COMPARISON OF HABITATS OF TWO CRAYFISHES OF THE GENUS *PROCAMBARUS* IN ILLINOIS AND LOUISIANA

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As part of a study of the biology of the crayfishes of central and southeastern Illinois, the author investigated the aquatic habitats of the crayfishes found in that state (Brown, 1955). The limnological data consisted of records of the temperature of the water, dissolved carbon dioxide, hydrogen-ion concentration, dissolved oxygen, and total alkalinity. Additionally, data were compiled on physical factors such as the general type of habitat, types of bottoms, and the turbidity of the water.

Subsequently, during a study of crayfishes in Louisiana, two forms, *Procambarus clarkii* (Girard) 1852 and *P. blandingii acutus* (Girard) 1852, which also occur in both of these rather widely separated states, were collected. According to Hagen (1870), *P. b. acutus* has been reported in both Illinois and Louisiana over a long period of time, while *P. clarkii* appears to be a relatively recent migrant into Illinois (Brown, 1955). In the light of these facts the author became interested in comparing the habitats of these forms in the two states. It was hoped that such an investigation might clarify the factors responsible for the difference in the distributional pattern and indicate the probability of the success of *P. clarkii* in Illinois.

Materials and Methods

The comparisons of *P. clarkii* are based on only nine collections in Alexander, Massac, and Pulaski counties in Illinois, and records from ten collecting stations in East and West Baton Rouge parishes, Louisiana. On the other hand, *P. b. acutus* was collected throughout Illinois, while the data from Louisiana were obtained from nine stations in East and West Baton Rouge parishes. It is unlikely that these data represent the true range of variation over the entire state of Louisiana. However, it is felt that they are sufficient to serve as a basis of comparison of the types of habitats occupied by these two forms in the two rather widely separated areas.

Standard limnological methods were used (Welch, 1948). Temperature determinations were made with a Centigrade chemical thermometer. La Motte colored glass standards were used for the hydrogen-ion tests. Total alkalinity values were arrived at by titrating .02N sulfuric acid against methyl orange, and the Rideal-Stewart modification of the Winkler Method was used in the determinations of dissolved oxygen. A Kemmerer water sampler was used for collecting the samples for both of these determinations. A nomogram based on Moore's equation (1939) was used to find values for dissolved carbon dioxide. The references to turbidity are estimates of relative clearness of the water rather than to exacting quantitative measurements.

Results and Discussion

Since the temperature of the water varies with the climate, the occurrence of the two forms in the two states, whose mean annual temperatures are quite different, suggests that both forms have a very wide range of tolerance to varying temperatures (Table 1). The data agree with those of Park (1945); he found that pond or lentic crayfishes are found predominantly in lentic situations (Table 2). A comparison of the mean temperatures of the waters in which they were found suggests that temperature might be an important factor in that the mean temperature of the water of the habitat differs by only 1.5°C. for *P. b. acutus* and 1°C. for *P. clarkii* in the two states. However, the ranges are based on samplings during the warmer season.

According to Welch (1951), the literature contains numerous positive contentions that pH is an important limiting factor for certain organisms. However, he also points out that other workers regard pH as of secondary importance, and that some investigators have claimed for some organisms no correlations of any sort with the pH range as it occurs in natural, unmodified waters. The latter appears to be true for these crayfishes (Table 1). The mean of the hydrogen-ion concentrations for waters inhabited by *P. b.*

Table 1.—Chemical Data from the Habitats of the Crayfishes.

	Temperature °C		Hydrogen-ion		Dissolved O_2[1]	
	Range	Mean	Range	Mean	Range	Mean
P. clarkii						
Illinois	22–34	27	6.8–8.0	7.3	1–11.3	4.1
Louisiana	20–33	28	6.8–7.6	7.0	1.3–7.4	4.0
P. b. acutus						
Illinois	8–35	23	6.3–8.2	7.2	1–12	5.0
Louisiana	20–33	24.5	6.8–7.6	7.1	1.8–7.4	4.5

	Dissolved CO_2[1]		Total alkalinity[1]	
	Range	Mean	Range	Mean
P. clarkii				
Illinois	1–50	13	59–202	112
Louisiana	0.14	3.8	13–217	59.5
P. b. acutus				
Illinois	0–50	10	50–463	190
Louisiana	0–13	4.2	13–217	88.3

[1] In parts per million.
Illinois data—spring, summer, fall, 1953, 1954.
Louisiana data—spring, summer, 1957, 1958.

acutus in the two states differs by only 0.1 and that of *P. clarkii* by only 0.3. This suggests a preference. Both forms do, however, inhabit waters in the two states whose hydrogen-ion concentrations are about the same, at least during the periods tested.

Both of the crayfishes live in waters whose dissolved oxygen concentration becomes either rather low or very high (Table 1). The dissolved oxygen concentrations range higher in Illinois for both forms because they also occur in streams which have rapids and other means of aeration. The means for both forms in the two states do not appear to be significantly different, varying in the case of *P. b. acutus* by 0.5 p.p.m. and that of *P. clarkii* by only 0.1 p.p.m. These data suggest that both crayfishes live in waters with essentially the same oxygen concentration in the two states.

There seems to be a greater difference in the concentration of the dissolved carbon dioxide than in any of the previous factors. These results may best be explained on the basis of the data from the individual samplings. This is particularly true in the instance of the samplings in Louisiana. In six instances the carbon dioxide concentration was either 1 or 0 p.p.m., and, therefore, the means are low. A comparison of the means of the dissolved carbon dioxide concentrations suggests that this factor may be critical. However, it is also noted that both the means and the ranges are uniformly high for both crayfishes in Illinois and low for both in Louisiana.

The waters in the southern part of Illinois showed lower total alkalinity values than did those of the other parts of the state. *P. clarkii* was found only in the southern part of Illinois. The total alkalinity values for the habitats in Louisiana ran even lower than those of southern Illinois (Table 1). Maximal alkalinity of the waters in Illinois inhabited by *P. b. acutus* ranged up to 463 p.p.m., that of the habitat of *P. clarkii* was 202 p.p.m.; in Louisiana these values were 217 p.p.m. in each case. Therefore, it is seen that the total alkalinity ranges for both *P. clarkii* and *P. b. acutus* in Illinois and Louisiana are rather wide. The total alkalinity values suggest that there is a considerable difference between the habitat preferences of these forms in the two states, but both forms tolerate wide ranges of alkalinity.

Rhodes (1944) wrote that *P. b. acutus* is "rather tolerant regarding ecological factors", and Hobbs and Marchand (1943) usually found *P. clarkii* in lentic situations in Kentucky and Tennessee. During this study both forms were usually found in situations comparable to those reported from other areas. The general types of habitats from which the two forms were collected in both states do not differ greatly. The higher percentage of *P. clarkii* in running water in Louisiana (Table 2) is probably due to abnormally frequent rains while the collections were being made; this resulted in the occurrence of crayfishes in running water in streams which are normally intermittent.

Rhoades (1944) found *P. clarkii* predominantly in mud-bottomed sloughs or temporary situations. The information gained in investi-

gating the two forms in Illinois suggests that both crayfishes seem to exhibit a preference for mud-bottomed situations. The percentages of collecting stations with mud bottoms from which both forms were collected in both states are almost identical (Table 2). The fact that *P. b. acutus* was on sandy and rocky bottoms in Illinois may be attributed to the fact that such habitats are relatively abundant in that state.

The final aspect for consideration is that of turbidity. It was noted while collecting various species of crayfishes that these two forms, in particular, seemed to show a decided preference for turbid waters. During the present study only *P. b. acutus* was found in clear water. With the exception of the instances in which *P. b. acutus* was collected from clear water situations, the turbidity of the waters from which the two forms were collected in the two states is strikingly similar (Table 2).

TABLE 2.—Distribution of Crayfish Related to Physical Factors in the Habitat.[1]

WATER	Running	Intermittent	Pond	Temporary pond
P. clarkii				
Illinois	..	44	12	44
Louisiana	40	20	10	30
P. b. acutus				
Illinois	37	50	7	6
Louisiana	50	12.5	12.5	25

TYPES OF BOTTOMS	Soft mud	Sandy	Rocky	Sand and mud	Clay
P. clarkii					
Illinois	100	..	..	....	....
Louisiana	90	..	..	....	10
P. b. acutus					
Illinois	71	9	5	9	6
Louisiana	75	..	..	12.5	12.5

TURBIDITY	Low	Medium	High
P. P. clarkii			
Illinois	....	34	66
Louisiana	....	60	40
P. b. acutus			
Illinois	15	45	40
Louisiana	12.5	50	37.5

[1] Expressed in percentages of occurrence of crayfish.

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Summary

The limited section of southern Illinois from which *P. clarkii* was collected affords essentially the same types of physical conditions as those found in Louisiana where this species abounds. This is not true for *P. b. acutus*. The present study, like that of Hobbs and Shoup (1942), showed no evident correlation between alkalinity, pH, dissolved oxygen, dissolved carbon dioxide, or temperature and the distribution of the crayfishes. The data seemed to indicate a marked similiarity of conditions, both physical and chemical, under which the two crayfishes live in the two states. However, the conditions under which *P. clarkii* lives in both Illinois and Louisiana seem to be more nearly the same than do those under which *P. b. acutus* lives in the two states; these conditions might serve as a limiting factor for the further dispersal of *P. clarkii* in Illinois and adjacent areas.

Literature Cited

Brown, Paul L. 1955. The biology of the crayfishes of central and southeastern Illinois. Unpubl. doctoral thesis, Univ. Ill., Urbana, 158 pp.

Hagen, Hermann A. 1870. Monograph of the North American Astacidae. 3. Cat. Mus. Comp. Zool., Harvard Coll., No. 3, 109 pp.

Hobbs, Horton H., Jr. 1942. A generic revision of the crayfishes of the subfamily Cambarinae (*Decapoda, Astacidae*) with description of a new genus and species. Amer. Midl. Nat., 28:334-357.

Hobbs, Horton H., Jr., and Lewis J. Marchand. 1943. A contribution toward a knowledge of the Reelfoot Lake Area. Jour. Tenn. Acad. Sci., 18:6-35.

Hobbs, Horton H., Jr., and C. S. Shoup. 1942. On the crayfishes collected from the Big South Fork of the Cumberland River in Tennessee during the summer of 1938. Amer. Midl. Nat., 28:634-644.

Moore, Edward M. 1939. Graphic determination of carbon dioxide and the three forms of alkalinity. Jour. Amer. Water Works Assoc., 31:51-65.

Park, T. 1945. A further report on toleration experiments by ecology classes. Ecology, 26:305-308.

Rhoades, Rendell. 1944. The crayfishes of Kentucky. Amer. Midl. Nat., 31:111-149.

Welch, P. S. 1948. Limnological methods. Philadelphia, Blakiston Co., 381 pp.

1951. Limnology. New York, McGraw-Hill Book Co., 471 pp.

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