BULLETINS
OF THE
Zoological Society of San Diego

No. 6
Differential Characteristics of Southwestern Rattlesnakes Allied to Crotalus Atrox

By
L. M. KLAUBER
Curator of Reptiles
Zoological Society of San Diego

San Diego, California
MAY 21, 1930
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DIFFERENTIAL CHARACTERISTICS OF SOUTHWESTERN RATTLESNAKES ALLIED TO CROTALUS ATROX

INTRODUCTION

For the past two years I have been engaged in a study of the rattlesnakes of Lower California and have found it necessary, in order to understand the relationships of the species inhabiting that peninsula and adjacent islands, to become familiar with allied species from nearby areas. Particularly, it has been found essential to investigate Crotalus atrox, since forms obviously related to this species apparently reach their maximum differential development in Lower California. While the work on the rattlesnakes of this territory is by no means complete, it is believed desirable to publish an initial discussion of the characters of the atrox group, since, although no new forms have been disclosed, the revival of species lately considered invalid appears necessary.

SPECIES RECOGNIZED AND SUMMARY OF CONCLUSIONS

The following species are recognized as a closely related group:
A. Crotalus adamanteus Beauvois, 1799, Diamond-back Rattlesnake.
B. Crotalus atrox Baird and Girard, 1853, Desert Diamond Rattlesnake.
C. Crotalus tortugensis Van Denburgh and Slevin, 1921, Tortuga Island Diamond Rattlesnake.
D. Crotalus lucasensis Van Denburgh, 1920, San Lucan Diamond Rattlesnake.
E. Crotalus ruber (Cope), 1892, Red Diamond Rattlesnake.
F. Crotalus exsul Garman, 1883, Cedros Island Diamond Rattlesnake.

Crotalus adamanteus has not been adequately investigated, and is mentioned herein only incidentally to complete the group.

Those conclusions reached as a result of this study, which involve essential differences from recent publications on the subject, are as follows:

1. No valid subspecies of Crotalus atrox are found.
2. It is necessary to revive Cope's designation of ruber for the Red Diamond Rattlesnake of the mainland, since this is found to be specifically distinct from Cedros Island exsul.
3. Tortugensis and lucasensis are valid species. Lucasensis may eventually prove a subspecies of ruber but material from the critical area is now lacking.
AVAILABLE MATERIAL

Table No. 1 summarizes the material of which detailed scale counts and measurements were made.

**TABLE No. 1—SPECIMENS EXAMINED**

<table>
<thead>
<tr>
<th><strong>ADAMANTEUS</strong></th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATROX</strong></td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td>90</td>
</tr>
<tr>
<td>California</td>
<td>14</td>
</tr>
<tr>
<td>Lower California</td>
<td>2</td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
</tr>
<tr>
<td>San Luis Potosi</td>
<td>1</td>
</tr>
<tr>
<td>Tamaulipas</td>
<td>1</td>
</tr>
<tr>
<td>Coahuila</td>
<td>2</td>
</tr>
<tr>
<td>Chihuahua</td>
<td>5</td>
</tr>
<tr>
<td>Sonora</td>
<td>12</td>
</tr>
<tr>
<td>Tiburon Island</td>
<td>3</td>
</tr>
<tr>
<td>Total, Mexico</td>
<td>24</td>
</tr>
<tr>
<td>New Mexico</td>
<td>2</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>13</td>
</tr>
<tr>
<td>Texas</td>
<td>77</td>
</tr>
<tr>
<td>Total, atrox</td>
<td>222</td>
</tr>
</tbody>
</table>

| **TORTUGENSIS** | 18 |
| **LUCASENSIS** |
| Islands |
| San José | 5 |
| Santa Margarita | 1 |
| Total, Islands | 6 |
| Mainland | 42 |
| Total, lucasensis | 48 |

| **RUBER** |
| Islands |
| South San Lorenzo | 3 |
| San Marcos | 1 |
| Monserrate | 1 |
| Angel de la Guarda | 5 |
| Total, Islands | 10 |
| Lower California Mainland | 31 |
| San Diego County | 54 |
| Other California Counties | 10 |
| Total, ruber | 105 |

| **EXSUL** | 20 |
| Grand Total | 423 |
It should be explained that not every point was checked on every specimen. Some characters are illegible on account of the condition of the specimens; other possible differential characteristics were not discovered or investigated prior to the time borrowed specimens were returned to their owners. However, usually where differential characteristics are utilized in making determinations, sufficient numbers of counts are available to eliminate, due to abnormal specimens, excessive departures from a true mean.

In addition to the specimens inspected in detail, a considerable number of other preserved specimens of *adamanteus* and *atrox* have been examined superficially.

As to live material, I have seen not less than 50 *adamanteus*, 500 *atrox* and 500 *ruber* and have had some opportunity of observing their habits. Of *lucasensis* I have seen 13 live specimens and of *exsul*, 4; *tortugensis* has not been seen in the live state.

I have been much aided by new material not available to previous workers. Of preserved material, several museums have recently made important acquisitions; particularly, the University of California and the California Academy of Sciences have lately increased their collections from both the northern and southern sections of Lower California. Important Lower California material is to be found in the United States National Museum, the Field Museum of Natural History, the American Museum of Natural History and the Museum of Comparative Zoology at Cambridge. My own collection has lately been augmented, through the kindly assistance of Mr. C. C. Lamb of the University of California, by specimens from the Cape region, which were fortunately sent to me alive.

Much Arizona and Texas material is available in many institutions. From the Santa Fe Railway I have secured a number of fine Arizona specimens, all forwarded alive, some from points along the northern edge of the known range of *atrox*.

Of Mexican mainland material, not so much is available, but I have recently had the opportunity of seeing six live specimens of *atrox* from Sonora.

**CURRENT CLASSIFICATIONS**

The two most authoritative recent works covering the general herpetology of the southwest, or major portions of this area, appeared almost simultaneously. These are "The Reptiles of Western North
America” by the late Dr. John Van Denburgh, published November 23, 1922; and “The Amphibians and Reptiles of Lower California and the Neighboring Islands”, by Karl Patterson Schmidt, issued December 7, 1922. While both works did much to clarify previous uncertainties with reference to taxonomy and distribution, they are not fully in accord on many points. Stejneger and Barbour and likewise Blanchard in their widely used works have followed Schmidt in their treatment of the rattlers. More recently Dr. Afranio do Amaral has published several papers on the rattlesnakes, one of which deals particularly with the forms allied to atrox; he has also summarized his results in a key and phylogeny. Do Amaral in many conclusions does not concur with either Van Denburgh or Schmidt; these differences in some instances are important, as the writer has observed in attempting to verify relationships and ranges, particularly in Lower California.

Table No. 2 indicates the differences in designation utilized in these several papers.

<table>
<thead>
<tr>
<th>TABLE No. 2—RECENT CLASSIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Van Denburgh</strong> 1922</td>
</tr>
<tr>
<td>1 atrox</td>
</tr>
<tr>
<td>2 tortugensis</td>
</tr>
<tr>
<td>3 lucasensis</td>
</tr>
<tr>
<td>4 exsul</td>
</tr>
<tr>
<td>5 exsul</td>
</tr>
<tr>
<td>6 exsul</td>
</tr>
</tbody>
</table>

**Notes:**
- Line 4. Refers exclusively to the diamond-backs of Angel de la Guarda Island, described by Schmidt as a new subspecies, C. atrox elegans.
- Line 5. Refers to the mainland Lower California and California form.
- Line 6. Refers exclusively to snakes from Cedros Island.

---

1 Van Denburgh, 1922. Where a reference cited in a footnote likewise appears in the final list of references the complete citation is not repeated in the footnote.
2 Schmidt, 1922.
3 Stejneger and Barbour, 1923, p. 122.
4 Blanchard, 1925, p. 47.
5 Do Amaral, 1929 a.
6 Do Amaral, 1929 b, 1929 c.
RELATIONSHIPS OF SPECIES

I find it desirable to discuss the conclusions I have reached, first as between species and, secondly, in a summary of trends of characteristics through the group. While this involves some repetition, it has advantages in clarity of presentation and availability for reference.

The Southwest, and particularly Lower California and its adjacent islands, is interesting to the student of rattlesnakes, since this territory exhibits the highest variability in the development of the *atrox* group. In fact, all of the known representatives of this group, with the exception of *Crotalus adamanteus*, are to be found within this area.

The close relationship of the components of this group has been evident to all investigators. In size, form, scutellation and character of markings, they have much in common and, while average differences may be noted, the discovery of invariable key characters is difficult.

SURVEY BY SPECIES

Adamanteus:

*Crotalus adamanteus* will not be here discussed at length; this species, occurring only in southeastern United States, is evidently an independent offshoot of *C. atrox*, divergent from those forms found in the Southwest.

Atrox:

From several standpoints, *C. atrox* is the most important member of this group. There is evidence that it is the trunk from which the other species have branched, and furthermore, it is territorially by far the most widespread. (See Map 1). In Mexico it has been recorded from San Luis Potosi northward across the central tableland, and along the International Boundary it occurs from the Gulf of Mexico to the Gulf of California. In the United States it is widespread in Texas (except the eastern portion), Oklahoma, eastern and southern New Mexico, southern and western Arizona and southeastern California. Specimens have been recorded from south-central Colorado⁷ and in Arkansas.⁸ A colony recently noted in Wisconsin was no doubt started by escaped specimens from some snake exhibit.⁹ In Lower California it occurs at least in the

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⁹ Pope, T. E. B., 1928. Year Book of Public Museum of the City of Milwaukee, Vol. 8, Pt. 1, p. 167. Mr. Pope writes (Nov. 8, 1929), "Last week I received a letter from Mr. L. C. Stuart of the Museum of Zoology at Ann Arbor, Michigan, to the effect that a number of years ago, several specimens of this species (*atrox*) escaped from a circus in the vicinity of Pittsville in Wood County and that it is still rumored that a colony of them has become established along a creek a few miles to the west. Perhaps our specimens resulted from that accidental importation."
northeastern desert area. It is found on the Island of Tiburon in the Gulf of California. (See Appendix No. 1).

With a snake so widespread in its range and occupying territories so different in topography and climate, it might reasonably be expected that a number of subspecies would be shown to exist. However, to date I have not been able to determine consistent differential characteristics of geographical races. From Mexico, adequate material has not been available and it would seem that the greatest likelihood of discovering subspecies would be involved in segregating southerly and northerly forms.

Kennicott in 1861\(^\text{10}\) described Caudisona atrox var. sonoraensis from “Sonora and vicinity,” particularly based on the smoother appearance of the scales on the crown and the point of intersection of the postocular light stripe with the mouth. Cope, in one of his earlier papers,\(^\text{11}\) followed Kennicott, although in his later work he did not consider this subspecies valid. Recently, sonoraensis has been again revived by do Amaral,\(^\text{12}\) based on color, ventral scale count and character of markings. It is to be noted, however, that both Cope (in the 1861 paper) and do Amaral have included as representatives of sonoraensis, diamond-backs from the Cape region of Lower California. Remembering that Kennicott’s original description referred to specimens from Sonora and vicinity (no type specimen nor type locality was designated), it appears to me that this is an incorrect view of the situation. If we take a group, B+C, and differentiate it from A, the difference may be due to a difference between C and A, rather than a difference between B and A. This, in fact, is what seems to have occurred in do Amaral’s verification of sonoraensis. For the Cape specimens C do cause the group B (the Sonora specimens) plus C to diverge from A, the eastern specimens. But with the Cape specimens omitted, the difference is no longer appreciable.

Only twelve specimens of this species from Sonora have been available; however, such as there are show no important differences from Arizona material; and from the latter area, which might well be expected to have rattlers similar to those of Sonora, adequate specimens may be had. Besides, we may infer from our knowledge of the sources of Kennicott’s material that, by “vicinity” of Sonora, he meant southern Arizona. He

\(^\text{10}\) Kennicott, 1861, p. 206.
\(^\text{11}\) Cope, 1861, p. 292.
\(^\text{12}\) Do Amaral, 1929 a, p. 85.
states, in fact, that his *sonoraensis* is different from "the more eastern
types" and thus we know that he was not indicating a divergence of the
Sonora specimens from the northerly, or Arizona, form.

I have made a tabulation of the results of an examination of the 12
Sonora specimens, 90 specimens from Arizona, and 90 specimens from
Oklahoma and Texas. The results are indicated in Table No. 3, which
gives the average for each differential characteristic.

**TABLE No. 3—COMPARISON OF OKLAHOMA-TEXAS WITH
ARIZONA AND SONORA SPECIMENS OF
CROTALUS ATROX**

<table>
<thead>
<tr>
<th>Specimens examined</th>
<th>Oklahoma-Texas</th>
<th>Arizona</th>
<th>Sonora</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90</td>
<td>90</td>
<td>12</td>
</tr>
<tr>
<td>Scale rows</td>
<td>25.3</td>
<td>25.9</td>
<td>25.7</td>
</tr>
<tr>
<td>Ventrals, males</td>
<td>181</td>
<td>184</td>
<td>183</td>
</tr>
<tr>
<td>Ventrals, females</td>
<td>183</td>
<td>187</td>
<td>185</td>
</tr>
<tr>
<td>Caudals, males</td>
<td>25.5</td>
<td>25.0</td>
<td>25.4</td>
</tr>
<tr>
<td>Caudals, females</td>
<td>20.4</td>
<td>19.9</td>
<td>20.0</td>
</tr>
<tr>
<td>Supralabials</td>
<td>15.6</td>
<td>15.3</td>
<td>15.0</td>
</tr>
<tr>
<td>Infra labials</td>
<td>16.8</td>
<td>16.9</td>
<td>16.3</td>
</tr>
<tr>
<td>Percent, divided</td>
<td>6.0</td>
<td>11.8</td>
<td>8.3</td>
</tr>
<tr>
<td>first infra labials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scales before supraoculars</td>
<td>21.5</td>
<td>18.1</td>
<td>16.8</td>
</tr>
<tr>
<td>Minimum scale rows</td>
<td>4.98</td>
<td>4.27</td>
<td>4.58</td>
</tr>
<tr>
<td>Postnasal—upper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preocular contact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(percent, of each</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper preocular in</td>
<td>52</td>
<td>87</td>
<td>76</td>
</tr>
<tr>
<td>contact with</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>postnasal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact prevented</td>
<td>40</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>by upper loreal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact prevented</td>
<td>5</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>by canthal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indeterminate (border line)</td>
<td>3</td>
<td>3</td>
<td>...</td>
</tr>
<tr>
<td>Ratio total length</td>
<td>21.6</td>
<td>23.0</td>
<td>22.9</td>
</tr>
<tr>
<td>to head length</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio distance across</td>
<td>2.52</td>
<td>2.66</td>
<td>2.65</td>
</tr>
<tr>
<td>to distance between supraoculars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio tail to total length, males</td>
<td>0.0782</td>
<td>0.0757</td>
<td>0.0775</td>
</tr>
<tr>
<td>Ratio tail to total length, females</td>
<td>0.0608</td>
<td>0.0583</td>
<td>0.0590</td>
</tr>
<tr>
<td>Location of postocular light stripe</td>
<td>2.76</td>
<td>2.30</td>
<td>2.04</td>
</tr>
<tr>
<td>(scales in front of commissure)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body blotches</td>
<td>34.8</td>
<td>36.0</td>
<td>35.7</td>
</tr>
</tbody>
</table>

**Note:** Figures indicate averages unless otherwise stated.

It will be noted from the table that there appear to be no strongly
accentuated differences. The Arizona specimens do have a slightly
higher ventral scale count, and also the percentage of divided first infralabials is higher for the western specimens. Likewise they have a somewhat reduced number of scale rows between supraoculars, and number of scales on the nose, thus showing a simpler and probably more primitive scale formula. The relationship of the upper preocular to postnasal (see Plate 1, figs. 1-4), however, is more nearly normal in the eastern specimens, which have a higher percentage not in contact. Contact of the postnasal with the upper preocular is not usual in the rattlesnakes, atrox being the most conspicuous example having a high proportion with this contact; and the Arizona specimens are high amongst atrox. The western specimens appear to have a slightly smaller head and a proportionately shorter tail. But all of these differences, while they would probably continue to be consistent in larger series, are nevertheless so inconsiderable, and individual overlapping is so great, that I do not believe subspecific distinction justified.

In color, the Arizona specimens, and those of California likewise, usually are lighter, with a creamy or pinkish cast, compared with the darker gray or gray-brown specimens of Texas and Oklahoma. However, this characteristic also is not consistent, since specimens from the higher altitudes in Arizona are darker than those from the lowlands.

Referring to the specific differential characteristics mentioned by Kennicott, I find that the smoothness of the crown is by no means consistent. Instead of being smaller, the scales on the crown average somewhat larger in the Arizona and Sonora specimens. The intersection of the postocular light stripe does fall further back in the Arizona than in the Oklahoma-Texas specimens, yet the average difference in position is less than half a scale. Occasionally a single specimen will have the intersection at the second scale on one side and the third on the other.

As to the differences mentioned by do Amaral, these are primarily based on color and markings, but these likewise fail if we first withdraw the red-brown specimens from the Cape region and the adjacent islands (lucasensis). With these out, the remaining specimens, whether from Sonora or Arizona, are not sufficiently or consistently different from eastern representatives to warrant consideration as a separate subspecies. I have seen no specimens of atrox from California, Arizona or Sonora, alive or well preserved, approximating the red or red-brown color of ruber or lucasensis; or lacking the strongly characteristic atrox punctations which are absent in ruber and are present in lucasensis to a minor degree. (See Plate 2).
Lest too much importance be assigned to the difference in the ventral scale count between the eastern and western groups of *atrox*, I would state that the northern representatives of the former (from Oklahoma) more closely approximate the Arizona figures. (See Table No. 6).

It may be noted at this point that I have excluded from this study all specimens of *C. scutulatus*, a form often considered indistinguishable from, or a subspecies of, *atrox*, but which I believe to be a valid species, more closely allied to *confluentus* than *atrox*, as discussed elsewhere.\(^{13}\)

I therefore conclude that *C. atrox sonoraensis* is invalid, and that, as far as *atrox* may be judged from available material, the trinomial is not justified.

*Tortugensis*:

*C. tortugensis* is quite closely related to *atrox*, more so than to *lucasensis*, *ruber* or *exsul*. This form, first described by Van Denburgh and Slevin,\(^{14}\) was also recognized by Schmidt but has lately been considered invalid by do Amaral, who believes it without essential differences from *atrox* (*sonoraensis*).\(^{15}\) But I find, not only the color and pattern differences mentioned by the original describers, but likewise differences in scutellation and form as well, as will be noted by reference to Table No. 4.

Of these differences, I consider the postnasal-preocular relationship (see Plate 1, figs. 1-4) and the head size most definite and with the least overlapping. From the table it will be observed, as to the first characteristic, that 3 percent. of the available specimens of each species are borderline or intermediate cases. Of the *atrox* specimens 94 percent. either have contact between these two scales or such contact is prevented by an upper loreal; the remaining 3 percent. have such contact prevented by a lower loreal-canthal contact. But in *tortugensis* exactly an opposite ratio exists; only 3 percent. have a postnasal-preocular contact, while 94 percent. have such contact prevented by the lower loreal-canthal contact.

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13 Klauber, 1930, p. 117. See also Appendix No. 2.
14 Van Denburgh and Slevin, 1921, p. 398.
15 Do Amaral, 1929 a, p. 85.
TABLE No. 4—COMPARISON OF SPECIES OF THE ATROX GROUP

<table>
<thead>
<tr>
<th></th>
<th>Atrox</th>
<th>Tortugensis</th>
<th>Lucasensis</th>
<th>Ruber</th>
<th>Exsul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of specimens</td>
<td>222</td>
<td>18</td>
<td>42</td>
<td>95</td>
<td>20</td>
</tr>
<tr>
<td>Scale rows</td>
<td>25.5</td>
<td>26.8</td>
<td>26.7</td>
<td>28.7</td>
<td>27.1</td>
</tr>
<tr>
<td>Ventrals, males</td>
<td>183</td>
<td>185</td>
<td>189</td>
<td>193</td>
<td>191</td>
</tr>
<tr>
<td>Ventrals, females</td>
<td>186</td>
<td>187</td>
<td>191</td>
<td>197</td>
<td>194</td>
</tr>
<tr>
<td>Caudals, males</td>
<td>25.3</td>
<td>23.9</td>
<td>25.3</td>
<td>25.4</td>
<td>22.1</td>
</tr>
<tr>
<td>Caudals, females</td>
<td>20.1</td>
<td>18.5</td>
<td>19.9</td>
<td>20.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Supralabials</td>
<td>15.4</td>
<td>15.5</td>
<td>15.7</td>
<td>16.3</td>
<td>16.8</td>
</tr>
<tr>
<td>Infralabials</td>
<td>16.8</td>
<td>16.4</td>
<td>17.4</td>
<td>17.6</td>
<td>16.7</td>
</tr>
<tr>
<td>Percent. divided first infralabials</td>
<td>9.6</td>
<td>11.1</td>
<td>81.3</td>
<td>90.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Canthals</td>
<td>1.98</td>
<td>1.94</td>
<td>2.05</td>
<td>2.06</td>
<td>2.25</td>
</tr>
<tr>
<td>Scales before supraoculars</td>
<td>19.2</td>
<td>13.5</td>
<td>20.7</td>
<td>20.3</td>
<td>23.3</td>
</tr>
<tr>
<td>Minimum scale rows between supraoculars</td>
<td>4.56</td>
<td>4.20</td>
<td>5.84</td>
<td>6.50</td>
<td>7.62</td>
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<td>Postnasal—preocular contact (percent. of each type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper preocular in contact with postnasal</td>
<td>69</td>
<td>3</td>
<td>...</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>Contact prevented by upper loreal</td>
<td>25</td>
<td>...</td>
<td>76</td>
<td>25</td>
<td>87</td>
</tr>
<tr>
<td>Contact prevented by canthal</td>
<td>3</td>
<td>94</td>
<td>23</td>
<td>72</td>
<td>13</td>
</tr>
<tr>
<td>Indeterminate (borderline)</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td>Prenasal—supralabial contact (percent. of each type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prenasal in contact with supralabials</td>
<td>94</td>
<td>100</td>
<td>67</td>
<td>80</td>
<td>6</td>
</tr>
<tr>
<td>Partial contact</td>
<td>1</td>
<td>...</td>
<td>5</td>
<td>5</td>
<td>...</td>
</tr>
<tr>
<td>No contact</td>
<td>5</td>
<td>...</td>
<td>28</td>
<td>15</td>
<td>94</td>
</tr>
<tr>
<td>Ratio total length to head length</td>
<td>22.6</td>
<td>24.7</td>
<td>21.9</td>
<td>21.7</td>
<td>21.1</td>
</tr>
<tr>
<td>Ratio distance across to distance between supraoculars</td>
<td>2.62</td>
<td>2.71</td>
<td>2.34</td>
<td>2.21</td>
<td>2.14</td>
</tr>
<tr>
<td>Rostral shape (percent. of each type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher than wide</td>
<td>100</td>
<td>80</td>
<td>89</td>
<td>39</td>
<td>94</td>
</tr>
<tr>
<td>Equal</td>
<td>...</td>
<td>3</td>
<td>18</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Wider than high</td>
<td>...</td>
<td>20</td>
<td>8</td>
<td>43</td>
<td>...</td>
</tr>
<tr>
<td>Ratio tail to total length, males</td>
<td>0.0774</td>
<td>0.0747</td>
<td>0.0752</td>
<td>0.0694</td>
<td>0.0695</td>
</tr>
<tr>
<td>Ratio tail to total length, females</td>
<td>0.0594</td>
<td>0.0571</td>
<td>0.0549</td>
<td>0.0547</td>
<td>0.0554</td>
</tr>
<tr>
<td>Location of postocular light stripe*</td>
<td>2.42</td>
<td>2.77</td>
<td>2.47</td>
<td>2.67</td>
<td>2.67</td>
</tr>
<tr>
<td>Body blotches</td>
<td>34.9</td>
<td>36.5</td>
<td>30.2</td>
<td>35.9</td>
<td>31.9</td>
</tr>
<tr>
<td>Percent. of intergenials</td>
<td>1.5</td>
<td>15.1</td>
<td>1.4</td>
<td>3.0</td>
<td>91.6</td>
</tr>
</tbody>
</table>

Notes: Figures indicate averages unless otherwise stated. Island specimens are omitted from Lucasensis and Ruber tabulations. * Number of scales counting forward from the commissure.
The comparative head ratios of 24.7 in *tortugensis* and 22.6 in *atrox* constitute too great a difference to be the result of chance abnormalities.

The difference in average dorsal scale rows of 25.5 for *atrox* and 26.8 for *tortugensis* does not seem important, but expressed as in Table No. 5 showing 26 percent of *atrox* to have 27 rows against 89 percent of *tortugensis*, the difference is rendered more conspicuous.

As to pattern it may be noted that, in *tortugensis*, the light borders of the diamonds characteristic of *atrox* are absent except along the middorsal line. The dorsal blotches have a purplish cast and the general tone is darker than in *atrox*. The secondary or side series is more in evidence in the island form. The postocular light line in *tortugensis* seems invariably interrupted at the first scale row above the supralabials, this row being dark. This being an island form and, therefore, without possibility of territorial intergradation, I conclude that the differences of proportions, pattern and scutellation are sufficient to validate the species.

*Lucasensis* and *ruber*:

We now come to the Lower California mainland representatives of the *atrox* group. The Cape form is here referred to by Van Denburgh's designation, *Crotalus lucasensis*. Schmidt relegates *lucasensis* to subspecific status, as *Crotalus atrox lucasensis*. He says,\(^{16}\) "As *Crotalus atrox* certainly enters the peninsula of Lower California at the north, and as the differences on which *lucasensis* is based are slight, the use of a trinomial seems warranted." More recently, as above stated, do Amaral has referred this form to *Crotalus atrox sonoraensis*. Yet although the relationship is close and the original derivation of *lucasensis* from *atrox* is unquestioned, there are consistent differences, some of which are without overlapping; there appears to be no present indication of intergradation, nor is there any area in which such intergradation may reasonably be expected.

We first proceed to a geographical consideration of the situation. From Map 2 it will be noted that the closely allied *ruber* and *lucasensis* have been taken in three general localities, not including islands; first a northern area (southerly San Diegan and San Pedro Mártir) where the snakes are unquestionably *ruber*; secondly, the Cape region, where they are typically *lucasensis*; and lastly, a central area where rattlers have been taken at several points in the vicinity of Santa Rosalía and at San

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\(^{16}\) Schmidt, 1922, p. 699.
Bartolomé Bay on the opposite coast. A decision as to the classification of this last group is of obvious importance.

Mocquard, who first classified the diamond-back rattlers of this central district, referred to them as *C. confluentus.*17 He had five specimens, (two being with heads only). But later he referred to the same specimens as *C. confluentus var. atrox.*18 Van Denburgh, having available for study from this central area only one specimen (from Turtle Bay), classified this as *C. exsul*, and tentatively placed the Mocquard specimens in the same classification.19 Schmidt, while having available a good series from the Cape region, had from the central area only one specimen, from the head of Concepción Bay. This he classified as *C. atrox lucasensis*, placing the Mocquard specimens in the same category.20

I have examined six specimens from this central area; CAS 42047 from Turtle Bay, CAS 55886 and 59557 from San Bartolomé Bay, MVZ 10681 from San Ignacio, AMNH 6883 from the head of Concepción Bay and USNM 23884 from Playa María Bay. I have had a fairly wide experience, both in field and zoological garden, with *ruber*, which, once thought to be rare, is now known to be quite common in the foothills and mountains of southern and Lower California, from Riverside County south to the San Pedro Mártirs. From this experience and a tabulation of scale characters, I would unhesitatingly place these central Lower California specimens in the *ruber* classification rather than under *lucasensis*. They seem to have the same color and pattern differences from typical *lucasensis* of the Cape region that show in the San Diego County specimens. These color differences will be discussed more fully below. Mocquard’s color description of his specimens seems likewise to suggest *ruber* rather than *lucasensis*.

Returning to the relationship between *atrox* and *lucasensis*, we find that with the central district diamond-backs reclassified as *ruber*, the situation no longer has the aspect suggested by Schmidt. Instead of *atrox* and *lucasensis* being separated by a moderate distance with possible intergradation, we have on the contrary over 600 miles of mountain, valley and desert between the nearest recorded peninsula specimens of the two species; and what is probably as important as the distance, there ranges between them, *ruber*, another closely related species. The distance across

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17 Mocquard, 1899, p. 332.
18 Mocquard, 1909, p. 969.
19 Van Denburgh, 1922, p. 922.
20 Schmidt, 1922, p. 698.
the Gulf between the Cape region *lucasensis* and *atrox* of mainland Mexico is of course less; but with the sea between, *lucasensis* is sufficiently and constantly different to rank as a full species. *Lucasensis* cannot be considered a subspecies of *atrox* unless *ruber* is likewise.

As to the relationship of the two latter, if intergradation occurs it would be expected in the desert-foothill fringe of the mountains of San Diego, Imperial and Riverside Counties in California. Here, fortunately, extensive material is available. In San Diego County I have seen specimens of *ruber* far down on the eastern side of the mountains almost at the desert edge, from such localities as Borego Palm Canyon, Coyote Creek near Beatty's Ranch, San Felipe Valley,21 Sentenac Canyon, Yaqui Well, Dos Cabezas, Agua Caliente Spring (near Vallecito) and Mountain Springs. I have lately noted a specimen 5½ miles east of Mountain Springs on the El Centro highway, this being, so far as I know, the first specimen recorded from well within Imperial County.

*Atrox*, on the other hand, ranges westward across the Imperial Valley, at least to Seeley and Dixieland. Thus, only sixteen miles at most (probably less)21a separate the ranges of these two species. A similar condition exists in Riverside County, where *C. atrox* occurs in the Coachella Valley, having been collected at Indio, Coachella, Thermal and Mecca, while *rubcr* has been taken in the closely adjacent San Jacinto Mountains. But, while in Arizona and elsewhere, *atrox* is not only a snake of the floor of the desert, but is found at considerable altitudes on mesas and rock strewn mountains, in southern California, in habitats of similar character to the west of the desert, it has been supplanted by *rubcr*.

Examining these closely contiguous specimens of *atrox* and *rubcr*, we find that, while they exhibit minor differences from the typical forms, there still is no real evidence of intergradation. *Rubcr* from the desert edge is lighter and yellower in color, with lateral diamond borders more distinct than in those taken in the coast foothills. (See Plate 4). *Atrox* from California usually has the pinkish or creamy cast previously mentioned. Yet, even with these suggestive variations, *rubcr* and *atrox* still retain their constant differences of color, pattern, form and scutellation, fully deserving specific separation.

There is no reason to presume that the relationship between *rubcr*

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21 Not to be confused with San Felipe in Lower California.

21a Since the above was written two specimens of *atrox* have been collected at Carrizo Springs, San Diego County, California, by F. E. Walker, thus reducing the separation to ten miles. There is every reason to believe that *atrox* and *rubcr* contact or overlap in the narrow desert washes in this vicinity.
and atrox on the desert edge south of the International Boundary, from which locality few specimens of either are available, differs from that to the north.  

It will now be appropriate to discuss the characteristics whereby atrox, lucasensis and ruber may be differentiated, reference being again made to Table No. 4, which contains a summary of those points susceptible of statistical presentation.

From this table certain generalizations are at once evident. First, it may be noted, that some of the character differences which have been investigated do not show important or directive trends between these three species. Such average differences as are indicated, are of such minor character, compared with the range within a species, that they may be assumed the result of random deviations. On the other hand, some are so considerable that they cannot be deemed the result of chance. Amongst the latter may be included number of scale rows, ventrals, supralabials, infralabials, frequency of divided first infralabials, minimum scale rows between supraoculars, postnasal-preocular contact, head ratio, supraocular space ratio, rostral shape, tail length ratio, and the number of body blotches. Here we have some twelve more or less independent characters and, of these twelve, it may be observed that every one except the number of body blotches shows lucasensis to be intermediate between atrox and ruber. The same condition is found in color and markings. If we use in our comparisons only Arizona atrox instead of all specimens, the situation is unchanged.

With lucasensis thus lying in an intermediate position in eleven characteristics, it must next be determined which of the other two species it more nearly approaches. We find that it lies on the atrox side of the median in four characters, namely: Scale rows, supralabials, rostral shape and tail ratio. On the other hand lucasensis tends toward ruber in seven characteristics: Ventrals (average of both sexes), infralabials, divided

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22 Van Denburgh, 1922, p. 922 records exul (== ruber) as being found in the Cocopah Mountains of Lower California. This is a range of desert mountains in which ruber would not be expected based on my experiences in southern California. Investigation indicates that Van Denburgh published this locality on the authority of a list of U.S.N.M. specimens which presumably he had not seen. Amongst these is USNM 37566 from the east base of the Cocopah Mts.; this specimen was originally classified as exul but was later (and correctly) reclassified, by Schmidt, as mitchelli. The Cocopah locality for ruber should therefore be suppressed.

Another locality of similar character from the same list is given under lucasensis (p. 926) as “Pidaluingua [Pichilinque?] Bay”. An error seems to have occurred either in transcribing the list or reading the transcription; the original entry in the U.S.N.M. ledger under No. 15134 is quite clearly Pichilinque and therefore Pidaluingua, which is non-existent, should be suppressed.
first infralabials, minimum scale rows between supraoculars, postnasal-preocular contact, head proportion and supraocular spacing.

The tail length ratio does not appear to have consistent importance in locating the position of *lucasensis* with reference to the mean between *atrox* and *ruber*, since it shows a tendency in one direction for the males and in the opposite direction for the females. Similarly the labials may be eliminated, since the supralabials are on one side of the midpoint, while the infralabials are on the opposite. As to the ventrals, there is here not an important deviation from a mid position, or, at least, a deviation decided enough to be deemed more than accidental, for here again the sexes show opposite tendencies. Most important of all I consider the percentage of divided first infralabials, the postnasal-preocular relationship and the minimum scale rows between supraoculars, particularly the first two. We have here two characteristics, one of which marks *ruber* strongly amongst all rattlesnakes (except *exsul*) and another especially distinctive of *atrox*; and in both of these characters *lucasensis* is clearly nearer *ruber* than *atrox*. It would seem therefore that *lucasensis* is more closely allied to the former.

In markings likewise, while the close relationship of these three species is indicated, nevertheless differences are evident both in color and pattern. Comparing *lucasensis* with *atrox*, there will at once be noted a brightness and definite quality in the markings of *lucasensis* not evident in the other species. In *lucasensis* the light borders of the diamonds are quite clearly marked, even on the sides, while in *atrox* they are less distinct. *Lucasensis* usually has light areas within the diamonds; these are not evident in *atrox*. The same is true of the head stripes, which are definite and more in contrast with the ground color in *lucasensis*; the supraocular cross mark is more often in evidence and the preocular light stripe is wider and more distinctly outlined. The rostral of *lucasensis* usually has a light edge which is not present in *atrox*. The ground color or general tone of *lucasensis* is darker and tends to a red- or olive-brown, while in *atrox* the ground color is gray, buff or cream and the general effect, gray-brown.

In *atrox*, black or dark brown punctations, which constitute the most essential feature of both the dorsal and lateral blotches, are always prominently in evidence in well preserved specimens. They seem to constitute a third color in the general scheme, as if superimposed upon a lighter brown forming the base color of the blotches. These punctations are rarely evident in *lucasensis*, and when present are not so prominent a feature of the pattern. In *lucasensis* the dark interior borders of the
diamonds are relatively free from punctations and are definitely outlined; in *atrox* they are broken and consist largely of punctations. (See Plates 2 and 3).

Compared to *ruber*, *lucasensis* is seen at once to be intermediate with *atrox*, although more closely resembling *ruber*. The ground color of *ruber* is redder or pinker than *lucasensis*. However, the markings in *lucasensis* are brighter and more clearly outlined, the diamonds being more complete on the sides. In this particular *lucasensis* more nearly resembles specimens of *ruber* from the edge of the Colorado Desert. (Plate 4, fig. 2). In *lucasensis* the light areas in the centers of the diamonds are more in evidence, thus giving a triple color appearance compared with the two colors of *ruber*. Punctations of the *atrox* type seem never to be present in *ruber*.

In *lucasensis* the head markings are brighter than in *ruber* and in this particular *atrox* and *ruber* more nearly resemble each other than either resembles *lucasensis*. The preocular light stripe in *lucasensis* is wider and plainer than in *ruber*. The light edge of the rostral seems absent in *ruber*, even when from the desert edge.

Ventrally, *atrox* is usually buff or cream, *lucasensis* yellow and *ruberr* pink or salmon.

I have tried the experiment of classifying *atrox*, *lucasensis* and *ruberr* entirely on pattern and color, no recourse being had to scutellation. Thirty-two specimens of *atrox*, twelve of *lucasensis* and twenty-two of *ruberr* were well mixed in a large container. They were assorted adults and juveniles, specimens preserved in a uniform manner, and all in good condition. The classification proceeded about as rapidly as the specimens could be taken out and no errors were made. In most cases the general color effect was a sufficient criterion; the punctated blotches in *atrox* were particularly useful. One adult *atrox* from San Antonio, Texas, required a more careful consideration, for in this the punctations were not particularly striking and the olive touch characteristic of *lucasensis* was present to a certain degree. The dark, rather than light, blotch centers were, however, conclusive. Some newly born *ruberr* required care, as they lack the red tone of the adults, but the blotch characteristics permitted a correct decision.

An attempt to segregate the *atrox* specimens in the same manner between eastern and western forms resulted in 16 western specimens being correctly selected, this lot containing no easterners. But in the dark, presumably eastern group, out of 16, 7 were found to be from Arizona,
the other 9 being correctly chosen. Most of the 7 were from higher alti-
tudes.

Summarizing color and pattern, lucasensis and ruber, being both
fundamentally reddish or red-brown while atrox is gray-brown, are more
closely related to each other than to atrox, thus checking the findings based
on form and scutellation.

In disposition, the few live specimens of lucasensis that I have seen
were intermediate between the usually placid ruber and the nervous atrox.

As has been explained above, it seems hardly credible that with ruber
occupying the center of the Lower California peninsula, probably from
gulf to ocean, there can be any direct intergradation between atrox and
lucasensis. This being the case, the differences pointed out certainly justify
consideration of lucasensis as a species separate from atrox.

Next arises the natural question as to whether lucasensis and ruber
are specifically distinct. Is this a single species varying by degrees from
the Cape region of Lower California up the peninsula to the final range
limit in Riverside and Los Angeles Counties, California, or is there a
gap between the two? This cannot be definitely determined from the
material now at hand. If we divide available ruber material into three
groups, namely, Lower California, San Diego County, and other Cali-
fornia counties, no definite and consistent tendencies can be noted in any
characteristics. For instance, the San Diego County material has a some-
what lower ratio of first divided infralabials than the specimens to the
north and south, although there is not a sufficient difference to be con-
sidered important. On the other hand, the San Diego County specimens
have a higher number of scale rows, to a small degree, than the specimens
on either side. Thus, in one of these characteristics, there is a slight leaning
toward lucasensis and in the other a tendency away. Altogether, taken
as a group, these specimens of ruber seem to be quite homogeneous, with-
out a definite change from south to north. As to the particular six speci-
mens which have been taken in the vicinity of Santa Rosalia and San
Bartolomé Bay, which specimens are from the present southerly limit of
the known range of ruber, these show the following directive trends: They
show a tendency in seven out of fourteen characteristics to vary toward
lucasensis rather than away from it, i.e., they are on the lucasensis side of
the ruber mean; in the other seven characteristics they are on the opposite
side of the ruber mean from lucasensis. There is a brownish tone in the
color, especially in the gulf coast specimens; however, this tendency and
particularly the lateral light areas is not as striking in these specimens as in those from eastern San Diego County.

Two important tendencies are on the anti-*lucasensis* side of the *ruber* mean, these being the high percentage of divided first infralabials and the postnasal-preocular relationship; for all these southern representatives show contact prevented by an overlapping canthal, which is more characteristic of *ruber* than *lucasensis*. Thus the data so far available indicate, for *ruber* as a whole, a homogeneous unit without a marked trend at its southerly end toward *lucasensis*. *Lucasensis*, on the other hand, is known from so small an area that no territorial variations are to be expected.

Whether *lucasensis* will ultimately be shown to be a subspecies of *ruber* will depend upon the specimens that may be collected in the future between Concepción Bay and La Paz, from which territory at present no material is available. From the likeness between the two species, it might well be expected that they will finally be proven conspecific. On the other hand the character of the country is such that there may be an actual gap between their ranges. If this gap is filled by intergrades, the character variation which takes place from La Paz north to Concepción Bay must be more rapid and marked than that now found between Concepción Bay, Lower California and Riverside, California, the latter being a greater distance and one over which there is likewise much variation in ecological conditions.

From the tabulations presented in Table No. 4, island specimens of *ruber* and *lucasensis* have been omitted. It was thought that these might represent incipient races or subspecies and therefore it would be undesirable to modify the mainland averages by their inclusion. Grouped, the island specimens indicate nothing of particular interest. Of the specimens referred to *lucasensis*, a few show slight *atrox* tendencies; others lean toward *ruber* and the same is true of the *ruber* island specimens. A sufficient number of specimens is not available from any one island (with the exception of Cedros, mentioned elsewhere) upon which to draw definite conclusions. They are therefore considered to belong to the group which they most nearly resemble. Nor is it to be understood that these island specimens give anything like an adequate intergradative bridge between *atrox* and *lucasensis* or between *lucasensis* and *ruber*. They seem on the contrary to fall rather definitely either in the one species or the other. The inference may properly be drawn that these species once covered a much larger area now partially submerged.

In 1922 Schmidt described as *Crotalus atrox elegans* the snakes of
the diamond-back group found on Angel de la Guarda Island.23 Van Denburgh, in his publication of approximately the same date, had available two specimens from this island and considered these exsul (i. e., the form here referred to as ruber).24 Later do Amaral placed these island snakes in the classification which he called atrox sonoraensis.25 I have examined five Angel de la Guarda specimens and find that they present no outstanding differences from ruber either in color, form or scutellation. The ventral scale counts are high, all first infralabials are divided and the color is red; I therefore concur with Van Denburgh in classifying them as ruber.

Exsul:

We come finally to the snakes of Cedros (Cerros) Island, originally described by Garman as Crotalus exsul.26 These snakes I find to be sufficiently different from the mainland snakes, both in scutellation and pattern, to warrant specific separation, thus again reviving, for the mainland form, Cope’s designation Crotalus ruber.27 Differences in form and scale counts are indicated in Table No. 4. It will be noted that in some characters (i. e., scale rows, postnasal-preocular arrangement, prenasal-supralabial contact and shape of rostral) there is a tendency toward lucasensis. On the other hand, in the number of ventrals, percentage of divided first infralabials, minimum scale rows between supraoculars, and tail length ratio, the tendency is toward ruber, as it is also in color and pattern. In general it would appear that exsul shows the greatest trend of any member of this group to subdivision of head scales, as exemplified in the frequent separation of prenasals from supralabials, number of scales on the nose, high ratio of upper loreals, number of scale rows between supraoculars, etc. Not only has this species the highest percentage of upper loreals of any member of this group (87 percent. against 76 percent. in lucasensis), but also it is unique in having the prenasals separated from the supralabials in a majority of cases; 94 percent., compared with 25 percent. in island ruber, 15 percent, in mainland ruber, 25 percent. in island and 28 percent. in mainland lucasensis. And finally we have the

23 Schmidt, 1922, p. 699.
24 Van Denburgh, 1922, p. 922.
25 Do Amaral, 1929 a, p. 85.
26 Garman, 1883, p. 114.
most easily checked and definite of all the scale characters of this form, namely the presence of small paired intergenials in 92 percent., compared with 17 percent. in island l\textit{ucasensis}, 15 in \textit{tortugensis}, 7 in island \textit{ruber}, 3 in mainland \textit{ruber} and less than 2 percent. in mainland \textit{lucasensis} and \textit{atrox}. As far as differentiation from mainland specimens is concerned, this is as definite and consistent a scale character as is available in distinguishing \textit{Crotalus} species. (See Plate 1, fig. 10).

The snakes of Cedros Island are, compared with the mainland specimens, stunted. It is well known that \textit{Crotalus ruber} reaches a length in excess of 1830 mm. (6 ft.) ; on the other hand the longest available Cedros Island specimen measured 940 mm.\textsuperscript{28} This probably would be of little importance were it not substantiated by other characteristics. Stunted specimens of \textit{Crotalus confluentus oreganus} occur on Los Coronados Islands, and a stunted form of \textit{Crotalus confluentus confluentus} is common in the neighborhood of Winslow, Arizona.

The color differences of this form likewise are noticeable. The Cedros specimens are pinker, the mainland browner and darker. The island specimens have relatively larger blotches poorly defined anteriorly and with lateral edges ill defined throughout. The light, bordering scales of the \textit{exsul} blotches are pinker and less contrasting, while the \textit{ruber} blotches have whiter borders. In \textit{exsul} the secondary or side series of blotches is relatively poorly defined; and the blotches are more often subcircular, while in \textit{ruber} they are diamonds. In \textit{exsul} the tail stripes are often interrupted at some points and fused in others, so as to form marks approaching longitudinal stripes rather than circular rings, such as are always found in \textit{ruber}. Altogether there is every indication that \textit{exsul} has been separated from the mainland for a very long time, so that the differentiation is now quite definite and consistent.

**SURVEY OF DIFFERENTIAL CHARACTERISTICS**

It will be of interest to discuss differential characteristics, not from the standpoint of individual species, but rather to show trends through the group.

\textsuperscript{28} Schmidt, 1922, p. 700, mentions a "very large specimen USNM 64588 of this species, without definite locality, but almost certainly from Cedros Island." I have examined this specimen and would classify it as \textit{mitchelli}, which species not having been definitely recorded from Cedros based on any other specimen, the locality should be considered uncertain. At any rate this specimen does not weaken the theory that \textit{exsul} is a comparatively small species.
Dorsal Scale Rows:

The number of dorsal scale rows is, of course, always of primary importance in ophidian classification. In the particular group here under consideration the differences are not sufficient to be utilized as key characters. Nevertheless the trend from a normal 25 in *atrox* to a normal of 29 in *ruber* is evident. Table No. 5 summarizes the situation, from the material thus far at hand, somewhat more completely than can be shown in the tables which give averages only. A rather definite trend in *atrox* from east to west and thence through *tortugensis*, *exsul* and *lucasensis* to *ruber* will be noted. This is one character in which *exsul* is nearer *lucasensis* than *ruber*.

**TABLE No. 5—SCALE ROWS**

(Distribution in percent.)

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</table>

**Notes:** Five scattered specimens having even rows are grouped with the next lower odd class.
* Two specimens only.

Some study has been made of the dropping of scale rows without definite conclusions having been drawn. In general, it is believed that *atrox*, starting with a mid-body count of 25, first drops the 6th on each side to 23, then again the 6th to 21, and finally the 7th to 19. With a mid-body count of 27, rows are dropped in the order, 7, 6 and 6 to 21. *Ruber* starting with 29, drops the following: 6 or 7, 7 or 8, and finally 5 or 6 to 23; if starting with 31, the first row dropped is the seventh followed by the
previous order. However, the accuracy of these figures is not entirely trustworthy, for I find it often difficult to ascertain, in this genus, which of two scale rows is actually dropped. Two rows are condensed to form one, but as the two approach combination they remain of virtually equal size, so that there might be a difference of opinion as to which is finally suppressed. Similarly, it is often found that three rows seem condensed to form two, and in such case it is usually presumed that the middle row is the one dropped. Occasionally the suppressed row will reappear for a short space in the form of a few scattered scales. Sometimes a specimen with a subnormal number of dorsal scale rows will have a few scattered scales on one or both sides, indicating the location of the row which has failed to appear.

The keeling of the dorsal scales has been somewhat used in rattlesnake classification and may be relatively effective in distinguishing between widely divergent forms, but it does not seem to be useful in such closely related species as constitute the _atrox_ group. This again is a character which might be given varying interpretations by two investigators of the same specimen; for while the dorsal scales are always strongly carinated, those on the sides become progressively less so, and it is difficult to determine on which row the ridge finally disappears. Held at an appropriate angle with the light, faint evidences of keeling are sometimes to be seen, which normally would not be noted. Methods of preservation and particularly the crowding or softening of specimens appear likewise to affect this character.

In the group here under consideration all but the first row or, more often, the first and second rows on each side are keeled.

**Ventral s:**

The ventral scale count is one of the most useful of all characters by reason of its definiteness and ease of determination. Even live specimens can be quite accurately counted by holding them tightly with a bundle of rags or waste against a glass surface and then turning the entire assembly upside down. With the rattlesnakes there is seldom a question as to more than one or two scales at the throat; that is to say, whether or not these are true ventrals or head scales, and likewise few half scales in the series are encountered to complicate the situation.

Variations in the group now under discussion are indicated in Table No. 6. There will be noted a rather definite increase westward in _atrox_
from Texas to Arizona and California. A few extreme southerly specimens from Mexico show low counts. In the group as a whole, the increase continues progressively through *tortugensis*, *lucasensis* and *exsul*, reaching its highest development in *ruber*.

**TABLE No. 6—VENTRALS**

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<th>Males</th>
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<td>194</td>
</tr>
</tbody>
</table>

**Caudals:**

In *Crotalus* the caudal scale count is neither as definite nor as important as that of the ventrals, except in some few species of peculiar form, as, for instance, *stejnegeri*. There is some indefiniteness as to the proper point of beginning and terminating the count at each end of the series, especially at the rattle, at which point the scales on the ventral surface tend to break up and fan out into small scales resembling dorsals. In this group, scales at either end of the series are often divided; this occasionally occurs in the middle.

A tabulation of the results of this investigation is contained in Table No. 7. Aside from evidence of some reduction in island forms, I do not believe there are sufficient differences to be deemed more than the results of chance.
Klauber: Rattlesnakes Allied to Crotalus Atrox  

TABLE No. 7—CAUDALS

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</table>

**Labials:**

The supralabials constitute a definite and interesting characteristic; seldom are there abnormal scales to render the count questionable. In the group under consideration, the fifth supralabial is usually the largest; occasionally the sixth, particularly in *ruber*. I have made some tabulations of the supralabials which touch the large scales forming the border of the pit, but this has failed to disclose anything of interest in the *atrox* group, although this characteristic may prove of service in the genus as a whole. Some species give indication of a coalescence of the last two supralabials into a single long scale in contrast to the rest of the series, but this feature is not found in the *atrox* group.

From Table No. 8 it will be noted that there is a progressive tendency of the supralabials to increase in *atrox* from the south in Mexico, to the north in the United States, and that there is also an increase through *lucaseensis* and *ruber* to *exsul*, which constitutes the ultimate in the subdivision of these scales, as it often does in other scale characters as well.
**TABLE No. 8—LABIALS**
(Total counts. Infralabials in bold face)

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<td>15</td>
<td>60</td>
<td>71</td>
<td>21</td>
<td>4</td>
<td>...</td>
<td>...</td>
<td>17.6</td>
</tr>
<tr>
<td><strong>EXSUL</strong></td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>21</td>
<td>8</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>13</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>16.7</td>
</tr>
</tbody>
</table>

The infralabials are of the same general nature as the supralabials, the results being likewise shown in Table No. 8. However, it is interesting
to observe that here the island forms have lower average counts than the mainland, and that the highest averages are reached in *ruber* rather than *exsul*.

The division of the first infralabials is one of the few relatively consistent key characters which can be used within this group. This division is occasional in a number of *Crotalus* species, having been noted in several of the subspecies of *confluentus*, but there it is present in proportionately few specimens. In the *atrox* group, however, it shows progressive and consistent development from east to west; for the Texas and Oklahoma specimens of *atrox* show 6 percent., Arizona 12 percent. and California 18 percent. divided. Specimens from Sonora average 8 percent. From Lower California not enough specimens of *atrox* are available upon which to base a conclusion. *Tortugensis* has 11 percent. divided. But immediately we come to the California and Lower California species other than *atrox* and *tortugensis*, whether from islands or mainland, we have no group with less than 80 percent. divided; for island *ruber* have 80 percent., island *lucasensis* 92 percent., mainland *lucasensis* 81 percent., mainland *ruber* 90 percent., and *exsul* 100 percent. This, therefore, proves to be an important character, one easily checked, and one which seldom fails to differentiate *atrox* and *tortugensis* from the purely Californian forms. (See Plate 1, figs. 8 and 9).

**Head Scales:**

The shape of the rostral has often been used in the classification of rattlesnakes, as in other genera. In *Crotalus* it is found to be a fairly good character in some cases, but difficult of interpretation in others. *Tigris, stephensi* and *enyo*, for instance, usually have rostrals so much wider than high, that the character may be used in distinguishing from related species. On the other hand there are some species in which great variability is found, as for instance, in *mitchellii*. There is further complication in the condition of many specimens and the peculiar shape of the rostral in others, even though well preserved; for often there are long lateral points at the lower corners of the triangle which are curved under the first supralabials, thus rendering it difficult to determine with accuracy either the altitude of the triangle or the width of its base.

In the present group it is interesting to observe that in *atrox* the height is proportionately so much greater than the width (about 35 percent.

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29 An investigation of an entirely separate lot of 26 specimens showed 96.2 percent. divided.
cent.) that there is never a borderline case, and all specimens examined were found to have rostrals higher than wide. On the other hand, in tortugensis there is an approach toward equality, so that only 80 percent. of the specimens are higher than wide. In the California forms there is a gradual progression through exsul and lucasensis to ruber (see Table No. 4), in which it is found that 43 percent. of rostrals are wider than high. However, in ruber there is so often approximate equality, that accuracy cannot be assured; it is sufficient to note that the marked superiority of height evident in atrox has been lost.

The contact of the prenasals with the rostral is always positive in this group, except that in exsul there is evidence of the beginning of the division which is so characteristic of mitchelli. It may be noted in mitchelli, that the separation is caused by the splitting of the prenasal rather than the rostral itself, as can be observed from transition specimens allied to stephensi. This splitting is also occasional in oreganus, particularly Arizona specimens. Here, in exsul, we again note this impending separation, and in USNM 24397 it is actually in evidence on the right and partially so on the left.

The other scales in contact with the rostral are a pair of internasals; rarely indeed, in the atrox group, are these in any way disturbed. They constitute, in the forms now under discussion, a quite definite character, thus differing from the confluentus group in which the internasals may vary from two to six or more.

The intersection of the prenasal with the first supralabial is often prevented by the extension of the group of small scales anterior to the pit. (See Plate 1, figs. 5-7). Sometimes but a single one of these scales will be present and in contact with the rostral, followed by a gap in the row which permits contact of supralabial and prenasal. This I have considered partial contact (Plate 1, fig. 6).

In the present group, Table No. 9 indicates a specific variation in contact. There is no pronounced geographical difference in atrox itself, but immediately we come to the California forms, it will be noted that absence of contact is quite frequent. By far the greatest deviation from what may be considered the rattlesnake normal is found in exsul, in which a majority of the specimens show lack of contact. The figure of 94 percent. for 20 specimens is quite conclusive on this point.
KLAUBER: Rattlesnakes Allied to Crotalus Atrox 29

TABLE No. 9—PRENASAL—SUPRALABIAL CONTACT
(Percent. in each class)

<table>
<thead>
<tr>
<th>Contact</th>
<th>Part Contact</th>
<th>No Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATROX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td>90</td>
<td>2</td>
</tr>
<tr>
<td>California</td>
<td>100</td>
<td>...</td>
</tr>
<tr>
<td>Mexico</td>
<td>95</td>
<td>...</td>
</tr>
<tr>
<td>New Mexico*</td>
<td>100</td>
<td>...</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>92</td>
<td>...</td>
</tr>
<tr>
<td>Texas</td>
<td>97</td>
<td>1</td>
</tr>
<tr>
<td>All atrox</td>
<td>94</td>
<td>1</td>
</tr>
<tr>
<td>TORTUGENESIS</td>
<td>100</td>
<td>...</td>
</tr>
<tr>
<td>LUCASENSIS, Islands</td>
<td>75</td>
<td>...</td>
</tr>
<tr>
<td>Mainland</td>
<td>67</td>
<td>5</td>
</tr>
<tr>
<td>RUBER, Islands</td>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>Mainland</td>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td>EXSUL</td>
<td>6</td>
<td>...</td>
</tr>
</tbody>
</table>

* Not conclusive, only 2 specimens.

Back of the internasals, along the canthus rostralis, there is on each side a pair of scales which may be termed canthals. These likewise are rather consistent in the atrox group, although subject to wide variations in other species of the genus. The posterior canthals are conspicuously larger in size than either the internasals or the precanthal in atrox; in lucasensis and ruber the difference is less pronounced and occasionally the middle is the larger. Rarely in atrox and tortugensis the internasals and precanthal are fused. Thus we find that the canthals for all atrox average 1.98 and for tortugensis 1.94. On the other hand, in lucasensis, ruber and exsul, there is an occasional specimen found with three canthals on one or both sides, which brings the average for lucasensis to 2.05, with 2.06 for ruber and 2.25 for exsul.

On the top of the head between the canthals, as far back as the anterior portions of the supraoculars, lies a group of scales which, while not of orderly arrangement in most species of rattlesnakes, is of distinct interest in classification. In some species, as for instance, the degenerated forms, triseriatus and lepidus, or in certain large species like terrificus, the
canthals (now become prefrontals) and internasals may constitute the sole occupants of this area. In some, as for instance, *molossus* and *scutulatus*, there may be a collection of plates approaching a definite but not universal pattern. In still others of which the *confluentus* and *atrox* groups are representative, this area is usually filled with a number of small and irregularly arranged scales, sometimes interspersed with a few larger scattered plates. The posterior boundary of this area, usually accurately defined by a suture in *scutulatus* and *molossus*, has no definite limit in the *atrox* group, and therefore the counting of the scales on the anterior portion of the head is not a thoroughly accurate procedure. However, some interesting conclusions may be drawn, and, in this particular group, it is noted that we have an increasing number of scales in this area from a minimum in *tortugensis* to a maximum in *exsul*. Geographical variations within *atrox* appear unimportant; Texas and especially Oklahoma specimens have a somewhat greater number of scales than Arizona and California individuals. *Atrox, lucasensis* and *ruber* show no great differences from each other, the latter form being the intermediate of the three, while *lucasensis* is the higher. In character these scales appear more carinated in *atrox* than in the *lucasensis* or *ruber* and are set at angles posteriorly divergent, a condition not so evident in the other two forms.

I find the postnasal-preocular contact, which characteristic likewise involves the number of loreals, to be highly interesting, and, in this group, of some considerable importance. This constitutes a rather good characteristic for distinguishing badly faded specimens of *scutulatus* from *atrox*.

There seem to be four arrangements of the scales at this point: (1) Contact between the postnasal and upper preocular, usually without the presence of an upper loreal, but occasionally in spite of the presence of such a scale. (Plate 1, fig. 1). (Rarely in *atrox* even the lower loreal is absent). (2) The presence of a smaller upper loreal, preventing contact between the postnasal and the upper preocular. (Plate 1, fig. 2). (3) Contact between the postcanthal and the lower loreal, thus preventing contact between the postnasal and the upper preocular. (Plate 1, fig. 3). (4) And finally we have borderline cases in which the postnasal, postcanthal, upper preocular and a single loreal all meet at a point. (Plate 1, fig. 4).
Table No. 10 gives the results in percentage form of the investigation of this character in the *atrox* group. Here again we note a transition from *atrox* with a predominance of the first class and a few of the second, through *lucasesis* with a majority of the second class to *ruber* with a predominance of the third. In this characteristic, *exsul* is more nearly related to *lucasesis* and not, as usual, to *ruber*. Probably most interesting of all is *tortugensis*, which, in its high percentage of the third type shows a definite deviation from *atrox*. *Atrox*, in fact, in the predominance of the first type, shows divergence from all other rattlesnakes, and presumably, therefore, *tortugensis* is more closely akin to the ancestral type.

In this group the supraoculares are rarely, if ever, sutured or indented, although often of rough texture and striated, particularly in *atrox*. This characteristic is of interest in the case of other species, especially of the *confluens* group, in which some specimens having circular swirls are found which apparently are related to the development culminating in the horn of *cerastes*.

The average number of scale rows between the supraoculares, a character of much interest in the determination of *sclerulatus*, does not show great variation in the *atrox* group. This is a character not always easily evaluated, since the scale rows do not lie evenly and therefore cannot
be accurately counted as rows. It is necessary to scan the area to determine the minimum bridge and the result is frequently not typical by reason of the fusion of several scales into a single larger plate. In _scutulatus_ and other species of relatively constant and even formation, the minimum bridge is always at the anterior edge of this area; but in the other, more irregularly formed species, the minimum may be found further back, particularly at the center point where the supraoculars are nearest together.

It is at this point, likewise, that the determination of the ratio of the distance across the supraoculars to the space between them is made, a somewhat useful character in specimens which have not been distorted in preservation. It is quite accurate if the measurements can be made immediately after the specimen has been killed, before the head has been pressed out of shape in the container. It is obvious that these two characters, that is, the supraocular space ratio and the minimum bridge, are not entirely independent.

The results for this group are indicated in Table No. 11, from which it will be noted that there is a rather definite trend in both characteristics, from _tortugensis_ through _atrox, lucasensis_ and _ruber_ to _exsul_.

**TABLE No. 11—SUPRAOCULAR SEPARATION**
(Percent. of each number)

<table>
<thead>
<tr>
<th>Minimum Scale</th>
<th>Rows between Supraoculars</th>
<th>Supraocular</th>
<th>Arizona</th>
<th>21</th>
<th>43</th>
<th>26</th>
<th>9</th>
<th>1</th>
<th>Ave.</th>
<th>Ratio†</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATROX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td>43</td>
<td>43</td>
<td></td>
<td></td>
<td>1</td>
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<tr>
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<td></td>
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<td>25</td>
<td>75</td>
<td>1</td>
<td>5.75</td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>39</td>
<td>39</td>
<td>13</td>
<td></td>
<td>1</td>
<td>4.57</td>
</tr>
<tr>
<td>New Mexico*</td>
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<td></td>
<td></td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>4.50</td>
</tr>
<tr>
<td>Oklahoma</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>62</td>
<td>42</td>
<td>8</td>
<td></td>
<td>1</td>
<td>5.50</td>
</tr>
<tr>
<td>Texas</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>32</td>
<td>45</td>
<td>21</td>
<td>1</td>
<td>1</td>
<td>4.89</td>
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<tr>
<td>All atrox</td>
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<td></td>
<td></td>
<td>11</td>
<td>36</td>
<td>36</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>4.56</td>
</tr>
<tr>
<td>TORTUGENSIS</td>
<td></td>
<td></td>
<td></td>
<td>80</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>4.20</td>
</tr>
<tr>
<td>LUCASENSIS, Islands</td>
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<td></td>
<td></td>
<td>17</td>
<td>17</td>
<td>32</td>
<td>17</td>
<td></td>
<td>1</td>
<td>6.17</td>
</tr>
<tr>
<td>Mainland</td>
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<td></td>
<td></td>
<td>8</td>
<td>27</td>
<td>43</td>
<td>16</td>
<td>6</td>
<td>1</td>
<td>5.84</td>
</tr>
<tr>
<td>RUBER, Islands</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td>10</td>
<td>60</td>
<td>10</td>
<td>7.40</td>
</tr>
<tr>
<td>Mainland</td>
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<td></td>
<td></td>
<td>4</td>
<td>13</td>
<td>31</td>
<td>34</td>
<td>15</td>
<td>3</td>
<td>6.50</td>
</tr>
<tr>
<td>EXSUL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>38</td>
<td>44</td>
<td>12</td>
</tr>
</tbody>
</table>

* Not conclusive, only 2 specimens.
† Ratio of distance across supraoculars, to space between. The table shows the average for each species.
In the *atrox* group there are two characteristically shaped preoculars, the upper being larger, the lower crescent shaped, and so pointed, in fact, that occasionally it is not in actual contact with the eye. These species seem rarely to have a corner of the upper preocular cut off to form a third preocular. There is no tendency toward vertical or angular splitting of the upper preocular as in *mitchelli*. It is difficult to draw a line between post- and suboculars, and consequently, in recording, I have usually combined the two. The group as a whole shows no trends of interest in the number of these; it is of course a characteristic of interest in other species of the genus.

The scale rows between supralabials and orbit likewise constitute an unsatisfactory character in this group. Usually there is a pointed scale adjacent to the lower preocular upon which the opinion of observers might differ as to whether or not it truly constitutes an ocular. Further, there is an increasing number of rows posteriorly, so that the location and the angle at which the count is made affects the determination and the result is illusive. Similarly, the temporals constitute a character which does not seem to be useful in this group.

The keels on the posterior portion of the head in *atrox* seem to be more accentuated than in other species.

Below, we find no important variations in the mental. The genials seem to be proportionately somewhat longer and more sharply pointed in *atrox* than the other species, but this character is not always consistent. The number of infralabials in contact with the genials has been investigated without important results for this group, being normally three on each side for all species. In this investigation the first pair has been considered to be in contact, even though it may be divided.

The division of the first infralabials at their posterior ends into an additional pair of small triangular scales which may be called intergenials, is another interesting characteristic, largely but not entirely restricted to the *atrox* group. (See Plate 1, fig. 10). This division has been noted occasionally in subspecies of *confluentus*, but seems to be present in a very small percentage of specimens. Of the *atrox* group, it apparently reaches its highest development in island forms, for while the mainland specimens show 1.5 percent. for *atrox*, 1.4 percent. for *lucaseus* and 3.0 percent. for *rubus*, *tortugensis* shows 15.1 percent., island *lucaseus* 16.7 percent., and island *rubus* 7.1 percent. It is in *exsul*, however, that we find this character developed to a maximum, for in 18 specimens no less than 91.6 percent. of
the first infralabials have this division and the result is a key character which is about as constant as any scale character amongst the larger rattlesnakes.

I have not examined *adamanteus* for this character, but evidently some specimens have intergensials, since Baird’s figure in the Pacific Railroad Report shows such a division.30

**FORM:**

In form the species of the *atrox* group are much alike in proportion; stout and heavy of body with large heads. The head ratios shown in Table 4 indicate a rather definitely smaller head for *tortugensis*. *Atrox*, *lucasensis* and *ruber* are, as usual, intermediate, the former having a slightly smaller head proportionately than the two latter. *Exsul* has proportionately the largest head of all, though the difference from *ruber* is not great. Geographically, within *atrox*, Arizona and California specimens have slightly smaller heads than eastern specimens. Head ratios are of little value unless relatively large series are available, since individual deviations are to be expected, owing to the distortion of heads in preservation. Therefore, extremes must not be taken too seriously, and it is always advisable, where possible, to make measurements on freshly killed specimens while they are still limp.

Specimens seen alive indicate a sharper canthus rostralis in *atrox* as compared to *ruber*, though *atrox* itself in this regard does not present the angular appearance so characteristic of *scutulatus*.

Tail length ratios are highly variable, but indicate a rather definite trend from *atrox*, though *lucasensis* to *ruber*, the former having the longer tail.

From the rattles some interesting conclusions may be drawn, particularly where large numbers of snakes of a variety of species are investigated. It is a far cry from the minute rattles of *stejnegeri* and some of the forms of *Sistrurus* to the huge rattles occasionally found in *atrox* or *durissus*. For instance, I have seen adult specimens of *stejnegeri* with rattles 3 mm. across, while specimens of *atrox* have been noted having rattles 21 mm. and *durissus* 23 mm. wide. From the lengths of strings of rattles, if terminated in the original button, some deductions may be made as to the habitat of rattlesnakes, since if long strings with high numbers of rattles often occur in a species, it may be concluded that it is

30 1859, Vol. X. Reptiles: Plate XXIV, fig. 2, l.
Klauber: Rattlesnakes Allied to Crotalus Atrox

usually found in sandy areas rather than amongst rocks or brush, where the rattles would naturally be broken more frequently. Again, island species seem to have longer strings than mainland, probably because they are less often disturbed and have fewer enemies. From complete strings, that is, those terminated in the original button, one may make deductions as to relative sizes as between species. For an investigation of this character, however, a rather large number of specimens with complete strings must be available.

When rattles have reached parallelism, particularly if a long string of even sized rings is noted, one may conclude that an adult specimen is at hand, independent of other characters. By this means we are able to deduce that exsul does not reach a length of much more than half of ruber and this is borne out by the specimens at hand. Similar conclusions may be drawn with reference to oreganus on Los Coronados Islands, and confluentus in the vicinity of Winslow, Arizona. I believe that ruber on Angel de la Guarda Island is a somewhat smaller form than that of the mainland.

It is of interest to note the color of the terminal rattle, that is, the one next to the tail. For instance, in the atrox group the terminal black tail ring engages the rattle so that the last rattle is almost invariably black, whereas in scutulatus the last tail ring does not normally engage the rattle and the terminal rattle is therefore usually horn colored, except for a spot of black at the top.

From the standpoint of the atrox group alone, not much is to be deduced from the rattles except the relative sizes of exsul and Angel de la Guarda ruber as above mentioned. Tortugensis seems to be a somewhat smaller snake than atrox.

It is well known that adamanteus and atrox are unique amongst the rattlesnakes from the standpoint of size, with the possible exception of terrificus. Ruber and lucasensis closely follow these, but probably do not reach the extremes noted in the others. I have not myself made measurements of any remarkably large rattlesnakes in this group, but the literature is replete with references, and I have seen some large specimens in snake shows and zoos.
PATTERN:

The head markings of the *atrox* group are characteristic of the group as a whole, rather than of the individual species, and thus key characters are not to be secured from them except possibly in the case of *adamanteus* and *lucasensis*. *Adamanteus*, which I have not studied intensively, is usually identified by a light vertical line on the prenasal and first supralabial. All of the *atrox* group have a light stripe passing rather sharply downward and backward from the upper preocular to the mouth, the angle being steeper than in *confluentus*. This stripe is particularly broad and well defined in *lucasensis*. It is only moderately evident in *atrox* and *tortugensis*, while in *ruber* and especially in *exsul* it is sometimes obsolete in adult specimens.

A postocular light stripe of characteristic form is evident in the *atrox* group, and constitutes, in well preserved specimens, one of the most constant differences from the *confluentus* group and *scutulatus*. In *atrox* and its relatives, this line, one scale wide, arises at the upper posterior corner of the eye and passes backward and downward to intersect the mouth, usually at the second or third scale anterior to the commissure. Occasionally this line may be broken in transferring from one scale row to another, since it seems to follow scale rows rather than cross them. The point of intersection at the mouth varies somewhat in *atrox*, being further back in Arizona and Mexico than in Texas specimens. However, the difference is not sufficiently marked, nor constant, to be considered a key character. In *lucasensis* it is somewhat further advanced and in *ruber* and *exsul* still more so, yet in all of these, as will be seen by Table No. 4, the intersection averages between the second and third scales. Extreme variations in almost any species will be found to run from the first to the fourth supralabial, counting forward from the angle.

I have not seen any representative of the *atrox* group in which this postocular light stripe, if clearly in evidence, did not intersect the mouth. It is often obsolete in adult *ruber* and particularly in *exsul* and is indeterminate in many faded, poorly preserved specimens. Rarely a specimen of *atrox* may be seen in which there is apparent a tendency of this stripe to branch upon approaching the mouth, one branch intersecting in the usual way, the other passing backward above the commissure in a manner characteristic of *confluentus* or *scutulatus*. In the *atrox* group the line is rarely other than one scale wide.

The supraocular light cross dash so characteristic of all juvenile
specimens of *confluents* and the adults of most subspecies as well, takes a different form in *atrox* and its relatives, for here, instead of having definite borders of a contrasting color, it is usually merely a light area, or a light line with ill defined edges. It is absent in many adults (less often in *lucasensis*) and is rarely to be seen in adult *ruber* or *exsul*.

Aside from these light marks there are no conspicuous marks in the *atrox* group corresponding to the consistent head blotches present in some other species of the genus. *Atrox* and *lucasensis* are irregularly mottled, *ruber* more unicolor.

Primarily, the body pattern of all species of the *atrox* group consists of a series of dorsal diamonds with a secondary series of smaller blotches of double frequency on each side. The dorsal diamonds, from which the group derives its common name of “Diamond-backs,” are conspicuous in most species; especially so in *adamanteus* and *lucasensis*; somewhat less so in *atrox*, and still more poorly defined in *ruber* and *exsul*. The blotches are normally darker anteriorly; usually they are bordered by a row of light colored scales or light-edged scales, these being particularly evident in *lucasensis* and many specimens of *atrox*. The blotches are less often truncated longitudinally than in *confluents* or *scutulatus* and thus tend to be diamonds rather than hexagons. They are not open and extended down the sides as in *molossus, enyo* and *stephensi.* In *tortugensis* and in many specimens of *ruber* and *exsul*, the light borders are lacking, except on the middorsal line. In *exsul*, especially in the adult specimens, the borders are so poorly defined anteriorly that the blotches cannot be counted with certainty. In this species, likewise, the blotches tend toward a circular form.

The general tone of *atrox* is gray, or gray-brown; *tortugensis* is gray. *Ruber* and *exsul* are red or red-brown; *lucasensis* red-brown or olive-brown. The blotches in *atrox* are brown and in *tortugensis* purplish-brown. Both of these species are characterized by a punctated application of color, with many dark dots, of a size clearly visible to the unaided eye, upon a somewhat lighter blotch, as if the blotches were of a dual color. This is the most noticeable of all the pattern characteristics of *atrox*, and serves most readily and clearly to distinguish live specimens from any of the other members of the group, or from *scutulatus*. In *lucasensis*, punctations are

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31 I have lately seen two specimens of *ruber* in which the main blotches were opened laterally and were confluent with half the secondary series resulting in bands similar to those of *molossus*.
usually somewhat in evidence, but there is not the two color effect in the color application. In *ruber* and *exsul* conspicuous punctations are absent. (Plates 2-4). The light lines which form the borders of the blotches are usually white or tan in all species of the group; there is a tendency to pink in *exsul*. No great difference in number of body blotches, between *tortugensis*, *atrox* or *ruber* is to be noted, but there is a distinct reduction in *lucasensis* and *exsul*.

Ventrally, the *atrox* group is not strongly marked as is usual in *confluentus*, but may be lightly punctated with ground colored dots on a lighter background; thus *atrox* is usually cream, *lucasensis* yellow and *ruber* pink or salmon.

The sharply contrasting ash colored tail, crossed with jet black rings, is highly characteristic of the entire *atrox* group, and is one which distinguishes it quite readily from all other rattlesnakes. It is true that some specimens of *mitchelli* do have contrasting tail colors, but the rings are narrower and the contrast with the rest of the body not so extreme as in *atrox*. In *scutulatus* the black contrasting tail rings and the ash colored ground are present, and this is probably a characteristic which has so frequently led to *scutulatus* being confused with, or considered a subspecies of, *atrox*. However, the following differences are to be noted: In *scutulatus* the rings are relatively narrower than the interspaces, and it is seldom that all are black, the change from the color of the body blotches to the terminal black rings being more gradual; thus, there will often be but three rings out of five or six that are black. Also, the last ring seldom engages the rattles. On the other hand in *atrox* and its relatives, every tail ring is invariably black unless a black ring happens to be placed at the base of the tail, in which case the anterior portion of the ring (which is really a part of the body) may take the normal ground color, but the change from normal ground color to contrasting ash-gray tail with its black stripes is always characteristically sudden. The black rings are approximately equal to the interspaces. (See Plate 6).

In the number of tail stripes in the *atrox* group not much is to be learned, and there seem to be no differences in the several species.

In *atrox* and *tortugensis* there is an interesting tendency toward a middorsal tail stripe, for the rings are frequently offset on the middorsal line and, together with small clouds of black dots, give an appearance of a continuous dorsal dark line. (Plate 6). *Exsul* tends to have broken rings, the parts of which occasionally coalesce longitudinally with other rings to form the beginnings of side stripes.
TENTATIVE KEY TO WESTERN RATTLESNAKES ALLIED TO CROTALUS ATROX

1. First infralabials not usually divided transversely. General color gray or gray-brown. Punctations strongly in evidence in markings
First infralabials usually divided transversely. General color pink, red, red-brown or olive-brown. Punctations weakly in evidence or absent from markings

2. Upper preocular usually in contact with postnasal or such contact prevented by an upper loreal. Head larger
Upper preocular usually not in contact with postnasal and no upper loreal present. Head smaller

3. A pair of intergenials usually present. Generally no contact between prenasal and first supralabial. Size smaller
Intergenials usually absent. Prenasal normally in contact with first supralabial. Size larger

4. General color red-brown, olive-brown or yellow-brown. Light head and body markings brighter and more in contrast with ground color. Light areas usually present within diamonds. Light diamond borders usually more complete. Scale rows and ventrals average fewer
General color pink or red. Light head and body markings less conspicuous. Usually no light areas present within diamonds. Light diamond borders less complete. Scale rows and ventrals average higher in number
APPENDIX No. 1
THE RANGES OF THE RATTLENAKES CONSTITUTING
THE ATROX GROUP

In the preparation of the maps which accompany these notes some useful information on the ranges of the species under discussion was accumulated, which it seems desirable definitely to place on record. The sources of these data were essentially the following:

1. Letters from herpetologists resident in, or familiar with, marginal areas. The writer is greatly indebted to the several naturalists mentioned hereafter, who so courteously supplied much valuable information.

2. Preserved specimens from the several institutions to which acknowledgment is made elsewhere.

3. A partial, but by no means complete, survey of the literature. Border records particularly were sought. Obviously, because of some confusion in classification, especially the atrox-scitulatus situation, many locality records could not be accepted without verification of the specimens upon which they are based.

4. Records from my own collection and field experience, largely restricted to the extreme southwest (Arizona, southern California and Lower California).

CROTALUS ADAMANTEUS

C. S. Brimley (letter) considers Albemarle Sound the northern limit of the range of adamanteus along the Atlantic Coast. He records it from the following North Carolina counties: Washington, Dare, Craven, Carteret, Jones, Onslow, Pender, New Hanover and Brunswick. He states that in the coastal region south of the Neuse River it appears to be rather common. He believes that a line from the northwestern corner of Washington Co. to the southerly tip of Scotland Co. indicates the approximate northwesterly limit of the range. Mr. Brimley considers Jackson, Northampton Co., based on USNM 252, to be an uncertain locality record, as it should possibly be referred to Jacksonville, Onslow Co. On the other hand M. K. Brady (Copeia, No. 162, p. 28) cites evidence to show that adamanteus may occur in the Dismal Swamp on the Virginia-North Carolina line.

Prof. Franklin Sherman of Clemson College, South Carolina, has kindly supplied me with the following locality records from that state: Charleston, Port Terminals, Adams Run, Midland Park, Johns Island, Noels, Ten-mile (Charleston Co.); Greelyville (Williamsburg Co.); Mount Holly (Berkeley Co.); Yemassee (Beaufort Co.); and Ridgeway (Fairfield Co.). He writes that the last record, being considerably further inland than any other, was subject to some question, particularly as he did not see, personally, the specimen upon which it
Klauber: Rattlesnakes Allied to Crotalus Atrox  41

was based. However, after investigation, he feels that the record is to be considered authentic.

Southward and westward *adamanteus* is said to inhabit the coastal areas of Georgia, Alabama and Mississippi. Wright and Bishop (Proc. Acad. Nat. Sci. Phila., 1915, p. 190) record this species from the Okefinokee Swamp in Georgia. In Florida it is said to be widespread throughout the state, including the Keys (Stejneger, 1895, p. 435). The U. S. National Museum has a specimen from Brookhaven, Lincoln Co., Mississippi. Löding (Geol. Survey of Alabama, Museum Paper No. 5, p. 40) records it from Mobile and Baldwin Counties, Alabama.

The western range limit, in the southern Mississippi Valley, is the subject of considerable doubt. In Louisiana, Beyer has recorded it from St. Tammany Parish (Proc. Louisiana Soc. of Nat. for 1897-99, p. 42) but Percy Viosca, Jr. writes: "Geo. E. Beyer, when living, often told me that both *Crotalus adamanteus* and *C. horridus* were found together in St. Tammany Parish some forty or fifty years ago. I have also gotten reports from Washington Parish and from East and West Feliciana Parishes, but every time that I have tried to run one of these reports down it turned out to be *horridus*. I have covered every inch of the territory in which they have been reported to occur and negative results are so frequent, that I am beginning to doubt if the species has ever reached Louisiana. I also doubt the Arkansas records. . . ."

"There is a possibility that *adamanteus* was present in Louisiana as Beyer stated, and may have been destroyed by the razor-back hog which now roams freely all over Louisiana. Against this supposition, however, we have the fact that there is no authentic record available, as far as I can find out, in any museum records throughout the United States." (Letter dated March 14, 1930.)

Stewart Springer writes from Biloxi, Miss., "I have reliable reports of *adamanteus* from Cat Island off the coast, but have not seen specimens. . . ."

Byron C. Marshall of Imboden, Ark., writes under date of March 29, 1930, "In regard to *Crotalus atrox* and *C. adamanteus*, I am very sorry to say that I have never seen either from this state. *Atrox* may enter Arkansas, but I rather doubt it. On the other hand, I feel sure *adamanteus* should be found in a few numbers along the Mississippi River side of the state . . . ."

Apparently the only specimen from Arkansas in the National Museum (No. 4393) may be considered of doubtful locality. (Stejneger, 1895, p. 435. See also Hurter and Strecker, Trans. Acad. of Sci. of St. Louis, Vol. 18, No. 2, p. 27).

Summarizing the westerly range of *adamanteus* it would appear that both Arkansas and Louisiana records require further verification.
CROTALUS ATROX

*Crotalus atrox has been recorded from the following localities in Texas:

Cameron Co.
  *Brownsville
  *Boca Chica
  Harlingen
Hidalgo Co.
Zapata Co.
  San Pedro
*Nueces Co.
  *Corpus Christi
  *Japonica
Duval Co.
  *San Diego
San Patricio Co.
  Sinton
Aransas Co.
Refugio Co.
  Live Oak Co.
    Oakville
Bee Co.
  Beeville
Atascosa Co.
  New Somerset (Bexar Co.)
Goliad Co.
  Goliad
Calhoun Co.
  *Indianola (Type Locality)
Victoria Co.
  Jackson Co.
Matagorda Co.
  Harris Co.
Lavaca Co.
  Wilson Co.
    Floresville
Bexar Co.
  *San Antonio
  *Fort Sam Houston
  *Camp Bullis
  *Helotes
  *Camp Travis
Guadalupe Co.
  Seguin
Comal Co.
  Near New Braunfels
Kendall Co.
  *Waring
    Boerne
Hays Co.
  *San Marcos
  Travis Co.
    Manor
Williamson Co.
  Jarrell
Kerr Co.
  *Kerrville
Burnet Co.
  *Boquillas
    Terlingua
Llano Co.
  Kingsland
Mason Co.
  *Mason
  Lampasas Co.
    Lampasas
Coryell Co.
  Gatesville
Bell Co.
  Belton
Milam Co.
  Cameron
McLennan Co.
  China Springs
Limestone Co.
  Near Mount Calm (Hill Co.)
Bosque Co.
Somervell Co.
  Glen Rose
  Tarrant Co.
  Eastland Co.
    Cisco
  Concho Co.
    *4 mi. S. E. of Eden
Tom Green Co.
  Christoval
Maverick Co.
  *Eagle Pass
Specimens have been examined by the writer from the localities marked thus (*). Most of the other localities are derived from J. K. Strecker’s many publications and likewise from manuscript data which he has kindly supplied. In summary he writes: “In the central part of the state, the Brazos River forms the eastern boundary of the range of atrox, but in the southern part of our territory it ranges east along the coast to the Trinity River, perhaps beyond.”

The list of localities above given rather definitely checks Strecker’s summary, although there are gaps in the northwestern area.

It will be noted that many of the citations are counties only; this however is not of importance in Texas (except in the trans-Pecos region) for the counties are small and therefore the records adequately definite. Further to the west, in New Mexico, Arizona and particularly California, locality records which give only counties are virtually valueless, owing to the large areas included and the different life zones to be found in a single county.

The situation in Texas is little confused by scutulatus, for the range of the latter is probably confined to a few southwestern counties. (See Appendix No. 3). It would appear that scutulatus is much less common and less widespread in Texas than atrox, a condition different from that existing in Arizona where these two species have almost coincident ranges and seem to be equally plentiful. Thus, in Texas, we are safe in considering the published atrox records accurate without checking the specimens, which does not hold for Arizona.

From Oklahoma, Dr. A. I. Ortenburger has kindly furnished the following records: Woods, *Woodward, *Major, *Comanche, Pushmataha and *Le Flore Counties.

The Le Flore County specimen tends to verify, to a certain degree, the Arkansas record (from Perry County) although R. M. Perkins, who cites this, does not state that he actually saw a specimen (Perkins, 1928. Bull. Antivenin Inst. Amer., Vol. 2, No. 2, p. 49). Thus in conjunction with Marshall’s remarks previously quoted, we may consider Arkansas as uncertain.
The Trinidad, Colorado, record (Ellis and Henderson, Univ. Colo. Studies, Vol. 10, No. 2, p. 108) appears entirely possible, but verification by additional material would be desirable.

From New Mexico there are but few records available, notwithstanding the fact that atrox is said to be quite common in the southern and eastern parts of the state. I have available only the following:

Eddy Co.
*Pecos River at Lat. 32°
Guadalupe Co
Santa Rosa
Otero Co.
Alamogordo

Socorro Co.
San Marcial
Sierra Co.
Lake Valley
Hidalgo Co.
*Big Hatchet Mts. (East Base)
*Livermore Spring

The Eddy Co. record is based on USNM 4232. There are four specimens under this number, originally classified as confluentus, but one is atrox.

Van Denburgh, quoting Yarrow, gives as an atrox locality, Fort Wingate, McKinley Co. (Proc. Cal. Acad. Sci., 4th Ser., Vol. 13, No. 12, p. 227). However the specimen on which this is based (USNM 8399) has been reclassified as confluentus and the locality should therefore be suppressed.

When we come to Arizona the prevalence of scutulatus and its previous confusion with atrox prevent the utilization of records from the literature. The following localities, from all of which I have examined specimens, afford a fairly consistent outline of the range. Since specimens have been checked from all localities, the asterisk (*), to indicate verified points, is no longer used.

Cochise Co.
Fort Huachuca
Graham Co.
Ash Creek (Graham Mts.)
Camp Grant
Santa Cruz Co.
Tubac
Fort Buchanan
Pima Co.
Tucson
Kits Peak
Santa Catalina Mts.
Steam Pump (near Tucson)
Cañada del Oro
Willow Spring
6 mi. N. of Tucson
11½ mi. N. of Tucson
Tanque Verde
Fort Lowell
Bates’ Well (20 mi. S. of Ajo)
Romero Canyon

Pinal Co.
Casa Grande
Superior
33 mi. N.W. of Tucson (on Florence Road)
Randolph
Florence
Barkerville
Coolidge

Gila Co.
Roosevelt Lake
Rice
Maricopa Co.
Phoenix
18 mi. W. of Phoenix
Cave Creek
Wickenburg
Salt River
Divide
Mesa
Hot Springs
In California, the ranges of *scutulatus* and *atrox* do not coincide, as in Arizona. *Scutulatus* inhabits the Mojave Desert and Antelope Valley with a northern extension into the Indian Wells Valley. *Atrox* seems restricted to the Coachella and Imperial Valleys, although it is found beyond the Chocolate Mts. in the Palo Verde Valley. In each of these areas so many specimens of the one form have been taken, with none of the other, that separate ranges are strongly indicated.

Verified *atrox* records for California are as follows:

<table>
<thead>
<tr>
<th>Imperial Co.</th>
<th>Riverside Co.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fort Yuma</td>
<td>Indio</td>
</tr>
<tr>
<td>Picacho</td>
<td>Coachella</td>
</tr>
<tr>
<td>4 mi. S. of Potholes</td>
<td>Thermal</td>
</tr>
<tr>
<td>Bard</td>
<td>Mecca</td>
</tr>
<tr>
<td>Pilot Knob</td>
<td>Ripley</td>
</tr>
<tr>
<td>Laguna Station (New River)</td>
<td>Blythe</td>
</tr>
<tr>
<td>El Centro</td>
<td>Riverside Mts. (east of Rice)</td>
</tr>
<tr>
<td>6 mi. W. of Imperial</td>
<td>San Diego Co.</td>
</tr>
<tr>
<td>Seeley</td>
<td>Carrizo Springs</td>
</tr>
<tr>
<td>6 mi. S.E. of Seeley</td>
<td></td>
</tr>
<tr>
<td>Dixieland</td>
<td></td>
</tr>
</tbody>
</table>

In Lower California *atrox* has been definitely recorded from only one point, Las Palmas Canyon, Laguna Salada, from which the Museum of Vertebrate Zoology, University of California has two large specimens. While there is no particular reason to doubt the Murphy record cited by Schmidt (Schmidt, 1922, p. 698.), since *atrox* is to be expected along the east base of the Cocopah Mts., nevertheless the specimen seen might have been *mitchelli*.

Additional specimens of *atrox* from Lower California will be awaited with interest. The species probably occurs at least as far south as Point San Felipe.

In Mexico proper, the range of *atrox* is but imperfectly known. Specimens have been seen from the following localities:

<table>
<thead>
<tr>
<th>San Luis Potosi</th>
<th>Coahuila</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chihuahua</td>
<td>Jaral</td>
</tr>
<tr>
<td>Tamaulipas</td>
<td>Chihuahua</td>
</tr>
<tr>
<td>Soto de Marina</td>
<td>Santa Maria</td>
</tr>
<tr>
<td>Nuevo Leon</td>
<td>Santa Cruz</td>
</tr>
</tbody>
</table>
Chihuahua (Cont.)
Chihuahua
Lake Santa Maria
Sonora
San Bernardino
20 mi. S.E. of Sasabe, Ariz.
30 mi. W. of Caborca

2 mi. W. of Alamo Muerto
Colorado River, 10 mi. below U. S. Border at Monument 204.

Chihuahua Lake
Santa Maria
Sonora
San Bernardino
20 mi. S.E. of Sasabe, Ariz.
30 mi. W. of Caborca

Colonia Lerdo
Camar (Rio Mayo)
Tiburon Island

The Museum of Comparative Zoology, Harvard University, has specimens recorded from the following localities: Alvarez (San Luis Potosi); Manuel, Chocoy, Miquihuana (Tamaulipas); San Pedro (Coahuila); and Pacheco (Chihuahua). These I have not examined.

Atrox is probably far more widespread than these localities would indicate. Records in the literature are hardly to be trusted. Scutulatus and likewise basiliscus with which atrox may be confused, both range extensively over northern Mexico.

**CROTALUS TORTUGENSIS**

This species has been collected only on Tortuga Island, Gulf of California, where it is said to be quite common.

**CROTALUS LUCASENSIS**

The following localities, all in the Cape region of Lower California, or nearby islands, represent the record to date:

Cape San Lucas
La Paz
San José del Cabo
Sierra El Taste
Agua Caliente (Type Locality)
Pichilingue Bay
(cf. footnote, page 15)
Miraflores

La Laguna (Sierra de)
Santa Anita
Punta Arena
La Rivera
Todos Santos
Eureka
San José Island
Santa Margarita Island

Specimens have been examined from all of these localities except Punta Arena.

**CROTALUS RUBER**

This species has been collected in the following localities in Lower California:

Head of Concepción Bay
Mulegé
San Ignacio
Santa Rosalía
Turtle Bay
San Bartolomé Bay
Playa María Bay
San Quintín
Agua Escondito
Matomi
Santo Domingo

7 mi. N. of Santo Domingo
San Telmo
San Salado Canyon
San Pedro Mártir Mts.
El Cajon Canyon
San Matías
San José (Near lat. 31°)
Santa Catalina
Santo Tomás
Ensenada
10 mi. N. of Ensenada
27 mi. N. of Ensenada
Garcia
Redondo
Tecate
Tijuana

Specimens have been examined from all of the above localities except Mulegé, Santa Rosalía, Agua Escondito, Matomi and Santo Tomás.

From San Diego County, California, I have seen specimens from a considerable number of localities which may be grouped into faunal zones as follows:

Coast (Upper Sonoran)
  Tia Juana
  San Ysidro
  Otay
  Palm City
  Chula Vista
  Bonita
  National City
  Paradise Valley
  San Diego
  Ocean Beach
  Mission Valley
  Chesterton
  Grantville (Orcutt)
  Pacific Beach
  Rosedale
  Murphy Canyon
  Rose Canyon
  Soledad Mt.
  La Jolla
  Linda Vista
  Torrey Pines
  Del Mar
  Solana Beach
  Rancho Santa Fe
  Cardiff
  Encinitas
  Olivenhain
  Oceanside
  San Luis Rey
  San Onofre

Inland Valleys and Mesas (Lower Sonoran)
  Otay Dam (El Nido)
  Otay Mesa
  Sunnyside
  Sweetwater Dam

Monserrate Island
San Marcos Island
South San Lorenzo Island
Angel de la Guarda Island

Spring Valley
Jamacha
Helix
La Mesa
Hillside
Grossmont
El Cajon
Murray Dam
Bostonia
Mission Gorge
Santee
Flinn Springs
Lakeside
El Monte
Foster
Mussey
Miramar
Poway
Dean Canyon
Bernardo
San Pasqual
Escondido
San Marcos
Twin Oaks
Moosa
Bonsall
Pala
Fallbrook
De Luz

Foothills (Upper Sonoran)
  Campo
  Tecate
  Potrero
  Cottonwood
  Dulzura
  Honey Springs
Foothills (Cont.)
Deerhorn Flat
Barrett Dam
Lyons Valley
Jamul
Glen Lonely
Japatul
Suncrest
Alpine
Viejas
Descanso
El Capitan
Padre Barona
Shady Dell
Wildwood
San Vicente
Ramona
Witch Creek
Santa Ysabel
Valley Center

Rincon
Oak Grove
Mountains (Transition)
Laguna
Palomar
Desert Foothills (Lower Sonoran)
Jacumba
6 mi. N. of Jacumba
Mountain Springs
1/2 way bet. Mountain Springs and
Jacumba
Dos Cabezas
San Felipe Valley
Sentenac Canyon
Yaqui Well
Borego Palm Canyon
Coyote Creek near Beatty’s
Agua Caliente Spring (near Valle-
cito)

Other California records are as follows:

Imperial Co.
Mountain Springs
5 1/2 mi. E. of Mountain Springs

Riverside Co.
Riverside
8 mi. W. of Hemet
Whitewater
Cabazon
Dos Palmos Springs
Carrizo Creek
Moreno
San Jacinto
Banning

6 mi. S. of Beaumont
Eden Hot Springs
Mouth of San Andreas Canyon
Elsinore
Perris
Reche Canyon
Orange Co.
Black Star Canyon, Santa Ana
Mts.
San Clemente
Los Angeles Co.
Whittier

Thus, present records indicate that ruber has not crossed San Gorgonio Pass or San Timoteo Canyon to gain entrance to the San Bernardino Mountains.

CROTALUS EXSUL

This species has been taken only on Cedros (Cerros) Island off the Pacific Coast of Lower California.
**APPENDIX No. 2**

**COMPARISON OF CROTALUS SCUTULATUS WITH CROTALUS ATROX**

In a previous paper (Trans. S. D. Soc. Nat. Hist., Vol. 6, No. 3, pp. 95-144) I pointed out certain characteristics whereby the somewhat neglected species, *Crotalus scutulatus*, might be differentiated from *Crotalus confluentus, Crotalus atrox*, and other forms with which it is usually confused. Since, in the past, this confusion has been more often with *atrox* than any other species (although the relationship of *scutulatus* is probably closer to *confluentus* than *atrox*) it would appear desirable to develop in the present paper, somewhat more completely, the differences between *atrox* and *scutulatus*. The inclusion of specimens of *scutulatus* in *atrox* descriptions and summaries, has somewhat changed the character of such *atrox* data in the past; that is to say, such descriptions were not invariably based on pure *atrox*, but have been broadened to include specimens which should have been referred to *scutulatus*. It is the hope of the writer that this appendix will add weight to an apparently necessary differentiation.

Table No. 12 lists the more important characters which may be presented statistically.

**TABLE No. 12**

**COMPARISON OF ATROX AND SCUTULATUS**

<table>
<thead>
<tr>
<th>Character</th>
<th>Atrox</th>
<th>Scutulatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of specimens examined</td>
<td>222</td>
<td>159</td>
</tr>
<tr>
<td>Scale rows, average</td>
<td>25.5</td>
<td>26.6</td>
</tr>
<tr>
<td>Scale rows, range</td>
<td>23—27</td>
<td>23—29</td>
</tr>
<tr>
<td>Ventrals, males, average</td>
<td>183</td>
<td>178</td>
</tr>
<tr>
<td>Ventrals, males, range</td>
<td>173—192</td>
<td>166—187</td>
</tr>
<tr>
<td>Ventrals, females, average</td>
<td>186</td>
<td>181</td>
</tr>
<tr>
<td>Ventrals, females, range</td>
<td>176—195</td>
<td>168—192</td>
</tr>
<tr>
<td>Caudals, males, average</td>
<td>25.3</td>
<td>25.2</td>
</tr>
<tr>
<td>Caudals, males, range</td>
<td>19—30</td>
<td>22—28</td>
</tr>
<tr>
<td>Caudals, females, average</td>
<td>20.1</td>
<td>19.4</td>
</tr>
<tr>
<td>Caudals, females, range</td>
<td>16—23</td>
<td>16—23</td>
</tr>
<tr>
<td>Supralabials, average</td>
<td>15.4</td>
<td>14.9</td>
</tr>
<tr>
<td>Supralabials, range</td>
<td>13—18</td>
<td>13—17</td>
</tr>
<tr>
<td>Infraabials, average</td>
<td>16.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Infraabials, range</td>
<td>14—20</td>
<td>13—19</td>
</tr>
<tr>
<td>Percent, divided first infraabials</td>
<td>9.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Canthals, average</td>
<td>1.98</td>
<td>2.05</td>
</tr>
<tr>
<td></td>
<td>Atrox</td>
<td>Scutulatus</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>Scales before supraoculars, average</td>
<td>19.2</td>
<td>11.5</td>
</tr>
<tr>
<td>Scales before supraoculars, range</td>
<td>11—32</td>
<td>6—20</td>
</tr>
<tr>
<td>Minimum scale rows between supraoculars, average</td>
<td>4.56</td>
<td>2.06</td>
</tr>
<tr>
<td>Minimum scale rows between supraoculars, range</td>
<td>3—7</td>
<td>1—3</td>
</tr>
<tr>
<td>Postnasal-preocular contact (percent. of each type)</td>
<td></td>
<td></td>
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<tr>
<td>Upper preocular in contact with postnasal</td>
<td>69.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Contact prevented by upper loreal</td>
<td>25.5</td>
<td>0.4</td>
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<tr>
<td>Contact prevented by canthal</td>
<td>2.7</td>
<td>92.0</td>
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<tr>
<td>Indeterminate (borderline)</td>
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<td>4.3</td>
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<tr>
<td>Prenasal-supralabial contact (percent. of each type)</td>
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<tr>
<td>Prenasal in contact with supralabials</td>
<td>94</td>
<td>98</td>
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<tr>
<td>Partial contact</td>
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<tr>
<td>No contact</td>
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<td>Ratio total length to head length, average</td>
<td>22.6</td>
<td>24.0</td>
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<tr>
<td>Ratio distance across to distance between supraoculars, average</td>
<td>2.62</td>
<td>3.17</td>
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<tr>
<td>Rostral shape (percent. of each type)</td>
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<tr>
<td>Higher than wide</td>
<td>100</td>
<td>93</td>
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<tr>
<td>Equal</td>
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<td>7</td>
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<tr>
<td>Wider than high</td>
<td>...</td>
<td>...</td>
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<tr>
<td>Ratio tail to total length, males</td>
<td>.0774</td>
<td>.0731</td>
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<tr>
<td>Ratio tail to total length, females</td>
<td>.0594</td>
<td>.0532</td>
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<tr>
<td>Position of postocular light stripe (percent. of each type when determinate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersects mouth</td>
<td>100</td>
<td>...</td>
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<tr>
<td>Above mouth</td>
<td>...</td>
<td>100</td>
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<tr>
<td>Body blotches, average</td>
<td>34.9</td>
<td>37.0</td>
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<td>Body blotches, range</td>
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<td>Tail rings, males, average</td>
<td>5.04</td>
<td>5.07</td>
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<td>Tail rings, males, range</td>
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<td>Tail rings, females, average</td>
<td>4.08</td>
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<td>Tail rings, females, range</td>
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<td>Tail rings, percent. black, males</td>
<td>99.8</td>
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<td>Tail rings, percent. black, females</td>
<td>100</td>
<td>72</td>
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<td>Color of anterior rattle (percent. of each type)</td>
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<td>Light</td>
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<td>Half dark</td>
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<tr>
<td>Dark</td>
<td>85</td>
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Upon this table the following comments may be made, particular emphasis being given to those characteristics in which the two species show important differences, as there are others in which no essential dissimilarity is to be noted:

In number of dorsal scale rows the species are quite similar. About 70 percent of Arizona *atrox* have 25 rows, the corresponding figure for Arizona *scutulatus* being 72. Of California *atrox*, 50 percent have 27 rows, while 40 percent of California *scutulatus* have 27. Thus, in both species the California forms have a somewhat higher average number of dorsal scale rows.

The ventrals are consistently and definitely lower in *scutulatus* than *atrox*, averaging 5 below in each sex. We find that California specimens have higher counts than Arizona in both species, yet in each state *scutulatus* continues from 5 to 7 below *atrox*. The difference, therefore, cannot be explained by any theory of territorial races. The caudals do not show important trends.

The labials in *atrox* are somewhat higher in number than in *scutulatus*, this being particularly true of the infralabials, wherein the difference is too great to be the result of any chance collection. *Scutulatus* shows a somewhat reduced tendency toward divided first infralabials, the divergence being more marked in the California specimens, since the proportion of these having divided first infralabials is no greater than in those from Arizona, while the contrary is the case in *atrox*.

The canthals are normally two on a side in each species, thus differentiating both from most specimens of *confluentus* of all subspecies. Occasionally *scutulatus* has three canthals, thus bringing the average slightly above the *atrox* figure; rarely is a canthal fused with an internasal, this fusion being more usual in *atrox*. The internasals in both species are rarely other than two, which is an important difference from the subspecies of *confluentus*.

The scales on the top of the head anterior to a line joining the fronts of the supraoculars, constitute an important difference between *atrox* and *scutulatus*, as will be seen from the table. These plates in *scutulatus*, tend toward a rather definite arrangement of either six, eight or ten, while in *atrox* they are more haphazard. Furthermore, if we remember that amongst these scales are included two internasals and four canthals, and deduct these six from the figures of 19.2 for *atrox* and 11.5 for *scutulatus*, we find that in the remaining scales, *atrox* averages over twice as many as *scutulatus* (13.2 to 5.5). In *scutulatus* these scales are flatter and smoother than in *atrox*. Posterior to this group of scales in *scutulatus* there is, in almost all cases, a definite suture dividing them from the scales between the supraoculars, but this line is rarely evident in *atrox*. It should be mentioned that arrangements of the head scales similar to those of *scutulatus*, but usually of even more simple form, will be found in *molossus* and the subspecies of *terrificus*, but there are other characters which render the separation of *scutulatus* from those species comparatively simple.

The minimum scale rows between the supraoculars are, of course, one of the most definite differences between *atrox* and *scutulatus*. *Scutulatus* normally has a pair of plates of relatively large size between the anterior portions of the supraoculars, followed by three somewhat smaller. *Atrox* rarely has less than four at any point, and averages 4.5. Only 11 percent of *atrox* specimens have a mini-
mum bridge of three and I have yet to see a specimen with two. On the other hand, with scutulatus, out of 155 specimens only 11, or 7.1 percent, have three scales, 143 or 92.3 percent, having two scales. A single specimen was found with but one scale. Thus, we have here a characteristic which is sufficiently consistent to be a key character in most instances. Again, however, I wish to point out, as was done in a previous paper, that the differentiation between these two species has by no means been based exclusively on this character; it merely adds weight to other essential differences.

An important distinction is found, as will be noted from the table, in the postnasal-preocular contact. Stating this difference in a form suitable for use as a key, we find that 94.4 percent of atrox have the upper preocular in contact with the postnasal, or such contact is prevented by an upper loreal; while in scutulatus 92 percent, fail to have this contact although no upper loreal is present.

The prenasal-supralabial contact shows nothing of particular interest.

The head is smaller proportionately in scutulatus than in atrox; this conclusion being drawn from a sufficiently large number of specimens, many of which were measured when freshly killed, so that the result is believed to be accurate. Juvenile specimens as usual were omitted. As is the case in atrox, westerly forms of scutulatus have smaller heads than those from farther east. Scutulatus apparently has a proportionately smaller head than confluentus, the latter not differing essentially from atrox.

The ratio of the distance across the supraoculars to the space between shows that scutulatus has a narrower head, which is likewise evident from observing specimens in life; thus, not only are the scales larger in the supraocular bridge, but the reduction of space is likewise a reason for the fewer scales at this point.

The height of the rostral in scutulatus more nearly approaches the width than in atrox, as is shown by the greater number of specimens which have equality.

The canthus rostralis is definitely more angular in scutulatus than atrox.

Scutulatus has a shorter tail than atrox, but this difference is not so great as between atrox and some of the other members of its own group.

A key character, which in my experience has never failed in the case of live or well preserved specimens, is the position of the postocular light stripe. This line, one scale wide in both species, intersects the mouth in atrox, usually at the second or third scale in advance of the commissure, while in scutulatus it passes above the angle of the mouth, generally on the second row above the last supralabials; rarely on the first or third row. As pointed out elsewhere, I have seen one or two specimens of atrox with branching postocular light lines, one branch extending above the mouth. I have not seen this in scutulatus. It must be remembered that there will be many specimens in collections, which have been preservation a long time, in which the postocular line is so faded that its direction cannot be definitely determined.

The preocular light stripe is not so important; there seem to be no definite differences between the two species.

The supraocular cross mark, while much more prevalent in atrox than scutulatus, is not a particularly useful key character in distinguishing the two
species from each other, since, when present, it is of amorphous quality, varying from a line to a light patch, but lacking the contrasting outlines evident in *confluentus*. This is an excellent character wherewith to distinguish *atrox* or *scutulatus* from *confluentus confluentus* or *c.lutosus* or from juvenile specimens of other *confluentus* subspecies.

*Scutulatus* has a slightly higher body blotch count than *atrox*. In *scutulatus* the blotches are practically always truncated, thus becoming hexagons, while in *atrox* they are normally diamonds. In *scutulatus* the light, bordering scale row of the blotches is usually complete and unicolor; that is to say, each scale is light colored throughout. In *atrox*, on the other hand, this row is not so definite and may consist only of light tipped scales.

The very evident punctations which constitute so important an element of the *atrox* pattern, as described elsewhere, are absent in *scutulatus*, thus constituting an easy method of classifying live specimens. Under a low power microscope the *scutulatus* coloration will be seen to be the result of punctations, as is the case with many rattlesnakes, but they are not large and easily visible to the unaided eye as in *atrox*.

In color, *scutulatus* has a general trend toward green or olive, as compared to gray, buff or cream in *atrox*. The differences are particularly evident in desert specimens; not so much so in those from higher altitudes, especially in the vicinity of Prescott, Arizona.

The tail rings are different in the two species, notwithstanding the fact that the black tail rings of *scutulatus* have probably more often led to confusion with *atrox* than any other single characteristic, because it is these widely separated dark rings which distinguish *scutulatus* from most specimens of *confluentus*. In *atrox*, the black rings approximate the interspaces in width, while in *scutulatus* the dark rings are usually considerably narrower. In *atrox* the rings are uniformly black, while in *scutulatus* there is a gradual change, the anterior rings being dark brown. This difference is indicated in Table No. 12. See also Plate 6.

In *atrox* the last dark ring engages the rattle. Thus we find that 85 percent of the first anterior rattles are black. In *scutulatus*, on the other hand, normally the upper half only of this rattle is black.
APPENDIX No. 3

THE RANGE OF SCUTULATUS

Map 3 indicates the range of scutulatus as known at this time. In California the area covered seems to be entirely Lower Sonoran—the Mojave Desert, Antelope Valley and Indian Wells Valley. Specimens have been examined from all of the following localities except the last, which is based on data furnished by W. W. Bramlette of Little Lake. He states that in his experience this is the northern limit of what is termed in that country the “Green Velvet Rattler,” a rather apt descriptive term.

San Bernardino Co. Los Angeles Co.
Needles Llano
Ibis 5 mi. N.W. of Shoemaker
Goffs Littlerock
Providence Mts. Palmdale
Lucerne Valley Lancaster
Hesperia Fairmont
Victorville Half way bet. Fairmont and
Helendale Neenach
Wild Neenach
Barstow Kern Co.
Hawes Rich
Jim Grey Bissell
Kramer Rosamond
Atolia Willow Springs
15 and 18 mi. S. of Randsburg Mojave
(Kern Co.) Inyokern
15 mi. S. of Little Lake (Inyo Co.)

In Arizona scutulatus seems not restricted to the Lower Sonoran zone, but ascends to considerable altitudes, particularly in the vicinity of Prescott. Specimens from the higher areas are darker, a deep brown or even black replacing the green of the lowland forms. Some of the northern specimens are mottled with pink.

Specimens have been examined from the following specific localities:

Cochise Co. Graham Co.
Apache Camp Grant
San Pedro River, 3 mi. N. of Santa Cruz Co.
Mexican Boundary Fort Buchanan
San Pedro Valley, Huachuca Mts. Pima Co.
Ash Canyon, Huachuca Mts. Tucson
Fort Huachuca Steam Pump
Tombstone Catalina Mts.
15 mi. S. of Willcox Pinal Co.
Willcox Barkerville
12 mi. S. of Dos Cabezas Randolph
Chiricahua Mts. Casa Grande
Bowie Florence
Superior
Gila Co.
Globe
Maricopa Co.
Gila Bend
Maricopa Mts.
18 mi. W. of Phoenix
Peoria
Cave Creek
Wickenburg
Divide
Agua
Yuma Co.
Mohawk

Yavapai Co.
Congress Junction
Date (Date Creek)
Hillside
Skull Valley
Prescott
Fort Whipple
Entro
Granite
Drake
Mojave Co.
15 mi. S. of Hackberry
Kingman
Griffith

From New Mexico I have not seen a specimen. There is no doubt the species occurs in the southwestern corner and quite probably along the entire southern border of the state.

Texas localities are the following:
El Paso Co.
Pecos Co.
Fort Stockton
Duval Co.
Cameron Co.
Brownsville

I have seen specimens only from Fort Stockton and Brownsville and it so happens that both of these finally reached preserved collections from the reptile exhibits of zoological parks. Having had some experience in endeavoring to keep live specimens properly recorded, marked and segregated in a zoo in order to conserve their scientific value for later museum use, I think it only reasonable to state that these localities are hardly to be considered final unless backed by first hand material. Such records, noted in collections, as molossus from Los Angeles, Calif., or lutosus from southern Arizona lead one to question all localities solely dependent for verification on such sources. Therefore this Texas list, while reasonable in character, is not to be considered final.

From Mexico the data is very sketchy. I have examined specimens from the following points:
Sonora
Near Rio San Pedro
20 mi. S.E. of Sasabe, Ariz.
San Bernardino
Gulf of California?
Chihuahua
Chihuahua
Casas Grandes
Zacatecas?
Real de Pinos

Günther (Biol. Centr.-Amer., Rept. and Batr., 1902, p. 193, Plate 59) describes Crotalus salvini from Huamantla, Tlaxcala. Boulenger (Cat. Snakes Brit. Mus., 1896, Vol. 3, p. 575) considers this a synonym of scutulatus. If this specimen is scutulatus then the record for this species is carried farther to the south than the present known range of atrox.

Scutulatus probably ranges over a considerable area in northern Mexico. The few specimens available indicate that more material might permit division into northern and southern subspecies.
I am deeply indebted to many individuals and institutions for the loan of important material, and to others for gifts of specimens, without which this investigation would not have been possible. To the following especially I wish to tender my thanks: Dr. Leonhard Stejneger and Miss Doris M. Cochran of the United States National Museum; Dr. B. W. Evermann, Mr. J. R. Slevin and Miss Susie Peers of the California Academy of Sciences; Dr. Joseph Grinnell, Dr. Jean Lindsdale and Mr. C. C. Lamb of the Museum of Vertebrate Zoology, University of California; Dr. G. K. Noble of the American Museum of Natural History; Mr. K. P. Schmidt of the Field Museum of Natural History; Drs. C. D. Bunker and E. H. Taylor of the University of Kansas; Dr. A. Ruthven, Mrs. H. T. Gaige and Mr. H. K. Gloyd of the University of Michigan; Dr. A. H. Wright of Cornell University; Mr. G. S. Myers of Stanford University; Dr. Thos. Barbour and Mr. A. Loveridge of the Museum of Comparative Zoology, Harvard University; Mr. Howard R. Hill of the Los Angeles Museum; Mr. M. G. Netting of the Carnegie Museum; Mr. Chas. Bogert of the Trail Finders; Dr. A. I. Ortenburger of the University of Oklahoma; Col. M. L. Crimmins, U.S.A.; Mr. Clinton G. Abbott of the San Diego Society of Natural History; Messrs. F. Weinberg, W. B. Cannon and Tex. A. Schubach. Also to the following officials and employees of the Atchison, Topeka and Santa Fe Railway: General Manager W. K. Etter; Superintendents E. E. McCarty, R. H. Tuttle, G. W. Simpson and C. G. Fluhr; Division Engineer O. R. West; Roadmasters B. F. Gauldin, R. L. Borden, E. Conway, F. H. Rahmgren, J. A. Rohrer and R. E. Patton together with their many section foremen; also Division Passenger Agent W. B. Frisbie of San Diego.

The photographs are by L. C. Kobler, of the San Diego Consolidated Gas and Electric Co.
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Schmidt, K. P.

Stejneger, L.

Van Denburgh, J.

Van Denburgh, J. and Slevin, J. R.
Map 1

SOUTHERN UNITED STATES AND NORTHERN MEXICO
SHOWING KNOWN RANGES OF
SPECIES OF RATTLESNAKES
ALLIED TO CROTALUS ATROX

SCALE OF MILES
0 40 80 160
APRIL, 1930
DISTRIBUTION OF CROTALUS ATROX
AND RELATED SPECIES IN LOWER CALIFORNIA AND WESTERN SONORA

- ATROX
- LUCASENSIS
- TORTUGENSIS
- RUBER
- EXSUL

MAP OF LOWER CALIFORNIA

SCALE: 1:2,500,000

16° 15° 14° 13° 12° 11° 10° 9° 8° 7° 6° 5° 4° 3° 2° 1° 0°
NOTE: for the sake of legibility several intervening locations of C. ruber have been omitted in the density marked vicinity of San Diego.
PLATE I

Figs. 1-4. Postnasal—Preocular Arrangement
   Fig. 1. Postnasal in contact with upper preocular.
   Fig. 2. Contact prevented by upper loreal.
   Fig. 3. Contact prevented by postcanthal—loreal contact.
   Fig. 4. Borderline case: postnasal, postcanthal, upper preocular and loreal meeting at a point.

Figs. 5-7. Prenasal—Supralabial Arrangement
   Fig. 5. Prenasal in contact with first supralabial.
   Fig. 6. Prenasal in partial contact with first supralabial.
   Fig. 7. No contact between prenasal and first supralabial.

Figs. 8-10. Divisions in First Infralabials
   Fig. 8. No division in first infralabials.
   Fig. 9. First infralabials divided.
   Fig. 10. Intergenials present.

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PLATE 2

Group Photograph of *Crotalus atrox* and *Crotalus lucasensis*

Upper: *Crotalus atrox*. Desert Diamond Rattlesnake.

Lower: *Crotalus lucasensis*. San Lucan Diamond Rattlesnake.
LMK 2240. Young adult female. Collected at La Rivera, Lower California, Sept., 1929.

(Note: All photographs are of live specimens except Plate 6)
PLATE 3

Fig. 1. *Crotalus atrox*. Desert Diamond Rattlesnake.  
LMK 2149. Young adult male. Collected at Date, Yavapai County, Arizona, Aug. 7, 1929.

Fig. 2. *Crotalus lucasensis*. San Lucan Diamond Rattlesnake.  
LMK 2240. Young adult female. Collected at La Rivera, Lower California, Sept., 1929.
Fig. 1. *Crotalus ruber*. Red Diamond Rattlesnake. (Coast phase)
LMK 2428. Adult male. Collected at Santa Margarita, San Diego County, California, March, 1930.

Fig. 2. *Crotalus ruber*. Red Diamond Rattlesnake. (Desert-foothill phase)

PLATE 4
PLATE 5

Fig. 1. Left: *Crotalus atrox*. Desert Diamond Rattlesnake. LMK 2520. Young adult female. Collected at Kirkland, Yavapai County, Arizona, April 1, 1930.

Right: *Crotalus scutulatus*. Mojave Rattlesnake. LMK 2521. Young adult female. Collected at Date, Yavapai County, Arizona, April 4, 1930.

Fig. 2. *Crotalus scutulatus*. Mojave Rattlesnake. LMK 2521. Young adult female. Collected at Date, Yavapai County, Arizona, April 4, 1930.
PLATE 6
Rattlesnake Tails

Designations top to bottom. All are adult males, preserved specimens.


*Crotalus tortugensis*. Tortuga Island Diamond Rattlesnake. CAS 51332. Tortuga Island, Gulf of California.

*Crotalus lucasensis*. San Lucan Diamond Rattlesnake. LMK 2234. La Rivera, Lower California.

*Crotalus ruber*. Red Diamond Rattlesnake. LMK 1823. Pala, San Diego County, California.

*Crotalus exsul*. Cedros Island Diamond Rattlesnake. CAS 59565. Cedros Island.
