Bulletin No. 143 - Chemical Examination of Three Delphiniums

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Publication Information
University of Wyoming Agricultural Experiment Station (1925). "Bulletin No. 143 - Chemical Examination of Three Delphiniums." University of Wyoming Agricultural Experiment Station Bulletin 143, 49-70.

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A recent addition to the Delphinium group.

Chemical Examination of Three Delphiniums

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Chemical Examination of Three Delphiniums

By O. A. Beath

In a previous bulletin (No. 120) the author discussed some of the physical and chemical aspects of the three native Delphiniums, viz., Geyeri, Barbeyi, and glaucescens. In addition, their distribution and relative importance as poisonous plants was reviewed as completely as the facts warranted. A brief general summary of the Delphinium alkaloidal literature was likewise included. Since the publication of Bulletin No. 120, considerable attention has been given to the study of three additional species: D. bicolor, D. Nelsonii, and D. cuculatum. The first two are commonly referred to as low larkspurs and the third a tall species. While no chemical study has been made of it, the author has included a third low larkspur which has just been classified as D. venenosum, and which is described under another heading in this bulletin. Mention is made of this point because until recently it had been collected and classified as D. Nelsonii.

Because of the wide occurrence and importance of the Delphiniums in the Rocky Mountain region, the author has obtained the consent of Professor Aven Nelson, Botanist, to present a synopsis of the prevailing nomenclature with such suggestions as facts appear to indicate.

Some Rocky Mountain Larkspurs

By Aven Nelson*

Distribution and Habitat:

The University of Wyoming, through its Experiment Station staff, is making an exhaustive survey and study of the poisonous plants of the State. Professor O. A. Beath, Station Chemist, is not only studying the composition and prophylaxis of the plants which are reported to him, but is organizing our knowledge of their distribution and relative abundance. Both in epidemics and in sporadic outbreaks, he visits personally the districts from which

*Professor of Botany, University of Wyoming.
calls for help come. In this way he has established co-operative relationships with the stockmen of Wyoming that are giving him first-hand information on all the sources of trouble attributed to poisonous plants.

Since Professor Beath is a chemist rather than a plant taxonomist, the writer has been co-operating with him in the determination of the material under survey. Among the genera to which he has been compelled to give much attention is Delphinium. We had assumed that only a very few species were sufficiently abundant to give any concern or that possibly only a few possessed toxic properties. Most of those to which attention had been called were loosely designated as the “Tall Larkspurs,” and included such species as Delphinium Barbeyi, D. glaucescens, D. cuculatum, and others having the deep-set woody roots of this group.

The stockman’s “poison weed”, D. Geyeri, should have been included in the foregoing group instead of confusingly calling it the “Low Larkspur”. I am proposing, therefore, that we designate these two rather distinct groups as follows:

**TUBEROSAE:** Delphinium bicolor; D. Menziesii; D. venenosum; etc., etc.

**XYLORHIZAE:** D. Geyeri; D. Barbeyi; D. cuculatum; etc., etc.

In one of the areas that Professor Beath was called upon to investigate he found a tuberous rooted Delphinium so unlike any he had previously secured that he deemed it wise to bring from the field an abundance of material in the various stages of its development. This material compelled a re-examination of all accepted tuber-forming species of his range and a new evaluation of the characters upon which these species are based. This study led to the conclusion that these plants, reported as causing extensive stock losses, in the La Barge district of Wyoming were specifically distinct and were accordingly named and described as Delphinium venenosum (Fig. 1). In the past the writer had assumed that the tuberous rooted forms were not only small but scattering, making it improbable that any one animal would secure a lethal quantity. Such, however, would not be true for this new species since
it was growing in the greatest profusion in the above named area, often constituting, in fact, the largest single element of the vegetation of certain parks.

Figure 1—Delphinium venenosum.
In order to show its relationship, a key has been prepared for those species with which it is most likely to be confused. This is offered with the hope that it may help to clear up the relationship and distribution of some heretofore misunderstood species.

**KEY TO THE SECTION BICLORIA, *IN PART***

Roots short and thickened, often tuber-like, leaf-segments narrow, inflorescence few flowered, pedicles ascending or spreading, the lower relatively long, gradually shortening upward; sepals broad, dark-blue, spreading.

Roots fascicled, thick, woody-fibrous (not fleshy and tuber-like), normally attached to the stem as in plants with continuous stele; stems evidently viscid-pubescent, at least above, blades of the lateral petals about 10 mm. long.

Lateral sepals obtuse, much shorter than the spur... 1. *D. LEONARDII*

Lateral sepals acute, almost equaling the spur.... 2. *D. BICOLOR*

Roots thickened, forming irregular tubers which are more or less fascicled, readily detaching from the stem; flowers smaller; blades of the lateral petals about 5 mm. long.

Stems tall (5-10 dm.); flowers many (15-25).

Glabrous but for a little viscid pubescence on floral bracts, calyx and follicles; leaf-segment narrowly oblong; petals ochroleucous with blue veins................. 3. *D. VENENOSUM*

Sub-viscous with a short, dense, yellowish pilose pubescence in the elongated inflorescence; leaves mostly parted into linear-lanceolate segments but some of the lower often merely cleft and then somewhat flabelliform; petals blue.............................. 4. *D. COLUMBIANUM*

Stems low, mostly 1-3 dm. high (rarely up to 5 dm.); flowers few (3-10).

Pubescence on stems (if any) minute crisped and spreading.

Stems glabrous, pubescence of inflorescence from scarcely to evidently viscious; follicles short (7-12 mm.).

Leaves few, mostly basal, pedately parted or, the lower merely cleft flabelliform... 5. *D. DEPAUPERATUM*

Leaves more numerous and evenly distributed, all parted into narrow or even long-linear lobes

.......... 6. *D. NUTTALLIANUM*

*Acknowledgment is gladly made of help secured from the excellent treatment of this group by Dr. P. A. Rydberg in his Flora of the Rocky Mountains.
Stems minutely pubescent or glabrate, never viscid; follicles longer (15-20 mm.), at length acurate-divergent

7. D. Nelsonii

Pubescence on stems of long soft reflexed hairs; lower pedicles long, spreading-ascending; follicles at length widely recurving.

8. D. Menziesii

**DISTRIBUTION**

1. *Delphinium Leonardii* Rydb. This species seems to have a limited range and is still poorly represented by authentic herbarium specimens. Reported from Utah only and its distribution is given by Dr. Rydberg as "River-bank and beaches."

2. *Delphinium bicolor* Nutt. (Fig. 2.) The range commonly assigned to this species seems greater than the specimens at hand will justify. In Wyoming it occurs plentifully in the Big Horn Mountains, extends westward into Yellowstone National Park and eastward into the Black Hills and then northward, occurring probably in all of the mountain ranges of Montana and into the borders of Canada. It has been reported from Utah, Idaho,
Oregon, and Washington, but certainly some of the material so reported will be seen, on re-examination, to be referable to other species.

3. *Delphinium venenosum* A. Nels. The full range or distribution of this species is still to be determined. The specimens collected by Professor Beath were secured on the head-waters of La Barge Creek and of Gray's River in Lincoln County. It is known to have a considerable extension north and south (30-50 miles) on the high (8000-9500 ft.) denuded ridges and plateaus of Grey's River drainage basin. This district is all well within the boundaries of the Wyoming National Forest, a region singularly inaccessible in the past and even now is reached only over pack trails. The district has been visited by but few botanists and this particular part of it possibly by none at all. It is not strange, therefore, if occasionally a new species be found in a region so inadequately explored.

4. *Delphinium columbianum* Greene. This species is primarily of the Northwest, extending from British Columbia through Washington and into Oregon. There is evidence also that it occurs in western and northern Idaho. (Syn. *D. Nuttallii* Gray).

5. *Delphinium depauperatum* Nutt. The relationship of this species seems to have been misunderstood, as evidenced by its reduction to varietal rank or even complete synonomy under *D. Nuttallianum*. All the characters point to *D. columbianum* as its nearest ally and its distribution connects or overlaps the range of that species. It seems to center in southwestern Idaho with extensions into northern Nevada and northwestward into Oregon, where it overlaps the range of *D. columbianum*. Too often the name is applied to any depauperate specimen of this group of species, but, as a matter of fact, it is a taller plant than *D. Nuttallianum* or *D. Nelsonii*.

6. *Delphinium Nuttallianum* Pritzel. In this we have either a very variable species or an aggregate of weak species not yet satisfactorily discriminated. It is the northwest analogue of *D. Nelsonii*,—the ranges of these more or less overlapping. The range of *D. Nuttallianum* as here understood extends from northern Nevada through eastern Oregon and Washington, eastward
through Idaho to western Montana and then to the borders of Utah and Wyoming. (Syn. D. pauciflorum Nutt.) Delphinium Helleri Rydb. has been taken out of this complex but is still too inadequately known to be given a place in this list of plants now under consideration because of their economic importance.

7. Delphinium Nelsonii Greene. (Fig. 3.) This is not a near ally of D. Menziesii as some have supposed. If it is ever merged with another species it must be with D. Nuttallianum. This, however, would merely further multiply the difficulties of that overburdened name. I am inclined, therefore, to hold the name D. Nelsonii for the fairly consistent unit which has Wyoming as the center of its distribution with extensions into Utah, Colorado, western Nebraska, South Dakota, Montana and some what overlapping in Idaho the range of D. Nuttallianum. (D. pinetorum Tidestrom is an interesting relative satisfactorily distinct but as yet known only inadequately from a limited district in northern Arizona). The foregoing comment will apply equally well to D. dumetorum Greene, described from "dry hills", southwestern Colorado.

8. Delphinium Mensiesii D.C. This is the first published (1818) of the species in this group and, as originally described and limited, is easily recognizable. So many other forms were referred to it from time to time that its true diagnostic characters were forgotten. The key above recalls these. Its range is first of all Oregon, but it extends (less abundantly) into the states that border upon Oregon.

EXPERIMENTAL

Only those parts of the chemical study have been included in this publication which appeared to give general characterizations of the various plant products and more particularly the toxic or poisonous compounds.

On the whole, the larkspur resins yield much the same type of substances. Inasmuch as this was touched upon in the previous publication, no additional data are given for those Delphiniums more recently investigated.
Figure 3—Delphinium Nelsonii.
Proximate analysis.

*D. Nelsonii* was selected as a type species of the low larkspur for the proximate analysis study. The several determinations were made according to the procedure outlined under official methods in the Journal of the Association of Agriculture Chemists. The results here tabulated are expressed in per cent (bone dry basis).

<table>
<thead>
<tr>
<th></th>
<th>No. 1</th>
<th>No. 2</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>7.19</td>
<td>7.39</td>
<td>7.29</td>
</tr>
<tr>
<td>Ligroin Extract (93°)</td>
<td>2.33</td>
<td>....</td>
<td>2.33</td>
</tr>
<tr>
<td>Alcoholic extract (100°)</td>
<td>24.00</td>
<td>....</td>
<td>24.00</td>
</tr>
<tr>
<td>Starch (diastase)</td>
<td>1.30</td>
<td>1.18</td>
<td>1.24</td>
</tr>
<tr>
<td>Pentosans</td>
<td>13.85</td>
<td>13.60</td>
<td>13.72</td>
</tr>
<tr>
<td>Ash</td>
<td>9.75</td>
<td>9.75</td>
<td>9.75</td>
</tr>
<tr>
<td>Reducing sugars*</td>
<td>6.66</td>
<td>6.66</td>
<td>6.66</td>
</tr>
<tr>
<td>Sucrose</td>
<td>6.56</td>
<td>6.66</td>
<td>6.61</td>
</tr>
<tr>
<td>Alkaloid total</td>
<td>0.170</td>
<td>0.158</td>
<td>0.164</td>
</tr>
</tbody>
</table>

*Calculated as dextrose.

The proximate analysis of the tall larkspur, *D. glaucescens*, was reported on in Bulletin No. 120. In order to compare similar data of the two types of plants, the results of the *D. glaucescens* are reproduced here for convenience.

<table>
<thead>
<tr>
<th></th>
<th>No. 1</th>
<th>No. 2</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol extract (100°)</td>
<td>15.17</td>
<td>15.00</td>
<td>15.08</td>
</tr>
<tr>
<td>Ligroin extract (93°)</td>
<td>1.89</td>
<td>1.35</td>
<td>1.62</td>
</tr>
<tr>
<td>Starch</td>
<td>2.63</td>
<td>2.70</td>
<td>2.66</td>
</tr>
<tr>
<td>Pentosans</td>
<td>15.17</td>
<td>15.00</td>
<td>15.08</td>
</tr>
<tr>
<td>Reducing sugars*</td>
<td>1.77</td>
<td>1.66</td>
<td>1.71</td>
</tr>
<tr>
<td>Sucrose</td>
<td>0.59</td>
<td>0.47</td>
<td>0.53</td>
</tr>
<tr>
<td>Alkaloid total</td>
<td>0.25</td>
<td>0.21</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*Calculated as glucose.

It will be noted in the case of *D. Nelsonii* that certain substances and extractives are found in considerably larger quantities than in *D. glaucescens*. From the point of view of alkaloidal content, *D. glaucescens* exceeds *D. Nelsonii* appreciably. This point will be discussed more fully in another part of this bulletin.
Alkaloidal assays.

In the assay of the Delphiniums the general practice of completely extracting a definite quantity of plant material was followed. The solvent chloroform is the most satisfactory reagent for completely extracting the larkspur alkaloids. The results tabulated below should be interpreted as comparative rather than illustrating absolute values, because each species has been found to have a small quantity of a water soluble alkaloid, insoluble in all the ordinary organic solvents, hence it is retained by the mother liquors after the chloroformic extraction. The indicators, lacmoid and thymol blue, gave good results in the titrations. The percentage of alkaloid in all cases was calculated as delphinin \((C_{31}H_{49}O_7N)\), and reported on a bone-dry basis.

<table>
<thead>
<tr>
<th>Species</th>
<th>(In bloom)</th>
<th>(above ground)</th>
<th>(roots)</th>
<th>Above Ground</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>D. Nelsonii</em></td>
<td>0.170</td>
<td>0.170</td>
<td>0.164</td>
<td>0.158</td>
<td>0.155</td>
</tr>
<tr>
<td>(In bloom)</td>
<td>b. d.</td>
<td>b. d.</td>
<td>e. d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. Nelsonii</em></td>
<td>0.164</td>
<td>0.155</td>
<td>0.159</td>
<td>0.155</td>
<td>0.159</td>
</tr>
<tr>
<td>(roots)</td>
<td>b. d.</td>
<td>b. d.</td>
<td>e. d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. bicolor</em></td>
<td>0.371</td>
<td>0.385</td>
<td>0.378</td>
<td>0.385</td>
<td>0.385</td>
</tr>
<tr>
<td>(In bloom)</td>
<td>b. d.</td>
<td>b. d.</td>
<td>e. d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. cuculatum</em></td>
<td>1.756</td>
<td>1.744</td>
<td>1.750</td>
<td>1.744</td>
<td>1.750</td>
</tr>
<tr>
<td>(above ground)</td>
<td>b. d.</td>
<td>b. d.</td>
<td>e. d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. cuculatum</em></td>
<td>1.16</td>
<td>1.12</td>
<td>1.14</td>
<td>1.12</td>
<td>1.14</td>
</tr>
</tbody>
</table>

The data pertaining to the roots have no practical significance as related to range poisoning because it is very seldom that the underground portions are pulled up by livestock. *D. cuculatum* species gives the highest yield of all Delphiniums so far examined at the Wyoming Station. Its toxicity relationship is discussed in another part of this bulletin. It should be noted that the plant samples reported above were collected at the flowering stage. Preliminary tests have been made which show the alkaloidal content to be appreciably higher in the younger growth. This is also true for all the species so far examined. Plants just emerging from the ground show a maximum quantity of alkaloid. From this point in their growth to the blooming stage, there is a gradual diminution. To compare the alkaloidal content of corresponding stages of growth fairly, it is evident that the blooming plants offer the most satisfactory selection.
To show the specific variation of the alkaloidal content of extreme stages of growth, the tall larkspur *D. glaucescens* was collected in the spring of 1924 at the time of the first appearance of the leaves, the short stems were almost free from coloring. The moisture content was 90%. Assays gave for this collection an average per cent, based on a bone-dry basis, of 1.365. At the blooming stage, plants from the same area gave an average of 0.23 per cent.

As indicated by the alkaloidal assays of the low larkspurs *D. Nelsonii* and *D. bicolor* the quantity of alkaloid is comparatively small. Consequently one of the difficulties involved in the study of these plants has been the collection of sufficient material for our work. In addition to the low alkaloidal content, the plants are small and hence present another task in the collection where quantity is desirable.

**Toxicity relationships.**

In attempting to arrive at definite conclusions in toxicity tests only those fractions of the alkaloidal section which were precipitated by ammonia are reported here. All the larkspurs yield to this reaction and the precipitate thus obtained constitutes the major portion of the total yield. It also has been found to be the most potent including the several smaller fractions. In referring to this particular substance it has, for convenience, been designated as the "A" product.

As pointed out in previous reports, most larkspurs yield upon the ammonia treatment an amorphous product. Of the six species studied at the Wyoming Station, two offer exceptions; these are *D. glaucescens* and *D. cuculatum*. It should also be mentioned that in most species the original precipitate thrown out from the aqueous acid mother liquor lends itself to hydrolysis by alcoholic potash treatment. The low species, *D. Nelsonii* and *D. bicolor*, however, yield an amorphous product that so far has not given the corresponding hydrolytic compounds. These two species appear to be at variance with the other types in this respect.

The table given below includes the results of the tests made by injecting intravenously definite alcoholic fractions of the alkaloid referred to above. The data are given for comparative pur-
poses only: It being well known that much larger doses are required where given by way of the digestive tract. The rabbits used in the tests were fully developed and healthy, weighing between two and three kilograms.

**TOXICITY OF SOME DELPHINIUMS—INTRAVENOUS INJECTION**

<table>
<thead>
<tr>
<th>Species</th>
<th>Toxic dose (mg/kg)</th>
<th>Lethal dose (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>D. geyeri</em> (alkaloid ppt by NH₃)</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>(immature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. Geyeri</em> (alkaloid ppt by NH₃)</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>(mature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. glaucescens</em> (alkaloid ppt by NH₃)</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>(mature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. Barbeyi</em> (alkaloid ppt by NH₃)</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>(mature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. cuculatum</em> (alkaloid ppt by NH₃)</td>
<td>33</td>
<td>40</td>
</tr>
<tr>
<td>(mature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. Nelsonii</em> (alkaloid ppt by NH₃)</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>(mature)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. bicolor</em> (alkaloid ppt by NH₃)</td>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

It is evident from an inspection of the table that the several *Delphiniums* vary considerably in the amount of alkaloid necessary to produce effects or to kill. This is to be expected, however, since field observations have indicated certain species to be more poisonous than others.

The toxic and lethal dosage of the tall larkspur, *D. cuculatum*, is much higher than any of the others listed. This must not be interpreted, however, as indicating all the facts involved. Quite the contrary in this instance, for *D. cuculatum* is one of the most
poisonous of all the native larkspurs. The assay of samples collected at the flowering stage and referred to under alkaloidal assays shows nearly two per cent of total alkaloids. The per cent of alkaloid in the young plants runs appreciably more, and naturally it is at this stage that most poisoning occurs. The conclusion to be reached in this case is that though the lethal dose is comparatively large the quantity of poison present is so great that it may be classified as the most poisonous tall larkspur. This, of course, is based on the tests as described above.

The difference between the toxic and lethal quantities is quite uniform for the six species. The minimum being shown by *D. Nelsonii*.

It would be interesting to know something of the physiological action of the alkaloids occurring in smaller quantities in several species. This, of course, must follow before our knowledge of delphinium poisoning is complete. Outside of the alkaloid referred to in the above tests, a few injections have been made of those occurring in smaller quantities. While pronounced results have followed (none non-toxic) yet the dosage to kill requires far larger amounts than the one obtained in the initial extraction of the mother liquors, viz., the “A” product.

Similar symptoms shown by cattle poisoned from larkspurs, regardless of species, naturally indicates a type alkaloid having much the same toxic properties. Because of its preponderance (*D. bicolor* and *D. Nelsonii* the only alkaloid found) and its physiological activity, there can be no question but what the product referred to as “A” is the one predominating in all cases of larkspur poisoning.

**Alkaloidal properties.**

Only a few of the important chemical and physical properties of the Delphiniums under consideration are discussed here. Such data as ultimate composition, molecular weights, specific rotations, naturally belong to a technical review in an appropriate scientific journal.

In the table below, the alkaloidal constituents of the species *D. Geyeri, Barbeyi*, and *glaucescens* are given for the purpose of comparison.
The numbers given below the plant species refer to approximate elevations. The capital letters A, B, C, and D, refer to the alkaloids in the order of isolation from the original mother liquors. Question marks under D indicate the suspicion of an alkaloidal substance as determined by reagent tests. With the exception of the D. alkaloid from Geyeri (Fig. 4) the quantity is small and very unstable. All the D alkaloids are very soluble in water, slightly in alcohol, and insoluble in ether and chloroform.

Figure 4—An alkaloidal crystal from D. Geyeri. Although occurring in rather small quantities, in the plant, some physiological action undoubtedly results from its presence.

It will be noted that the two low species, D. bicolor and Nelsonii do not yield any crystalline alkaloids except a suspicion under the D group. Also it has been found impossible to break up the amorphous “A” product from these two species by hydrolysis. The other four species have reacted to the alcoholic potash treatment and yielded the compounds listed under the B group. Alkaloids under the C group were isolated by fractional chloroformic washings.

The crystal measurements of the larkspur alkaloids having definite melting points was presented at the 1925 American Chemical Society meeting.
Reference has been made to the toxicity tests of the group A alkaloids. Those in the remaining groups show much less physiological activity. They also occur in relatively small amounts.

![Figure 5—A drift fence in the Big Horn region. This serves a useful purpose during *D. bicolor*’s activity. (Courtesy of the Forest Service.)](image)

### DELPHINIUMS

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-8000</td>
<td>m.p. indf.</td>
<td>197-8°C.</td>
<td>207-8</td>
<td>214-5</td>
</tr>
<tr>
<td><em>glaucescens</em></td>
<td>Crys.</td>
<td>..................</td>
<td>..................</td>
<td>?</td>
</tr>
<tr>
<td>7-9000</td>
<td>208-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Barbeyi</em></td>
<td>Amorph.</td>
<td>Crys.</td>
<td>..................</td>
<td>?</td>
</tr>
<tr>
<td>8-11000</td>
<td>m.p. indf.</td>
<td>124-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9000</td>
<td>178</td>
<td>225-7°</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td><em>bicolor</em></td>
<td>Amorph.</td>
<td>..................</td>
<td>..................</td>
<td>Crys.</td>
</tr>
<tr>
<td>5-8000</td>
<td>m.p. indf.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Nelsonii</em></td>
<td>Amorph.</td>
<td>..................</td>
<td>..................</td>
<td>?</td>
</tr>
<tr>
<td>5-10000</td>
<td>m.p. indf.</td>
<td></td>
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</tr>
</tbody>
</table>

amorph. = amorphous; m.p. = melting point; crys. = crystalline; indf. = indefinite.
Range observations.

Of the three larkspur species, *bicolor*, *Nelsonii*, and *cuculatum*, the *Nelsonii* causes the least loss on the ranges of Wyoming. The bicolor is responsible for annual cattle losses of considerable magnitude in the Big Horn National Forest. Drift fences (Fig. 5) and riders are necessary in order to divert cattle from the poisonous area. The dense patches of bicolor occur here in the open sagebrush sections. Fig. 6 shows how the space between the

Figure 6—An illustration of the denseness of *D. bicolor* between the sage clumps.

Figure 7—One of the large sagebrush areas in the Big Horns where *D. bicolor* grows abundantly. Note the bones in the foreground (left).
clumps of sagebrush is matted with bicolor. In fact, scarcely any other vegetation is present except the larkspur and sagebrush. Naturally, this type of a grazing region has to be guarded carefully during the activity of the plant. This would be from the last of June through the greater part of July. Fig. 7 is a typical illustration of many of the bicolor areas in the Big Horns. In the left-hand corner of the picture may be observed a pile of bones, the result of *D. bicolor* poisoning.

So far as the author is aware, there are no figures available as to the quantity of *D. bicolor* necessary to poison. Authentic reports from the Forest Service and the author's observations of *D. bicolor* poisoning point to the conclusion that it is comparatively very toxic. *D. cuculatum* is also known to poison cattle heavily during its initial growth. As the plant develops it becomes very large, as illustrated in Fig. 8. The author has observed conditions in all the general *D. cuculatum* areas of Wyoming and noted very few losses from the flowering plants. This is to be expected, since cattle with a wide choice of good forage would not select this type of coarse browse. It is also to be noted that *D. cuculatum*’s distribution and habitat is such as to limit it to moun-
tainous areas. For this reason it acquires considerable growth
before cattle reach these points, and hence less trouble occurs. In
contrast to the habitat of *D. cuculatum*, that of *D. Geyeri* is selected.
Found growing on the open plains and foothills, and appearing
early in the spring of the year it naturally follows that cattle have
no choice in seeking ample green forage, and the result is a state-
wide, annual cattle loss from *D. Geyeri*. *D. cuculatum* is more
poisonous than the other tall species investigated at the Wyoming
Station and possibly more toxic than *D. Geyeri* in its early growth,
and yet cattle losses reported to us are greatly exceeded by *D.
Geyeri*. The conditions mentioned above appear to explain this
difference in losses.

Figure 9—A dense growth of *D. Nelsonii* in the Medicine Bow Forest.
This photograph was taken the day before the sheep entered.

In many of the national forests of the state where *D. cucul-
tum* grows abundantly, the grazing is confined to sheep (not pois-
onous to) so that in this manner the total *D. cuculatum* area is
correspondingly restricted.

*D. Nelsonii* occurs, as a rule, in scattered patches, as indicated
under the discussion of its distribution. Occasionally one may find
dense areas where *D. Nelsonii* more or less covers the ground.
Such points have been observed in the Medicine Bow National
along Nash's Fork, the Wyoming National above Kelly Ranger Station; and along the Little Sandstone in the Hayden National. These same areas are given over largely to sheep grazing so that *D. Nelsonii* in this and other similar cases is restricted to a class of livestock that devour the plants greedily the first opportunity afforded and, of course, advantageously. Fig. 9 shows a dense *D. Nelsonii* patch before the sheep entered the forest. Fig. 10, taken from the same point the day after a band of sheep had grazed over this area.

![Image of a dense *D. Nelsonii* patch before and after grazing by sheep.]

**Figure 10**—This is the same area as shown in Figure 9, and taken the day after the sheep had grazed over it. Practically all the *D. Nelsonii* has been eaten.

This same type of observation was made by the author in the Wyoming National Forest.

The use of sheep in destroying patches of larkspur and then permitting cattle to follow is being used in some localities advantageously.

**Control measures.**

In those cases where cattle are turned loose to graze during the dangerous period of larkspur growth, without drift fences or riders to guide their movements, it naturally follows that losses will continue as they have in the past.
On the other hand, where conditions have warranted, it has been found practical and profitable for a group of stockmen in poison areas to pool their interests to the extent of a well-planned co-operative riding schedule. It is true that many animals die before aid can be given, but organized efforts have done much to improve the situation. The administration of the drugs contained in the government formula is believed to be the most efficient for Delphinium poisoning at the present time.

The department of Research Chemistry for a number of years has kept a supply of these tablets on hand for distribution at actual cost. This amounts to about fifteen cents per dose.

**Summary.**

I. A new delphinium species has been definitely established and is named *D. venenosum*. It belongs to the group of tuberose larkspurs. Nothing is known of its specific toxicity.

II. *D. bicolor* and *D. cuculatum* species are responsible for cattle losses in those areas predominantly infested by these plants. The important chemical relationships of the two are discussed in this bulletin.

III. *D. Nelsonii* occurs widely distributed and occasionally may be found in dense patches. Under present range conditions it is classed as practically harmless to cattle.