OBSERVATIONS ON THE SYSTEMATICS AND ECOLOGY OF *CRYPTOBRANCHUS* FROM THE OZARK PLATEAUS OF MISSOURI AND ARKANSAS. -In the original description of *Cryptobranchus bishopi,* Grohman (1943, 0cc. Pap. Mus. Zool., Univ. Mich. No. 470:1-12) indicated that use of the binomial was somewhat in the classical sense, inasmuch as intergradation with C. *alleganiensis* had not been demonstrated. None of the characters examined was exclusive; some degree of overlap occurred in all. The most reliable features pointed out for distinguishing C. *bishopi* from C. *alleganiensis* were differences in dorsal mottling, in lower labial marking, in spiracle size, and in the ventral canal system of the pectoral portion of the lateral line system. Grobman's type series of 12 animals allowed only sketchy comparisons.

Through personal collecting activities we have had available over 150 *Cryptobranchus* from Missouri and Arkansas, of which 14 are from the range of *bishopi.* Seventy-eight specimens were examined in detail. The collections include particularly large series from the *alleganiensis* waters of the Niangua and Gasconade rivers of central Missouri, each tributary to the Missouri River system (the Niangua via the Osage River and the Gasconade directly tributary) . A modest number of animals from Big Piney River, a tributary to the Gasconade, also were examined. From the range of *bishopi,* the material includes 2 animals from the Eleven Point River, one of Grobman's original stream lots, 11 from Spring River, Arkansas, from which no specimens have previously been examined, and 1 from the North Fork of White River, another stream from which no previous record is available.

The measurements and descriptions of our animals essentially corroborate Grobman's findings, except in one respect, spiracular size. Grohman speaks of spiracular diameter, but in preserved specimens the spiracle is contracted to a vertical slit. This opening is markedly contracted and cannot be suitably measured by vernier calipers or dividers because of the elasticity of the tissues. Also, Grohman did not state if he measured the outside slit, or the more sharply defined internal slit. The outer flap is very wrinkled and flabby, and especially difficult to measure. However, though we cannot duplicate Grobman's data, there is little doubt that *bishopi* has smaller spiracular openings. There may be, however, bilateral variation in size.

Without reference to geographic data, at least 75% of the *Cryptobranchus* can be correctly allocated on the basis of dorsal markings; *bishopi* usually has splotches where *alleganiensis* has spots. Such differences are readily discerned in animals exceeding 120 mm snout-vent length. The patches of dark mottling on the lower labial surface of *bishopi* also appear to be definitive. In animals exceeding 120 mm snout-vent length, over 90% can be correctly allocated on the basis of the appearance of the lateral line system of the pectoral region: in *alleganiensis* the canals appear to be a series of papillate elevations, but the skin is smooth in *bishopi.*

Differences between C. *alleganiensis* and C. *bishopi* are otherwise slight, reflecting perhaps nothing more than expected from population to population. The differences in size given by Grohman break down: Grobman's largest *bishopi* had a total length of 45 cm, exceeded by our largest, which measures 39.7 cm snout-vent length and 56.8 cm total length. The largest Missouri *alleganiensis* that we secured measured 40.5 cm snout-vent and 62.6 cm total length. Additional collecting probably would bring to light C. *bishopi* larger than 57 cm total length.

Reproductive data for animals from the different streams show interesting contrasts. No adult females collected in early September from the Gasconade River were gravid, but 50 miles distant, in the Niangua River, all larger females contained ova nearly 6 mm in diameter and obviously ready for deposi- tion. A guarded nest containing 138 eggs was found under a stone in the Niangua River on 3 September 1954. On 14 Novem- ber 1954, we found 2 ripe females in the Niangua, but on that same date all large fe- males from the Gasconade had ova about 2 mm or less in diameter, clearly far from ready for deposition. From the Spring River in the range of *bishopi,* females had large ova up to 5 mm diameter in late August, but peak size of the ova was seen in late October. The spawning season, extending from early September through at least mid-Novem- ber in the Niangua River, is in sharp con- trast to the 2-week or so season reported in Pennsylvania and New York (Smith 1907,

Biol. Bull. 13:5-39). There is no complete separation of the spawning seasons for *alleganiensis* and *bishopi,* but on the whole, the former appear to oviposit 2 months or more earlier.

The seasonal differences in reproduction appear to hinge on environmental factors. The characteristic habitats of Missouri and Arkansas *Cryptobranchus* are streams that are fed by a heavy influx of waters from springs. Spring River, for several miles downstream from Mammoth Spring, Arkansas, maintains a temperature of approximately 15 ± 2 C through most of the year; the Eleven Point River holds temperatures below 17 C for many miles of its course, even in midsummer, and apparently does not drop much below 12.5 C in midwinter in these reaches. The Niangua River also is quite stable, not so much as the *bishopi* streams, but at the peak of summer heat it maintains temperatures under 21 C, dropping below 12 C in winter, at least in the areas checked by us. At such sites, then, the *Cryptobranchus* are living within relatively stenothermal ranges for lotic waters, and herein may rest an explanation for the similar breeding seasons in the Niangua and Spring rivers. But the Gasconade River is a larger stream, and spring waters are not so effective in modifying its temperatures. Thus, where we have collected *Cryptobranchus* in the Gasconade, summer temperatures reach 25 C, though by onset of winter they drop to levels of the other streams, perhaps colder. Development of ova in the Gasconade animals presumably takes place more rapidly because of increased metabolic rates in the warmer-bodied salamanders, and spawning therefore occurs in late summer.

Preliminary study of the population structure of *Cryptobranchus* in the Niangua and Gasconade systems indicates that at least 3 size groups are present in the postlarval stages. For example, a collection from the Niangua River made in September includes a group with snout-vent lengths I 10-139 mm, a group from 210-269 mm, and one from 310-349 mm. Since the larval period supposedly takes 3 years (Smith, *op. cit.),* we suggest that *Cryptobranchus* takes at least 6 years to reach full adult size wherein the snout-vent length is 30-32 cm. Extra large animals, such as several exceeding 40 cm snout-vent length, indicate a longevity of at least 7 years. Sexual maturity, however, is displayed by *bishopi* females over 238 mm snout-vent length (330 mm total length) and *alleganiensis* females over 247 mm snout-vent length with ripe ova, and by males over 244 mm snout-vent length with swollen cloaca! lips during the apparent spawning season. Sexual maturity appears to be attained during the fifth or sixth year as suggested by Bishop (1941, N. Y. St. Mus. Bull. No. 324: 1-365).

In the Ozarks, the chosen habitat includes clear or murky streams with suitable flat stones for concealment. Animals are readily found in riffles, but they also frequent the deeper, quiet stretches where fishing with baited lines at night is the most successful way to procure them. Electrical fish shockers used by the Missouri Conservation Commission personnel frequently turn up specimens. If large springs are near, the *Cryptobranchus* apparently concentrate not far downstream, just out of the area where there is essentially no temperature change during the year.

The habits of Ozark *Cryptobranchus* seem in general to correspond to those of the better studied Allegheny Plateau populations. They eat crayfishes in the main, occasionally taking various fishes and aquatic insects. The animals from Spring River in Arkansas characteristically harbor numerous leeches, indicated by Marvin Meyer of the University of Maine to be an undescribed species. This is the first instance known to us in which leeches have been found on *Cryptobranchus.* In total consideration of the morphology and ecology of *Cryptobranchus alleganiensis* and *C. bishopi,* and their allopatric distribu- tions, the best nomenclatorial usage appears to be subspecific designation for *bishopi,* de- spite the lack of demonstrated intergrada- tion. Schmidt (1953, A checklist of North American amphibians and reptiles. Sixth Ed. Am. Soc. Ichthyol. and Herpetol.) has al- ready used the trinomial combination, al- though his information must have been based solely on the original type description.

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HAROLD A. DUNDEE, *Department of Biology, Tulane University,* AND DEE S. DUNDEE, *Department of Biology, Louisiana State University, New Orleans, Louisiana.*