in the plant samples collected from roadsides in urban areas, which is not desirable for drug preparation [14]. In order to ensure suitable raw material for the chemical and pharmaceutical industries, cultivation of appropriate species on farm lands, is essential. As a first step, through morphometric analysis, this study attempts to identify the distinguishing characteristics of the four major species of Datura. The results of which could further be used to identify the appropriate species for utilisation in the drug industry through further phytochemical tests.

Datura is a genus in the family Solanaceae. Shrubs or annual or perennial herbs; stem pubescent or course. Large leaves, entire or deeply toothed. Calyx long tubular, persistent. Large bugle shaped flowers, white, cream or purple, solitary and erect with 5 to 10 lobes. Stamens 5 attached near base, filaments filiform; anthers linear longitudinally dehiscing. Fruit ellipsoid spinescent 4 celled capsule, dehiscing regularly (D. Stramonium and D. ferox) dehiscing irregularly (D.metel and D. innoxia). Seeds many; compressed black or brown [9,10] Variations within D. metel, like flower colour and multiple whorls, were not treated separately for this study.

Materials and Methods

Natural populations of D. metel, D. innoxia and D. ferox from in and...
around Bengaluru (12°.98’N 77°.58’E) were considered to measure morphological characters. Only *D. stramonium* was collected from Male Mahadeshwara hills (12°1’N 77°35’E), Chamarajnagar district, south of Bengaluru, as *stromonium* is found only on these hills. Since plants were available only in the wild and were not cultivated, places across the locations where they were found in the wild were identified. Random sampling method was used to collect the plants for observations. A total of one hundred well-grown and healthy plants for each of the species were collected. Fifteen morphological characteristics were measured. Longest stems of the plants were considered to measure its height. Leaves from these stems were selected for measuring length and breadth. Leaf length was measured considering the lowest base of the leaf to the tip, and breadth was measured at the widest portion of the leaf. The same leaf was considered for measuring the petiole length which was measured as the length from branch to the lowest base of the leaf. Fully bloomed flowers were selected for measuring the floral characteristics. The pedicel length was measured from branch to the base of the flower; length of the flower is from base of the flower to the tip of the corolla; corolla margin was measured using a string due to its sinuate feature. Length of the stamen was measured from the base to the anther and gynecium from the base of the ovary to stigma. Matured fruits were considered for measuring fruit length, breadth, spine length and weight. The number of spines were counted through visual observation. The seeds were separated from fruits and weighed [15]. The units of measurements are given in Table 1.

Statistical analyses were done using MS Excel. Descriptive statistics were generated, listing the mean and standard deviation for each characteristic. For each quantitative characteristic, the analysis of variance (ANOVA) test was conducted to test the equality of means, followed by post-hoc analysis to identify the characteristics that were different or similar among the species. Further, to identify which species were more similar to the others, a dendrogram was created using the means of the characteristics, using an online software [16]. Dendrograms help in grouping/identification of “clusters” of objects that are similar to each other. It provides a visual representation of the overall strength of a classification as well as the compactness and isolation of individual classes. A similarity matrix is also provided from the analysis. A similarity matrix is constructed based on the ratio of the number of attributes two objects share in common compared to the total list of attributes between them. Objects which have everything in common are identical, and have a similarity of 1.0. Objects which have nothing in common have a similarity value of 0.0 [17].

### Results and Discussion

Table 1 provides the characteristics of fifteen morphological traits of the four major species of *Datura* that have been considered for the present study. The results of the test of differences in means using ANOVA tests indicates that the species differ significantly with respect to most morphological characteristics, except for a few such as leaf length, petiole length and seed weight.

Table 2 which provides the similarity matrix of the species, indicates that *D. metel* and *D. innoxa* are more similar to each other, while *D. ferox* was different from all the other species. This is also confirmed by the dendrogram produced in Figure 1. This is in confirmation with the identification of different forms of *Datura* as species. Further studies can be taken up to identify similarities and differences through chemical and genetic analysis [18].

### Conclusion

The morphometric approach undertaken ascertains the differences in the morphological characteristics among the four species of *Datura*. This study assessed the morphological variation among commonly occurring, *Datura* plants to identify patterns of variation at the species levels. Unique phonetypes were observed, with differences in most

<table>
<thead>
<tr>
<th>Morphological characteristics</th>
<th><em>D. metel</em></th>
<th><em>D. ferox</em></th>
<th><em>D. stramonium</em></th>
<th><em>D. innoxa</em></th>
<th>F Value</th>
<th>CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Height (cm)</td>
<td>81.31 ± 16.51</td>
<td>32.20 ± 8.27</td>
<td>58.63 ± 9.48</td>
<td>69.35 ± 10.18</td>
<td>290.03</td>
<td>3.41</td>
</tr>
<tr>
<td>2. Petiole length (cm)</td>
<td>2.92 ± 1.03A</td>
<td>2.44 ± 0.25</td>
<td>7.15 ± 1.80A</td>
<td>2.43 ± 0.17</td>
<td>477.95</td>
<td>0.29</td>
</tr>
<tr>
<td>3. Leaf length (cm)</td>
<td>10.39 ± 1.27</td>
<td>9.36 ± 1.40A</td>
<td>16.16 ± 3.82</td>
<td>9.26 ± 1.41A</td>
<td>213.95</td>
<td>0.62</td>
</tr>
<tr>
<td>4. Leaf width (cm)</td>
<td>6.13 ± 0.85</td>
<td>7.61 ± 0.32A</td>
<td>11.07 ± 3.05</td>
<td>7.61 ± 0.23A</td>
<td>172.79</td>
<td>0.44</td>
</tr>
<tr>
<td>5. Pedicel length (cm)</td>
<td>0.72 ± 0.21</td>
<td>0.33 ± 0.09</td>
<td>0.87 ± 0.27</td>
<td>0.51 ± 0.11</td>
<td>165.94</td>
<td>0.05</td>
</tr>
<tr>
<td>6. Flower length (cm)</td>
<td>15.48 ± 1.06</td>
<td>6.98 ± 0.74</td>
<td>5.16 ± 0.22</td>
<td>14.87 ± 1.25</td>
<td>3460.55</td>
<td>0.25</td>
</tr>
<tr>
<td>7. Corolla margin (cm)</td>
<td>24.76 ± 1.63</td>
<td>11.72 ± 1.52</td>
<td>22.09 ± 2.96</td>
<td>35.23 ± 2.51</td>
<td>1863.22</td>
<td>0.62</td>
</tr>
<tr>
<td>8. Stamens length (cm)</td>
<td>7.00 ± 0.25</td>
<td>4.19 ± 0.60</td>
<td>2.99 ± 0.14</td>
<td>7.26 ± 0.38</td>
<td>3017.11</td>
<td>0.11</td>
</tr>
<tr>
<td>9. Pistil length(cm)</td>
<td>14.29 ± 1.16</td>
<td>6.09 ± 0.59</td>
<td>2.98 ± 0.13</td>
<td>14.64 ± 1.04</td>
<td>4902.89</td>
<td>0.23</td>
</tr>
<tr>
<td>10. Fruit length (cm)</td>
<td>11.36 ± 1.86</td>
<td>5.49 ± 0.52</td>
<td>2.82 ± 0.40</td>
<td>14.20 ± 1.58</td>
<td>1711.50</td>
<td>0.35</td>
</tr>
<tr>
<td>11. Fruit breadth (cm)</td>
<td>4.26 ± 0.75A</td>
<td>4.10 ± 0.74A</td>
<td>8.77 ± 4.30</td>
<td>4.28 ± 0.36Ac</td>
<td>105.13</td>
<td>0.62</td>
</tr>
<tr>
<td>12. Spine length (cm)</td>
<td>0.47 ± 0.17Ac</td>
<td>0.46 ± 0.10Ac</td>
<td>0.45 ± 0.14Ac</td>
<td>0.68 ± 0.28</td>
<td>28.71</td>
<td>0.05</td>
</tr>
<tr>
<td>13. No.of spines</td>
<td>242.93 ± 26.44</td>
<td>22.70 ± 3.11</td>
<td>134.36 ± 11.93</td>
<td>192.48 ± 18.03</td>
<td>3047.21</td>
<td>4.75</td>
</tr>
<tr>
<td>14. Fruit weight (gm)</td>
<td>26.05 ± 3.66</td>
<td>20.03 ± 2.66</td>
<td>59.62 ± 8.67</td>
<td>30.75 ± 4.73</td>
<td>1025.02</td>
<td>1.52</td>
</tr>
<tr>
<td>15. Seed weight (gm)</td>
<td>0.04 ± 0.01A</td>
<td>0.02 ± 0.00A</td>
<td>0.02 ± 0.02A</td>
<td>0.05 ± 0.05A</td>
<td>27.09</td>
<td>0.01</td>
</tr>
</tbody>
</table>

CD=Critical difference for post hoc ANOVA test.
Values with similar letter superscripts indicates that there is no significant differences in the characteristics for those species.

**Table 1**: Average values of morphological characteristics and results of ANOVA test for four selected species of *Datura*.

<table>
<thead>
<tr>
<th><em>D. metel</em></th>
<th><em>D. metel</em></th>
<th><em>D. ferox</em></th>
<th><em>D. stramonium</em></th>
<th><em>D. innoxa</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.669</td>
<td>0.942</td>
<td>0.996</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2**: Similarity matrix for the four species of *Datura*.
characteristics such as plant height, flower size and spines on fruits, suggesting a distinct morphological identities. The morphological characteristics became significantly different between any of the two species. The cluster tree generated gives a clear picture of the relationship among the four species. It may be concluded that the species have emerged from a common ancestor. Among the four species, morphologically, *D. metel* and *D. innoxia* were more similar and formed a cluster, while, and *D. stramonium* was different from this cluster, and *D. ferox* was distinct from the other three species. The results of this study provides sufficient evidence regarding the distinct morphological characterises of the species, which could be used in providing information to the collectors to identify authentic species for commercial purposes.

**Acknowledgement**
Our gratitude to Dr. Geeta R, Prof. Department of Botany, University of Delhi, who guided us to research on plant distribution and evolutionary biology.

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