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NOTES ON SALAMANDERS WITH THE DESCRIPTION OF A NEW SPECIES OF *CRYPTOBRANCHUS*

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DURING the past summer I had the opportunity to work through the salamander collection in the University of Michigan Museum of Zoology and was fortunate in locating the material that forms the basis for these notes. I am indebted to Mrs. Helen T. Gaige for the privilege of examining the specimens in that collection and to Dr. Doris M. Cochran and Charles M. Bogert for the loan of additional study material of the new *Cryptobranchus* from the United States National Museum and the American Museum of Natural History, respectively. I wish also to thank the authorities of the Museum of Comparative Zoology, of the Academy of Natural Sciences of Philadelphia, of the Cincinnati Society of Natural History, and of the Carnegie Museum, and Paul Anderson, for the loan of comparative material. Dr. Hobart M. Smith kindly examined certain U.S.N.M.[1] specimens for me. I am thankful to Dr. Sherman C. Bishop and Dr. Norman Hartweg for the

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[1] U.S.N.M. indicates the collections of the United States National Museum; U.M.M.Z., those of the University of Michigan Museum of Zoology; K.U.M., those of the University of Kansas Museum; S.C.B., those of Dr. S. C. Bishop; C.S.N.H., those of the Cincinnati Society of Natural History; and A.M.N.H., those of the American Museum of Natural History.

continual help they have given me in the preparation of this report. The drawings are the work of Mrs. Marion Leffler Stalker and the photographs of Ray Maas, both of the University of Rochester.

TRITURUS

There are no recent detailed published discussions of the distribution of the subspecies of *Triturus viridescens* in the Great Lakes region, and it would appear that the ranges given for *T. v. viridescens* Rafinesque and for *T. v. louisianensis* (Wolterstorff) from this area by Stejneger and Barbour (1939: 5) should be altered. By inference from these authors' statements of the ranges of the two subspecies it would seem that the two forms meet and intergrade in Wisconsin. Citations from the literature may be made to support this. Ruthven, Thompson, and Gaige (1928: 15–19) list only the typical subspecies as occurring in Michigan and describe it accurately. It is not unlikely that the specimens upon which their description was based were from the southeastern corner of the state, where typical *T. v. viridescens* is present. Pope and Dickinson (1928: 18–19) list *T. v. viridescens* as present in Wisconsin, but their photographs (Pl. 1, Fig. 3; Pl. 2, Fig. 1) of Wisconsin specimens are unmistakably of *T. v. louisianensis.* Their description portrays *viridescens* accurately, but since it was obviously taken from Ditmars (1905: 180) it applies to New York *viridescens* and not to Wisconsin *louisianensis.*

More than 150 U.M.M.Z. specimens of *Triturus viridescens* from twenty-eight counties in Michigan have been examined and of these about three-fourths may be readily allocated with either *v. viridescens* or *v. louisianensis* on the basis of the development of the black pigment which surrounds the dorsolateral red markings. Most of the specimens from the Upper Peninsula are *louisianensis,* and all those seen from the southeastern corner of the state are *viridescens.* Salamanders from the eastern part of the Upper Peninsula (Luce County) and from the northern part of the Lower Peninsula (Charlevoix, Emmet, Cheboygan, Presque Isle, Otsego, Alpena, and Alcona counties) seem closer to *viridescens,* and many from the central

part of the Lower Peninsula may represent either *viridescens, louisianensis,* or intergrades.

It would seem, then, that *v. viridescens* ranges westward through Ohio and Ontario to Michigan, where it is replaced by *v. louisianensis.* The form of Wisconsin and of the Michigan Upper Peninsula (except the eastern part) is *v. louisianensis.* This report thus adds *v. louisianensis* to the faunal lists of Michigan and Wisconsin and deletes *v. viridescens* from the Wisconsin list. The form in Illinois is probably *louisianensis* rather than *viridescens.*

EURYCEA

A series of seven specimens of *Eurycea lucifuga* Rafinesque (U.M.M.Z. No. 77387) from Dowelltown, Dekalb County, Tennessee, and one (U.M.M.Z. No. 77391) from Carthage, Smith County, Tennessee, apparently differ in several respects from the usual run of *lucifuga* material from outside this Nashville basin area. They are larger than other *lucifuga* specimens. Six individuals with complete tails average 168.2 mm. in total length, the smallest being 155 mm. and the largest 182 mm. Twenty-nine adult specimens of typical *lucifuga* from Missouri, Arkansas, Kentucky, Tennessee, and Alabama, which were measured by Bishop, range from 70 mm. to 161 mm. in total length, the average being 123.3 mm. One specimen (U.S.N.M. No. 25306) was measured by Smith at 163 mm., and Dunn (1926: 340) gives 167 mm. as the record for the largest specimen of *lucifuga* (U.S.N.M. No. 57108) he has seen. That the superiority in length of the Nashville basin examples is apparently the result of a proportionate increase in total length and not a disproportionate increase of any part is shown by the fact that the tail length is 43 per cent of the total length in these specimens as well as in a typical series of *lucifuga* from Tennessee and Missouri.

The dorsal markings in the Nashville basin individuals are diffuse and fused; often pigment specks are scattered throughout the area between the larger markings, giving a dusky and a blotched effect. In typical *lucifuga* the dorsal ground color between the well-defined distinct spots is unmarked (Plate I).

There is here a situation in which a series of salamanders from two localities within a unified physiographic area is distinguishable from salamanders outside this area on the basis of size and pattern differences. At present the Nashville basin specimens are not given taxonomic recognition because of the following considerations.[2]

Among more than three hundred *lucifuga* from over thirty-five localities outside the Nashville basin there were three specimens (C.S.N.H. No. 2263, Owen County, Indiana, 135 mm.; K.U.M. No. 18860, Madison County, Arkansas, 153 mm.; and S.C.B., Phelps Cave, Kentucky, 147 mm.) that resembled, in pattern, the Nashville basin individuals.

The characters that distinguish the Nashville basin form from typical *lucifuga* are those that may accompany old age in the Plethodontidae. It is supposedly true that among cold-blooded vertebrates increase in length continues with age under favorable conditions. In *Pseudotriton ruber* the well-defined distinct spots of young specimens fuse and form a dusky pattern as the salamanders grow older.

It may not be undesirable to grant taxonomic recognition to a form on the basis of characters that may be an expression of age differences (either in actual chronology or relative ontogeny), for such differences may well be under direct genetic control. Speciation of this nature has been observed in other genera and has been termed "hypermorphosis" (DeBeer, 1940: 65–70). It is conceivable, however, that in some manner environmental factors might have been effective in the production of the observed differences.

Joseph R. Bailey, who collected the specimens in question, informs me that they were found within caves, walking about on domestic animal carcasses and feeding upon the flies that had gathered there. The stomachs of some individuals that he

[2] Fankhauser (1939) reported upon some naturally occurring polyploids of *Eurycea b. bislineata;* in some instances the polyploids were larger than normal diploid individuals. An investigation to determine whether or not the Nashville basin specimens are polyploid *lucifuga* awaits the receipt of fresh material that will lend itself readily to cytological examination.

examined contained flies and maggots; it appears likely that the available food supply for these salamanders was relatively huge. The domestic animals upon which the flies were feeding had apparently fallen into the mouths of the caves and become trapped there.

CRYPTOBRANCHUS

Seven specimens in the University of Michigan collections are the first examples noticed of a species of *Cryptobranchus* from the eastern drainage basin of the Ozarks. At present there is generally recognized but one species, *alleganiensis* (Daudin), in the genus, although other names have been proposed. Of the other proposals (*gigantea, salamandroides, horrida, maxima, gigantesque, mucronata, fusca,* and *terassodactylos*)[3] none are applicable, for type localities of these, when more definite than North America, could be localized as the Ohio River, Kentucky River, Allegheny Mountains, French Broad River, South Carolina, or Tennessee River. None of them have been proposed from any region within the known range of the new Ozark form.

With the exception of *terassodactylos* all of these forms have been synonymized with *alleganiensis* for more than fifty years; *terassodactylos* has been described comparatively recently (Wellborn, 1936: 62–64). This description, apparently, applies to an anomalous specimen of *C. alleganiensis* with four toes. The locality given is North America. Wellborn quotes the description of a specimen from Lake Champlain, New York, which she regards as a larva of her new form. It is 280 mm. in length (*Cryptobranchus* larvae lose their gills at about 135 mm., *vide* Bishop, 1941: 49), and it is from northern New York (*Cryptobranchus* is known in New York only from the Allegheny and Susquehanna rivers and their tributaries in the southern part of the state). It seems evident that the alleged *Cryptobranchus terassodactylos* larva is a *Necturus m. maculosus* and, not being conspecific with *terassodactylos,* does not establish a locality for it. *C. terassodactylos* Wellborn is best considered a strict synonym of *C. alleganiensis* (Daudin).

[3] Many variant spellings of these and *alleganiensis* may be found.

Besides the seven University of Michigan specimens there are three National Museum examples and two in the American Museum of Natural History that form the basis for the description of the Ozark *Cryptobranchus*. It is fitting to associate with this hitherto unrecognized salamander the name of Sherman C. Bishop, of the University of Rochester, who has contributed largely to our understanding of the salamanders of the United States.

Cryptobranchus bishopi, new species

HOLOTYPE.—U.M.M.Z. No. 68930, collected in the Current River at Big Spring Park, Carter County, Missouri, by Edwin P. Creaser on August 25, 1930.

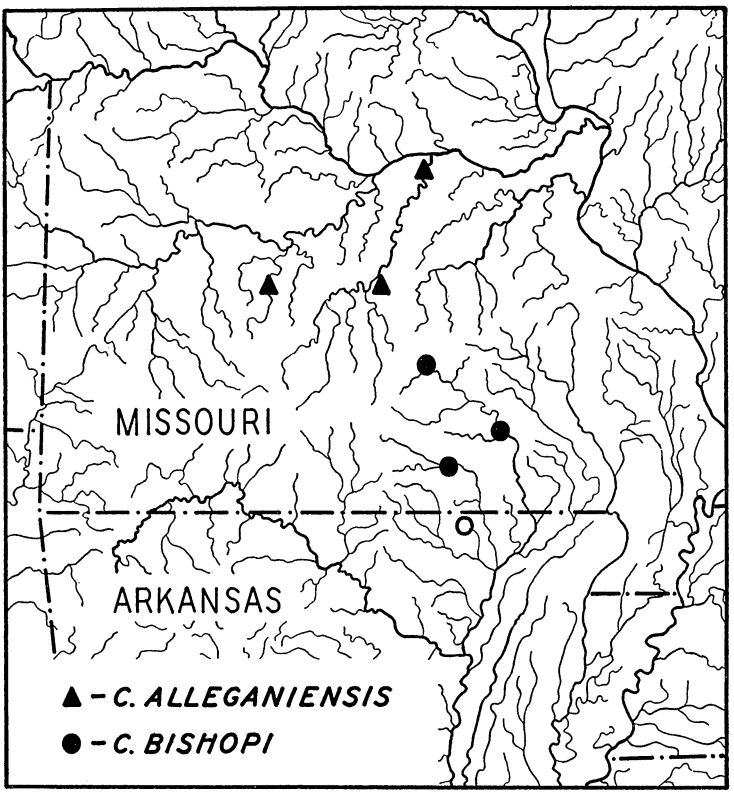
PARATYPES.—U.M.M.Z. Nos. 68929, 68931, 68932, 68916, 68897, and U.S.N.M. No. 94356, topotypes; U.M.M.Z. No. 68415, Greer Spring, Missouri; U.S.N.M. No. 57042, Oregon County, Missouri; U.S.N.M. No. 99751, Montauk State Park, Dent County, Missouri; and A.M.N.H. Nos. 23053 and 23054, Eleven Point River at Greer Springs, Missouri.

DIAGNOSIS.—A *Cryptobranchus* differing from *C. alleganiensis* in the wider distribution of black pigment and in the reduction of the size of the spiracular openings.

DESCRIPTION OF THE TYPE SERIES.—As compared with *alleganiensis* the twelve specimens constituting the type series show a great reduction in the size of the spiracular opening. In some (U.S.N.M. No. 57042, A.M.N.H. Nos. 23053–54, and the holotype) these openings are so reduced that their diameters are contained well over ten times in the distance between their external nares. The larger spiracular openings of the remaining examples of *bishopi* are considerably smaller than those in a series of typical *alleganiensis* from Missouri and New York. In the last mentioned eight specimens of *bishopi* the ratio between the spiracular diameter and the internarial distance is 3.8, which may be compared with 2.0, the corresponding ratio in the *alleganiensis* series. The least diameters of the *bishopi* spiracular openings were found to be 1.5 mm. and 0.5 mm. (U.S.N.M. No. 57042) and the greatest were 8 mm.

and 10 mm. (U.M.M.Z. No. 68929), these latter figures being somewhat smaller than the average diameter in adult *alleganiensis*.

The background color of *bishopi* is lighter than that of *alleganiensis*. The markings of *bishopi* may better be de-



MAP 1. The distributions of *Cryptobranchus alleganiensis* and *C. bishopi* in Missouri and Arkansas. The hollow circle represents a literature record (see text).

scribed as blotches; those of *alleganiensis* as spots. The extent of pigmentation of the individuals of *bishopi*, especially on the lateral surfaces of the tail, is attained by but few adults of *alleganiensis*. The lower labial region is markedly spotted in

bishopi, usually not so in *alleganiensis.* The ventral canals of the lateral line system in the pectoral region apparently are not as well developed in *bishopi* as in the majority of adult *alleganiensis.*

The prevomerine teeth in the series average 37, varying from 28 to 51 (the corresponding figures for a small series of *alleganiensis* being 38.5, 32, and 48). The interorbital distance contains the distance between the external nares 2.2 times in *bishopi;* 2.1 times in *alleganiensis.*

The average total length of the type specimens of the Ozark cryptobranchid is 37 cm., the smallest individual being 27 cm., the largest, 45 cm.

RANGE.—The known specimens of *bishopi* are from two localities on the Current River and one locality on the Eleven Point River in Missouri (Map 1). Two specimens listed by Black and Dellinger (1938: 4) as *C. alleganiensis* from the Spring River, Arkansas, may possibly be examples of *C. bishopi.* They are represented by a hollow circle on the accompanying map. All of these localities are on rivers that drain into the southward flowing Black River of Arkansas and Missouri. *C. bishopi* is apparently effectively isolated from *C. alleganiensis.* The available Missouri specimens of the latter are from the Missouri River drainage. A continuous water passageway between these localities and the *bishopi* stations would involve the junction of the White River (into which the Black River drains) and the Mississippi River (into which the Missouri River drains) in Desha County, Arkansas. As far as available records indicate[4] *Cryptobranchus* does not range this far south in the Mississippi Valley.

Although the distributional picture is one suggesting subspecific relationship with *alleganiensis,* inasmuch as the forms replace each other geographically, the binomial is here used, in a somewhat classical sense, for intergradation has not been observed. Intergradation, in order to occur, would probably

[4] The specimens upon which Cope's (1889: 42) Louisiana record is based are, according to Percy Viosca, Jr., apparently larval *Ambystoma talpoideum.*

depend on headwater stream capture in the region of the divide between the Black River and Missouri River watersheds.

REMARKS.—The greater extension of the blotching in *bishopi* may be considered a juvenile character; however, the closure of the spiracles probably represents a more adult stage of development. In this latter character *C. bishopi* approaches the condition of the Asiatic cryptobranchid, *Megalobatrachus*.

PSEUDOTRITON

A character often used in distinguishing between salamander species is the number of costal folds included between the toes of the adpressed limbs. A tabulation of this character for the races of *Pseudotriton ruber* reveals that there is not only an interrace gradient but also an intrarace gradient which is apparently correlated with size. It is evident that the larger (older) salamanders of a race have more costal folds included between the toes of their adpressed limbs than do the smaller (younger) specimens of the same race.

That this is also the situation in a series of seventy-eight specimens of *Plethodon c. cinereus* (Green) collected October 16, 1929, from Maplewood Park, Rochester, New York, is suggested by the measurements kindly made available to me by Miss Barbara H. Leonard of the University of Rochester. The females with seven costal grooves included between the toes of their adpressed limbs had a trunk length of 39.7 mm.; those with eight had a trunk length of 41.3 mm.; and those with nine had a trunk length of 45.4 mm. The difference between the first pair of means contains its standard error 2.4 times; between the second pair, eight times. In the males of this collection the individuals with six and seven folds between the toes of the adpressed limbs had a trunk length of 41.5 mm.; those with eight and nine folds a trunk length of 43.6 mm. The standard error is contained about 3.4 times by the difference between these means. In this series, then, with seasonal, geographical, racial, and sexual variation reduced to a minimum, there seems to be a correlation between the number of costal folds included between the toes of the adpressed limbs

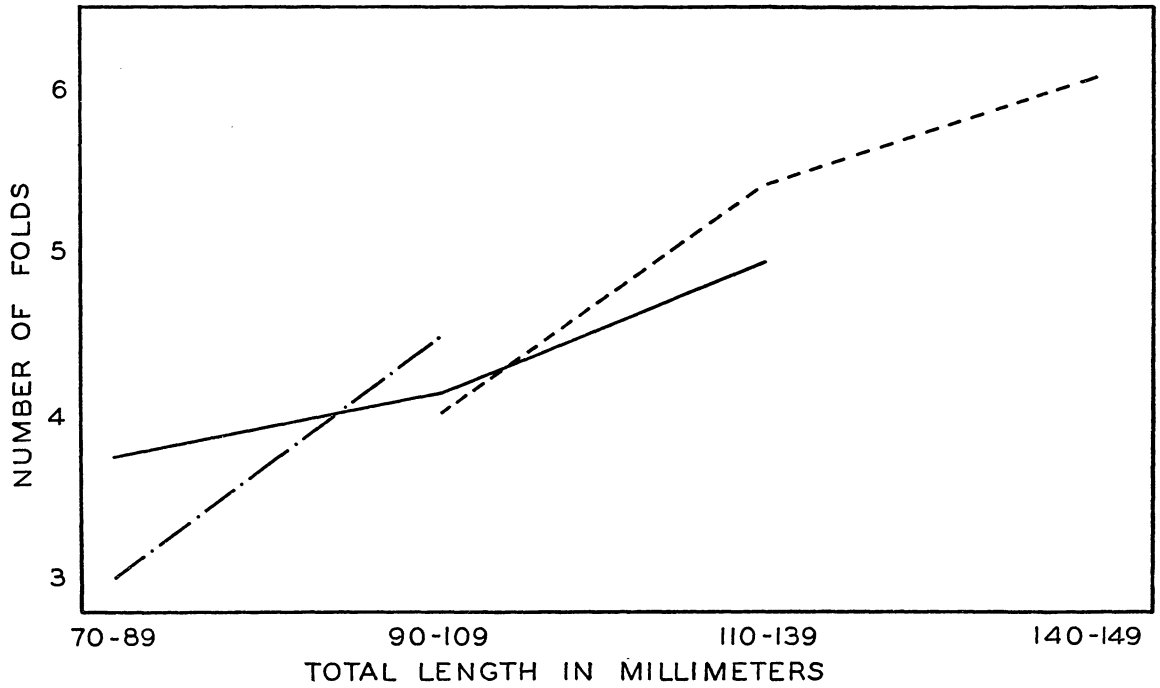


FIG. 1. Chart showing the relationship between the number of costal folds included between the toes of the adpressed limbs and the total length in *Pseudotriton ruber nitidus* (dot-dash line), *P. r. schencki* (solid line), and *P. r. ruber* and *P. r. vioscai* (broken line).

and the size (age). Dunn (1926: 135) has noticed a similar situation with regard to *Plethodon wehrlei* and Stuart (1940: 2–4) a comparable situation in the lizards *Lygosoma a. assatum* and *L. a. cherriei.*

The slopes of the lines are about the same for each race of *Pseudotriton ruber* (Fig. 1). Probably the most plausible explanation is that an ontogenetic difference exists in the growth rates of the limbs and trunk. Thus, there are more costal folds between the toes of the adpressed limbs in the larger (older) individuals because the limbs grow more slowly than the trunk does. Further, it appears that the genetic control of the developmental rates is similar in the several races of *Pseudotriton ruber.*

These examples, besides illustrating heterogonic growth, serve to illustrate a possible source of error in taxonomic work with salamanders whenever the number of costal folds included between the toes of the adpressed limbs is used as a character without determining whether, and to what extent, an ontogenetic change is involved.

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PLATE I

A comparison of four specimens of the Nashville basin *lucifuga* (U.M.M.Z. No. 77387), below, with four typical *lucifuga* (U.M.M.Z. No. 75839, Iron County, Missouri, average length, 125 mm.), above.