

THE CRAYFISHES OF WEST VIRGINIA.*

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To the extent that a natural resource of a country has, in the eyes of its people, a distinct economic significance either from a utilitarian viewpoint or from that of a sportsman, in exactly that degree will it receive adequate attention necessary for its preservation. This idea is well exemplified in the case of the fisheries of the State. As soon as the depletion of a species sets in, the demand for information concerning its life history and habits increases.

In the study of crayfishes we cannot say, perhaps, that they possess at the present time any great economic value, positively or negatively. On the other hand, from the point of view of an ecologist, they present almost ideal material for studies of habitat preference, and for investigations to determine the influence of environmental factors on pigmentation. What determines whether a crayfish shall be red or blue or brown? Is it to be explained on a purely genetical basis? Perhaps the factor of age may be significant. Allee ('27) studied the methods of aggregation in the case of the brittle starfish (*Ophioderma brevispina*) and discovered that the aggregations were formed in the main by individual (primary) responses to environmental conditions rather than by social (secondary) impulses. The results of this study substantiate his former conclusions arrived at in his work with land isopods. (Allee '26) What are the types of aggregation, if any, in the case of *Cambarus*? This is an excellent field for research that is in need of elaboration. In this paper the author will give an account of the crayfish-fauna of the State of West Virginia, as complete as possible from the chorological, biological, and ecological standpoint.

This report has resulted from a belief on the part of the author that altogether too little is known concerning the conditions under which crayfishes subsist, more particularly, perhaps, those conditions that will lead to optimum growth and development.

*Contribution from the Zoological Laboratory of West Virginia University.

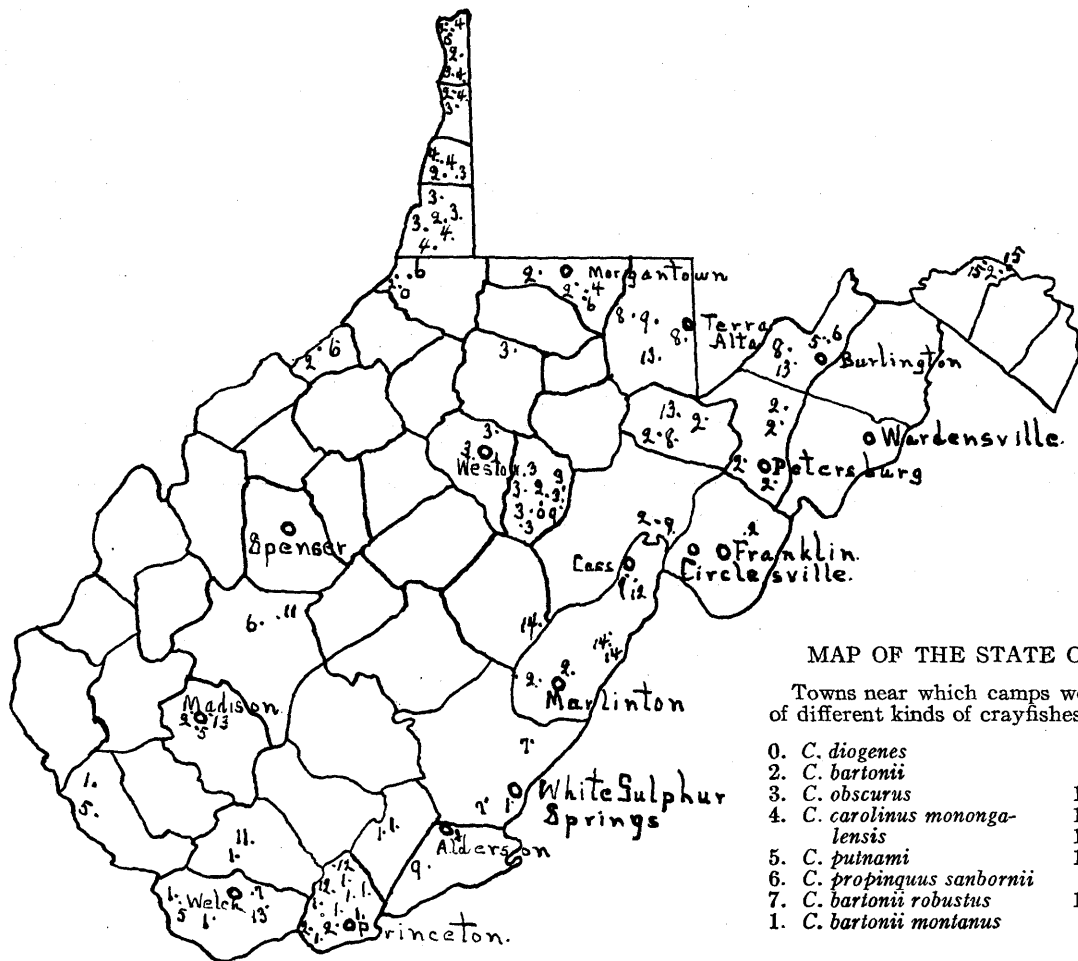


FIGURE 1

The material for this study was collected by the writer in connection with his work as a member of the West Virginia University Biological Expedition, consisting of students and instructors of West Virginia University carrying on field work in Bioecology.

The writer is indebted to Dr. A. M. Reese, under whose direction the study was conducted, for his invaluable assistance and guidance throughout the progress of the work. Thanks are due Dr. P. D. Strausbaugh for suggesting the problem and for many helpful suggestions and criticisms. Acknowledgment is made of the kindly assistance of Professor Weimer and the members of the West Virginia University Expedition who gave material assistance in collecting and to Dr. W. L. Schmitt for numerous identifications.

During the three months spent in the field (June, July, August, 1928) the party established successive headquarters in various regions of the State, each camp period lasting for about five days during which time field trips were made to the various points of ecological interest by means of autos. On the chart is listed the places in which collections of the various species were made, also all regions in which crayfishes have been hitherto collected in so far as these are included in the authentic records known to the author. (Figure 1).

At least eighty-five percent of the total area of the State of West Virginia consists of mountains and hills, the only broad valleys being those of the Ohio, Kanawha, Potomac and the Shenandoah rivers. Thus it is primarily a mountain state possessing wide diversity of physiographic conditions. To obtain a clear conception of the general surface features, West Virginia may be divided into three parts: (a) the Ohio Valley Section, (b) the Mountain Region, and (c) the Potomac Area. The first division includes about half of the State sloping westward from the Allegheny Mountains to the Ohio river. In all places the plateau is dissected by narrow valleys giving a great variety of habitats for animal and plant life. The altitude here ranges from 200 to 800 feet. The Allegheny region may be said to begin at the 1500 ft. elevation and includes thousands of mountain tops arranged irregularly, and deeply cleft. The highest ridge of the Alleghenies is Spruce Mountain located in Pendleton County, with an elevation of 4860 feet. The remainder of the State constitutes the Potomac system usually known as the Eastern Panhandle.

Despite the fact that there are no natural lakes in West Virginia, it is one of the best watered states on account of its never-failing springs, numerous streams, and creeks, winding their way around the mountain peaks and ridges. The entire drainage of the State with the exception of a small area in Monroe County is effected by two river systems—the Ohio and the Potomac. As will be emphasized later, these mountain streams and swiftly flowing creeks and rivers afford an excellent home for the *red crayfish*—furthermore, a study of some swampy areas lying beside the rivers revealed the presence of whole colonies of these interesting forms.

HISTORICAL STATEMENT.

In so far as the writer has been able to determine, no extensive crayfish studies have ever been undertaken in West Virginia. Consequently, the credit for the data that we have at the present time goes to men, who, while engaged in Biological Survey Work in the neighboring states of Pennsylvania, Ohio, Maryland and Kentucky, made numerous expeditions into West Virginia. Here may be mentioned such men as Ortman, Faxon, Hay, Hagen, Turner and Williamson.

Ortman, late of the Carnegie Museum, has made extensive collections in Pennsylvania, northern and eastern Ohio and northern West Virginia. The records obtained prior to 1906 are included in the monograph "The Crayfishes of Pennsylvania" (Ortman '06). These furnish some valuable information concerning the habits, distribution, and ecological preferences of many common West Virginia species. He places special emphasis on the fact that the life history and habits of different species of the genus *Cambarus* are by no means similar, the differences being accounted for primarily by the different ecological conditions under which they live. Hay ('02) tells of having found the species *C. bartonii tenebrosus* abundant in several caves in Virginia and West Virginia. In this same locality he also collected an albinistic specimen.

In July 1899, Hay collected typical examples of *Cambarus bartonii carinirostris* Hay from the Tygarts Valley River at Beverly and near Elkins. He also secured a few specimens at Albright, Preston County, and at Queens, Upshur County, in the above named river basins. Again in 1900, he collected upward of 100 specimens of a crayfish closely resembling

C. putnami Faxon in southwestern West Virginia. Both Hagen and Faxon have made numerous excursions into West Virginia and some interesting information is contained in their report.

Sparganum-Ludwigia-Cambarus putnami Associes.

Some interesting field observations were made of the species *C. putnami* Faxon at a small swampy area which lies in the valley of Pond Fork between the stream and the base of the mountain situated about two hundred and fifty yards south of Uneeda Station, West Virginia. This region is a typical river valley so characteristic of those of West Virginia and the general level of the valley floor at this point is about 700 feet. The soil is of an alluvial character with a large admixture of humus.

A plot of ground 250 yards by 50 yards which composed the major portion of the swamp was selected for study (Figure 2). Five plots chosen as representative parts were marked off, the size of each being twenty-five square meters. The number of holes in each area was counted and checked and then an attempt was made to find the actual depth of one burrow in each of the five areas. Crayfish holes were observed in large numbers all about the margin of the swamp indicating a rather numerous population of these animals. The temperature of the water in the swamp was 28 degrees Centigrade. The dominant plants of this area were those of the Burr-reed Community (*Sparganum eurycarpum*), Marsh Purslane (*Ludwigia palustris*) and Swamp Loosestrife (*Decoden verticillatus*).

In the central part of the swamp there was a small clump of black willows (*Salix nigra*), the only woody plant in the entire area. The Plant Community was further characterized by the presence of several species of sedges (*Carex vulpinoidea*, *C. crinita*, *Dulichium arundinaceum*) and two rushes (*Eleocharis tenuis* and *Juncus effusus*), commonly found growing in such habitats.

The animal life of the water consisted mainly of tadpoles, salamanders, water striders, crickets, toads, frogs, snakes, insect larvæ, and various species of entomostraca. The following is a list of predominant forms observed in this associes:

SCIENTIFIC NAME	COMMON NAME
<i>Natrix sipedon</i>	Water snake.
<i>Hyla crucifer</i>	Spring peeper.
<i>Triturus viridescens</i>	Yellow-backed Salamander.
<i>Diadophis punctatus</i>	Ring-necked Snake.
<i>Heterodon contortrix</i>	Hog-nosed snake.
<i>Rana clamitans</i>	Green frog.
<i>Rana catesbeiana</i>	Bull frog.
<i>Bufo americanus</i>	Common toad.

The accompanying diagram (Figure 2) will indicate the relative location of areas where following records were made.

AREA NO. I.

Hole No. 1.

Depth of water table below surface.....	33 cm.
Depth at which crayfish was found.....	86 cm.
Bottom not reached.	

Hole No. 2.

Depth of water table below surface.....	27 cm.
Depth at which crayfish was found.....	72 cm.
Bottom not reached.	
Number of crayfish holes—21.	

AREA NO. II.

Hole No. 1.

Depth of water table below surface.....	31 cm.
Depth at which crayfish was found.....	48 cm.
Number of crayfish holes in area—37.	

AREA NO. III.

Hole No. 1.

Depth of water table below surface.....	37 cm.
Crayfish not found.	
Depth of hole.....	145.5 cm.
Number of crayfish holes in area—25.	

AREA NO. IV.

Hole No. 1.

Depth of water table below surface.....	42 cm.
Number of crayfish holes in area—11.	

AREA NO. V.

Not tested for depth of water table.
Number of crayfish holes in area—21.

One hole in another part of the field was found to be over six feet in depth. The average number of holes in the five areas examined is 23, and on this basis the total number in the swamp is approximately 9615.

All the holes that were examined closely went straight down from four to eight inches, then they made an abrupt turn and continued downward to the water table. Crayfishes were seen lying near the edge of their burrow and it was found that upon the slightest stimulation they immediately crawled

over the edge and dropped into the holes. Thus it would seem that the perpendicular nature of the upper part of the hole is of advantage in that it affords an easy avenue of escape when attacked by enemies. It was not always possible to determine the full depth of the burrow because of the constant inflow of water. During the day crayfishes were usually found deep in their burrows.

Ortman ('06) distinguishes between three main types of ecological conditions among crayfishes. First, there are those species which generally live in the larger rivers; second, those preferring the ground water where it is not far from the surface and appears in the shape of springs and swamps; third, those that prefer intermediate conditions and select smaller streams

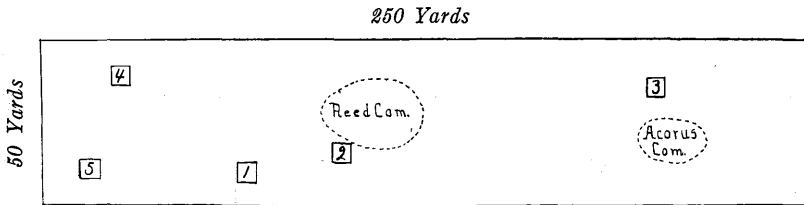


FIGURE 2

A drawing to show distribution of plots in the area in which studies of *Cambarus putnami* were made

for their homes. He aptly calls these the "river species," "mountain stream species," and the "burrowing species." Almost all the crayfishes of West Virginia will, in my estimation, fall in one of these categories, and so they will be used in the discussion that follows.

The data listed above would seem to point quite conclusively to the fact that *C. putnami* Faxon is a burrowing species. In the daytime, without exception, they were found in the ground water of their burrows. A few chimneys were observed at the entrance of some of the holes. Since the way of carrying the mud out of the holes seems to be identical in all burrowing species the following quotation from Ortman ('06) is of interest. "In digging, the chelæ of the first pereopods are used. The fingers are slightly spread out so they are about parallel, thus acting as forks for digging. They are pushed vertically down into the mud on both sides at the same time and a lump of mud is thus loosened and lifted toward the ventral surface of the body. In lifting, the chelipeds are bent

toward the body (the region of the mouth), and finally the ball of mud is appressed to the anterior part of the body and held in position by the chelæ. Very likely, also, the third maxillipeds take hold of it but it was impossible to ascertain this. In this position, as Goodman expresses it, carrying an armful of dirt, (or rather two armful), the crayfish walks slowly and deliberately to the mouth of the hole. I have repeatedly observed this coming out in nature. It advances to the top of the chimney and deposits the mud pellet upon the rim. Finally pushing it into proper position with the upper (outer) surface of the claws. This latter act apparently was seen by Mr. J. DeB. Abbot; but according to my experience the mud is not brought up upon the back of the claw but held as described above between the folded claws and the anterior part of the body."

In this particular region no chimney openings were found closed. In other regions of the state, such as at Welch, burrows of the species *C. bartonii robustus* Girard and *C. carolinus dubius* Faxon were found closed. The height of the chimneys averaged about nine inches.

How important a factor is the chimney of the crayfish habitat? Tarr ('84) states that he does not regard the chimney as a necessary part of the nest but simply the result of digging. In the estimation of Dr. A. E. Ortman, the construction of the hole is the chief aim for which the crayfish works. It not only affords protection for the crayfish and its young from such enemies as snakes, but protects the hole from the disturbing influences of rain and frost. Observations would indicate that females with eggs or young are usually found in closed holes. Various environmental factors such as slope of land and character of soil influence the shape of the chimneys. Young specimens usually build more regular chimneys than old ones, due probably to the fact that old specimens live in burrows that are practically completed, with the result that the mud that is removed is softer and makes rather irregular chimneys. Abbot ('84) is of the opinion that closed chimneys are caused by the falling in of the rim. On several occasions I have found burrows that were closed by a "stopper" extending down at least 18 mm. below the surface of the ground, and the firmness of the soil constituting the stopper was of such a nature that it could hardly be explained as an accidental falling in of the rim.

The above listed animals and plants present in the swamp are quite characteristic of the forms usually found in association with crayfish aggregations.

FOOD.

Observation of specimens in captivity as well as those in their natural environment leads one to believe that they are generally omniverous. They will eagerly devour almost any organic substance whether it be animal or vegetable. In captivity, I have known one instance in which *C. carolinus dubius* Faxon devoured a blue crayfish *C. carolinus dubius* Faxon (blue phase) (Newcombe '29) of almost equal size. On one occasion I observed a small form feeding on a dead fish. Some species are commonly known to devour their own cast off shell after moulting.

During the day crayfishes are usually found at rest, seeking shelter under a submerged log or rock crevice, while at night they are very active since it is at this time that they go in search of food. Quoting from Pearse ('10) "their activities are strictly utilitarian, being confined to such necessary movements as are concerned in mating, seeking and capturing food, and searching for environmental conditions."

DISTRIBUTION OF WEST VIRGINIA SPECIES.

The records of the localities and dates at which the different species of crayfishes from West Virginia have been reported, have been assembled and represented in the following tables:

TABLE I.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
<i>C. putnami</i>	McDowell	Barrenche creek, near Perryville	Summer of 1900	Hay
	Mingo	Horsefen Creek	"	"
	McDowell	War Creek	"	"
	Mineral	Patterson's Creek, near Burlington	Summer of 1928	Newcombe
	Boone	Near Uneeda	"	"
<i>C. obscurus</i>	Upshur	Queens	?	?
	"	Cheat River	?	?
	"	Ice's Ferry	?	?
	"	Sand Run	?	?
	"	Childer's Run	?	?
	"	Nubies' Run, near Buckhannon	?	?

TABLE I—Continued.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
<i>C. obscurus</i>	Lewis	Weston	?	?
	"	Hacker's Creek, near Jane Lew	?	?
	Harrison	Ten Mile Creek at Lumberport	?	?
	Hancock	Harmon's Creek, (Holiday's Cove)	?	Ortman
	Randolph	Cassidy	?	"
	Brooke	Harmon's Creek, (Colliers)	?	"
	Monongalia	Decker's Creek above Morgantown	?	"
	Ohio	Wheeling Creek (Elm Grove)	?	"
	Marshall	Wheeling Creek (Union Township)	?	"
	"	Grove Creek (Cameron) Pennsylvania Fork of Fish Creek, Nuss.	?	"
Wetzel	Fishing Creek, (New Martinsville)	?	"	
<i>C. propinquus sanbornii</i>	Pleasants	Middle Island Creek	?	?
	Wetzel	New Martinsville Fishing Creek	?	?
	Mineral	Patterson's Creek near Burlington	August, 1928	Newcombe
	Monongalia	Near Morgantown	April, 1929	"
Marshall	Fish Creek (Panhandle)	?	?	
<i>C. bartonii</i>	Morgan	Cherry Run	?	?
	Tucker	Blackwater Run, Davis	?	?
	Grant	Patterson Creek, South Branch of Potomac	?	Faxon
	Monongalia	Cheat River	?	Smith
	"	Morgantown	?	?
	Pleasants	St. Mary's	?	?
	Wetzel	New Martinsville	?	?
	Marshall	Cameron	?	?
	Ohio	Elm Grove	?	?
	Brooke	Colliers	?	?
	Hancock	Holiday's Cove	?	?
	"	Congo	?	?
	Pendleton	West Branch of Potomac River	?	?
	Mercer	Rich Creek	?	?
	"	Spanishburg	?	?
	Upshur	Nubies' Run, near Buckhannon	?	?
	Randolph	Glade Creek	?	Faxon
	Grant	North Hill Creek, near Petersburg	June, 1928	Newcombe
	Monroe	Wolf's Creek, near Alderson	"	"
	Boone	Jarrel's Run	"	"

TABLE I—Continued.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
<i>C. bartonii</i>	Ritchie	Petroleum	?	Faxon
	Pocahontas	Cranberry (7 miles from Hillsboro)	July, 1928	Newcombe
	"	Lion Lithia Springs, (near Dunmore)	August, 1928	"
<i>C. bartonii robustus</i>	MacDowell	Brook's Creek	July, 1928	Newcombe
	Greenbriar	Greenbriar River (near White Sulphur Spgs.)		
	Greenbriar	West Fork of Greenbriar River	?	?
	Mercer	Crane Creek	?	?
<i>C. bartonii montanus</i>	Greenbriar	Greenbriar River,	?	?
	"	Kanawha River	?	?
	Mingo	Horsepen Creek	?	Faxon
	Summers	Madam Creek, (near Hinton)	?	"
	Mercer	Bergens Springs, (near Hinton)	?	"
	"	Delasmeet Creek	?	"
	"	Kegley	?	"
	"	Bluestone River	?	"
	"	Abb's Valley	?	"
	"	East River	?	"
	"	Rich Creek	?	"
	"	Spanishburg	?	"
	Greenbriar	Barrenche	?	"
"	War Creek	?	"	
Wyoming	Guyandotte River (Baileysville)	?	"	
<i>C. limosus</i>	Morgan	Potomac	?	Ortman
	"	Cherry Run	?	"
<i>C. carolinus monongalensis</i>	Ohio	Bethany	April, 1929	Weimer
	Hancock	Congo	?	Ortman
	Westmoreland	Bethany	?	"
	Hancock	Holidays Cove	?	"
	Brooke	Colliers	?	"
	Ohio	Elm Grove	?	"
	Marshall	Cameron	?	"
	"	Nuss	?	"
Monongalia	Morgantown	?	"	
<i>C. carolinus carolinus</i>	Preston	Terra Alta	?	Faxon
	"	Reedsville	?	"
	Tucker	Parsons	?	"
	Mineral	Schell	?	"
	Southwestern	West Virginia	?	Hay

TABLE I—Continued.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
<i>C. bartonii carinirostris</i> .	Randolph	Candee Creek Osceola	July, 1899	Hay
	Preston	Albright	"	"
	Upshur	Queens'	?	"
	Pocahontas	West Fork of Green- briar River (near Dunmore)	?	"
	Monroe	Laurel Creek (near Greenville)	?	"
<i>C. bartonii veteranus</i>	Wyoming	Indian Creek, (near Baileysville)	?	?
	Mercer	Crane Creek	?	?
	Kanawha	Elk River, Cogars' Mills	?	?
<i>C. diogenes</i>	Hancock	Congo	?	?
	Brooke	Colliers	?	?
	Wetzel	New Martinsville	?	?
	Monongalia	Cobun's Run, (Near Morgantown)	April, 1929	Newcombe
	"	Childer's Run, (Near Buchanon)	?	Faxon
<i>C. bartonii longulus</i>	Pocahontas	West Fork of Green- briar River, (Near Durbin)	?	?
	Mercer	Bluestone River	?	?
	"	Abb's Run	?	?
<i>C. carolinus dubius</i>	Preston			
	Mineral			
	Tucker			
	Boone	Uneeda	June, 1929	Newcombe
	Mingo	Brooks Creek, (Near Welch)	July, 1929	"
<i>C. carolinus dubius</i> (blue phase)	Pocahontas	Cool Run, (near Cass)	August, 1929	Newcombe
	Pendleton	Spruce Mt. (Spruce Knob)	"	"
	Pocahontas	Bald Knob	"	"

In considering the distribution of individuals and species with reference to local factors such as temperature, purity and rapidity of stream, direct and detailed observations are very scarce, while conclusions as to distribution in the broader

sense, the range of species, groups and the genus itself are limited on account of insufficient investigation.

On the subject of the ecological phases of the distribution of crayfishes very little has appeared. Faxon ('85) records the occurrence of the same species in the headwaters of streams on the opposite sides of a water shed, as has been observed in fishes and gives as examples *C. extraneus* and *C. spinosus* in the upper waters of the Santee, Alabama and Tennessee rivers, and also states that the forms of the upper and lower part of a river may be different. To illustrate this point he gives *C. bartonii* and *C. latimanus*, *C. acuminatus* and *C. spinosus* in the upper part of the Santee River, while in the lower portion of the same basin live *C. blandingii acutus* and *C. troglodytes*. Only a relatively small number of observations have been recorded concerning the appearance of different species in different types of localities.

Crayfishes are found in a great variety of habitats from burrows in a prairie which is dry for a large part of the year, stagnant ponds, roadside ditches and salt marshes to the pure cold water of mountain streams and springs. Just as fish are known to be typical of each class of habitat, so, in all probability, are crayfishes, although, perhaps, to a less extent. It must be noted here that there are, in the limited literature on the habits and distribution of the different forms, numerous accounts of instances wherein the same species has been observed in entirely different environments. The author collected specimens of *C. carolinus dubius* Faxon at Brooks Creek, a cool swiftly flowing mountain stream, situated about two miles from Welch, W. Va., and also from a filthy stagnant pool near Morgantown. *C. putnami* Faxon, as will be shown later, was collected from two distinctly different types of habitat, one a swampy area at Uneededa, W. Va., the other a swiftly flowing stream, Patterson's Creek, two miles north of Burlington, W. Va. The species given are sufficient to illustrate the point in question.

It is possible to assign certain species quite definitely to some type of habitat. The burrowing species obviously have a great advantage over the other forms in the matter of distribution as they are able to occupy territory which is not available for others, except at certain seasons. *C. diogenes* Girard is the most widely distributed species of the genus, occurring in Boulder Co., Colorado at the foot of the Rocky Mountains

and in southeastern Wyoming, in Minnesota, Wisconsin, and Michigan; in New Jersey, Maryland, West Virginia, Virginia, North and South Carolina; and in Mississippi and southern Louisiana. *C. carolinus* long known from only the Appalachian region of Virginia is now known to occur in northeastern Indian Territory, Western Pennsylvania and West Virginia.

Among the species that appear to be confined to mountain streams may be mentioned *C. bartonii* Fabricius (common in West Virginia), *C. longulus* (also found in West Virginia), *C. extraneus*, *C. spinosus*, *C. acuminatus* and *C. forceps*. It is interesting to note the range in altitude as well as in longitude and latitude. *C. diogenes* Girard has been reported from Boulder County, Colorado and also southern Louisiana. I have observed a blue phase of *C. carolinus dubius* Faxon at an elevation of approximately 4500 feet at Spruce Knob, West Virginia, and also 2400 feet near Cass, West Virginia.

DISCUSSION OF SPECIES.

It is not the intention of the writer to include in this paper a thorough taxonomic description of the various species of West Virginia crayfishes. Considerable attention will be paid, however, to *C. carolinus dubius* Faxon and *C. carolinus monongalensis* Ortman on account of their resemblance to a new color phase of *C. carolinus dubius* Faxon collected by the author at Cass, West Virginia.

Cambarus carolinus monongalensis Ortman.

LOCALITY—Hancock County, Congo, Hollidays Cove;—Brooke County, Colliers;—Ohio County, Elm Grove;—Marshall County, Cameron, Nuss;—Monongalia County, Morgantown.

Cambarus carolinus dubius Faxon.

LOCALITY—Mineral County, Preston County, and Tucker County.
NEW LOCALITY—*Monongahela County, Westover, near Morgantown; MacDowell County, Brook's Creek, near Welch, West Virginia (U. S. N. M. No. 103761).

Cambarus carolinus carolinus Erichson.

LOCALITY—Preston County, Reedsville;—Tucker County, Parsons;—Mineral County, Schell;—Southwestern West Virginia (Hay);—Preston County, Terra Alta (Faxon).

*Under this heading are listed regions in which the writer made collections.

DISCUSSION OF TAXONOMY.

These three species exhibit considerable similarity and there does not seem to be a generally accepted basis for differentiating them. For this reason, the writer has endeavored to follow the classification of Faxon and has considered the three groups together. *Cambarus carolinus monongalensis* Ortman, commonly known as the blue or Monongahela crayfish, was first collected at Pittsburgh, Pennsylvania in 1898, by E. B. Williamson. Compared with the type of *C. dubius* these specimens showed a narrower rostrum with less pronounced angles at the base of the acumen, the outer border of the hand was evenly rounded not ridged and destitute of the serrature seen in *C. dubius* where this feature results from the regular role of transversely elongated marginal punctations giving to the margins a milled appearance; further, the carpus of the Pittsburgh form was armed with several accessory spines and tubercles beside the prominent internal median spine which is all the armature of the carpus in *C. dubius*.

E. A. Ortman, '06, showed that the blue crayfish and *C. dubius* both live in western Pennsylvania, that they occupy different areas separated by the Chestnut Ridge, a range of hills on the west of the Allegheny Mountains, *C. monogalensis* Ortman being found on the hills lying on the west of the range, while *C. dubius* lives in the mountain region to the east of Chestnut Rige between it and the principle range of the Allegheny Mountains. In this same paper, Ortman brought out clearly the color difference between the two forms, the dominant color of *C. dubius* being red, that of *C. monogalensis*, blue. The range of the latter form appears to be rather narrow, being restricted as far as is shown by Ortman, to Westmoreland, Allegheny, Beaver, Washington, Fayette, and Green Counties, Pennsylvania, and Hancock, Brooke, Ohio, Marshall, Monogalia counties of West Virginia at altitude ranging from 800 to 1200 feet above sea level.

Ortman compared his specimens of *C. monogalensis* with the northern race of *C. carolinus*, i.e., *C. dubius*, and came to the conclusion that they represented a distinct species. From the above, however, it is seen that three of the characters which Ortman thought more peculiar to *C. monogalensis* are also present in the southern typical form of *C. carolinus*, viz., the narrower rostrum, the non-serrated margin of the hand,

and the presence of more than one spine on the inner side of the carpus. There are thus left but two features to separate *C. monongalensis* from *C. carolinus*, namely, the uniserial disposition of the spines on the lower face of the merus of the cheliped and the color. Taking a broader conception of the geographical variations of these interesting forms Faxon considers *C. carolinus* Erichson, *C. dubius* Faxon, and *C. monogalensis* Ortman as three geographical races or sub-species of one species. For distinguishing these three sub-species he gives the following key:

- Lower face of merus with only one row of spines developed. Color, blue.....*C. carolinus monongalensis* (Ortman)
- Lower face of merus with two rows of spines developed. Color, red.....
- | | |
|---|--|
| <p>Margins of rostrum distinctly convergent; outer margin of band rounded, not serrated; more than one spine on inner margin of the hand.....<i>C. carolinus carolinus</i> (Erich.)</p> | <p>Rostrum broader with nearly parallel margins; outer margin of hand subserrate; only one spine on inner margin of the hand,
<i>C. carolinus dubius</i> Faxon</p> |
|---|--|
- Lower face of merus with two rows of spines developed. Color, red.....

The form spread over the southwestern part of West Virginia, as has been pointed out, is more or less intermediate between *carolinus* and *dubius*, while the pure *C. carolinus dubius* has been reported from Preston, Tucker, and Mineral Counties, West Virginia.

Cambarus carolinus dubius Faxon (Blue Phase).

The writer collected two young blue specimens at Cass, West Virginia and assumed them to be *C. carolinus monogalensis* Ortman. On identification, Dr. W. L. Schmidt found that the distinguishing characters absolutely preclude this. He found them to possess the lateral compression of the carapace and the areola wider than would be expected for the young of *dubius*, yet too narrow for the young of *C. bartonii*. He writes as follows: "On described characters and comparing your small specimens with my much larger *monogalensis* they cannot be that species. This rather upsets the exclusiveness of color of the latter, for your evidence shows *dubius* to have a blue phase, at least in the case of some—your two young."? (Specimens).

At a later date, I sent him several blue specimens that were collected for me by Prof. Weimer at Bethany, Ohio County, West Virginia. These he found to be Ortman's sub-species *monongalensis* possessing the single row of spines on the wider side of the merus of the chelipeds. He writes as follows: "There is no question about these specimens, but I was concerned enough to go back and look at the *dubius* that we had retained from your former sending and that, to the best of my knowledge, is a good *dubius* because there are two rows of spines beneath."

NEW LOCALITY—Pocahontas County, Cool Run, Cass; Bald Knob, near Cass;—Pendleton County, Spruce Knob (probably).

HABITAT—Cool Run is a cold mountain stream, swiftly flowing and the crayfishes were not obtained from the stream but from their hiding places in the side of the bank, a few feet above the water. It was a damp, rocky area and they seemed to be concealed under the rocks. No characteristic burrows were observed in this area. From the stream were collected several specimens of *C. bartonii* Fabricius. A blue specimen was observed at Spruce Knob in Pendleton County, elevation about 4500 feet, and it is quite possible that it was the same blue phase of *C. carolinus dubius* Faxon since Ortman's *monongalensis* has not to my knowledge been reported as far south. It is worth noting that the range of the latter is from 800 to 1200 feet while that of the former is 2400 feet to 4500 feet approximately. Although all the areas where the blue phase of *C. carolinus dubius* were found were cool, damp regions, there is no evidence to indicate that they inhabit streams. This discovery of a new color phase in the genus *Cambarus* which encroaches on the exclusiveness of *C. carolinus monongalensis* Ortman leads us to ask, "What are the factors that control color in crayfishes?" Are we to look to genetics for an explanation or is it to be accounted for on a purely ecological basis?

C. carolinus dubius Faxon.

As far as is known the red crayfish *C. carolinus dubius* Faxon occupies a very small area of the State. The writer collected specimens from Brook's Creek, situated about two miles from Welch, West Virginia, and also at Westover, one mile north of Morgantown. The former was a shallow rapidly

flowing stream, water being noticeably cold and very clear, while the latter was a very stagnant shallow pool. In no case did the writer find the blue phase of this species in the water of the stream. They were obtained by digging in the bank of soil, probably three feet above the water. Not enough habitats of this group were studied to justify any opinion concerning the ecological preference of this type. Ortman, in comparing *C. carolinus* and *monongalensis* says that although they are very closely allied, nevertheless the distinguishing characters are constant; identical in their ecological habits they are separated topographically. As to the actual causes of the differences of the specific characters, or in other words what external influences are responsible for them, little is known at the present time. It is certain, however, that these two species illustrate the rule that closely allied species occupy neighboring areas and they illustrate the fact that specific differentiation is due to isolation which is topographical in this case.

Cambarus propinquus Girard.

LOCALITY—This species has a limited range in West Virginia, having been found only in the northern tip of the state.

C. obscurus Hagen.

LOCALITY—Upshur County, Cheat River, Ices Ferry, Sand River, Queens, Childers River, Trubies Run (near Buckhannon);—Lewis County, Weston, Backer's Creek (near Jane Lew);—Harrison County, Ten Mile Creek (at Lumberport);—Randolph County, Cassidy;—Monongalia County, Decker's Creek;—Marshall County, New Martinsville.

Cambarus propinquus sanbornii Faxon.

LOCALITY—Kanawha County, Horse Creek; Wetzel County, Fishing Creek, New Martinsville; Pleasants County, Middle Island Creek, St. Marys.

NEW LOCALITY—Mineral County, Patterson's Creek, two miles north of Burlington; Lewis County, Bushy Fork, seven miles northwest of Weston. (U.S.N.M. No. 103,761).

These three species (*C. obscurus*, *C. propinquus*, *C. propinquus sanbornii*) resemble each other very closely. They live under similar ecological conditions and their ranges form a unit so it is evident that they are closely allied genetically. Within the established range of *C. obscurus* from Fish Creek in the southern part of the Panhandle of West Virginia to the upper

Allegheny and the Genessee Rivers in McKean and Potter Counties and from Cheat River at the West Virginia state line to the upper Shenago River in Crawford County, Pennsylvania, this species is remarkably uniform in taxonomic characters (Ortman '06). As is pointed out above, *C. propinquus sanbornii* and *C. propinquus* G. have a very narrow distribution in West Virginia.

Cambarus bartonii Fabricius.

LOCALITY—Morgan County, Cherry Run; Tucker County, Black Water River, Davis, Shavirs Fork, Parsons; Monongalia County, Cheat River (H. H. Smith, Collector) Morgantown; Pleasants County, St. Marys; Wetzel County, New Martinsville; Marshall County, Cameron; Ohio County, Elm Grove; Brooke County, Colliers; Hancock County, Holiday's Cove, Congo; Pendleton County, West Branch of Potomac River, five miles west of Circlesville; Mercer County, Rich Creek, Spanishburg; Upshur County, Trubies Run, seven miles above Buckhannon.

NEW LOCALITY—Boone County, Jarrels Run (near Uneeda); Monroe County, Wolfs' Creek (near Alderson); Grant County, North Mill Creek (situated about five miles from Petersburg); Pocahontas County, Cranberry River (seven miles from Hillsboro), Lion Lethia Springs (one mile from Dunmore); Mineral County, Patterson's Creek near Greenland Gap.

HABITAT—*Cambarus bartonii* Fabricius is essentially a "mountain stream species." It prefers irregular cool well aerated mountain streams and also frequents springs but is seldom if ever found in rivers. During the day they are to be found along the banks hiding under rocks while at night they go in search of food. Sometimes they scoop out a hollow under a stone and establish their residence. Ortman ('06) reports instances of finding rather complex burrows of this species going down to a depth of a foot or more. These burrows extend along the banks of the streams usually not more than a few feet from the water's edge. *C. bartonii* Fabricius is not an habitual chimney builder and is more commonly found under the sheltered parts of rocks.

Cambarus bartonii robustus Girard.

LOCALITY—In the U. S. N. M., there are many specimens from the West Fork of the Greenbrier River, West Virginia and from Crane Creek, West Virginia, which are nearly typical examples of *Cambarus bartonii robustus* Girard according to Faxon ('14).

NEW LOCALITY—MacDowell County, Brook's Creek near Welch; Greenbrier County, the Greenbrier River near White Sulphur Springs, West Virginia.

HABITAT—It is a common brook species found in habitats similar to *Cambarus bartonii* Fabricius.

Cambarus bartonii montanus Girard.

LOCALITY—Mingo County, Horsepen Creek; Summers County, Madam Creek, tributary of New River, opposite Hinton; Mercer County, Bergen's Springs, twelve miles from Hinton, Delasmeet Creek, Kegley, Mercer County, Bluestone River, just above its mouth. Mouth of Delasmeet Creek, Bluestone River, Abb's Valley, East River, Rich Creek, Spanishburg; MacDowell County, Barrenche Creek, Perryville, War Creek; Wyoming County, Guyandotte River, Baileysville, West Virginia.

Cambarus bartonii carinirostris Hay.

LOCALITY—This is a slightly differentiated form of *C. bartonii* found chiefly in the mountain streams of Randolph County, West Virginia the Cheat and Tygarts Valley Rivers and their tributaries. Outside of Randolph County, Hay secured a few specimens at Albright, Preston County, and at Queen's, Upshur County, in the above named river basins. According to Faxon it is also probably to be found in the upper waters of the Kanawha River basin further to the south since there are a few specimens in the U. S. N. M., from the West Fork of the Greenbrier River near Durbin, Pocahontas County, and from Laurel Creek, in second Water Cave near Greenville, Monroe County, that are pretty characteristic examples of this race.

Cambarus bartonii longulus Girard.

LOCALITY—Pocahontas County, West Fork of the Greenbrier River near Durbin, Bluestone River and Abb's Valley.

Cambarus bartonii veteranus Faxon.

LOCALITY—Wyoming County, Indian Creek, Baileysville; Mercer County, Crane Creek; Kanawha County, Elk River, Cogar's Mills, West Virginia.

HABITAT—There have been few observations made on the forms of *C. bartonii longulus*, *C. bartonii veteranus*, and *C. bartonii carinirostris* and *C. bartonii longirostris*. It is quite safe to assume, however, that with regard to ecological preference they bear marked similarity to *C. bartonii* previously described.

Cambarus diogenes Girard.

LOCALITY—Hancock County, Congo; Brooke County, Collier; Wetzel County, New Martinsville.

NEW LOCALITY—The writer collected several specimens from Cobun's Run Creek near Morgantown questionably determined as this species by Dr. W. L. Schmidt of the Smithsonian Institution. He has informed me that there are in the Nat. Mus. at Washington, ten juveniles also questionably determined as this species over the name of Walter Faxon. These came from Childer's Run, three miles northeast

from Buckhannon, West Virginia. Ortman ('06) after a thorough search concluded that this form is positively absent in Preston, Tucker, and Mineral Counties, West Virginia.

HABITAT—*Cambarus diogenes* has the widest range of any species of *Cambarus*. It belongs to the burrowing group and its holes and chimneys are to be found along river banks as well as in meadows and marshes often occurring at some distance from open water. As a natural consequence of the habit of preferring swamps to springs, *C. diogenes* is generally found at a lower elevation than *C. carolinus* and *monongalensis* where it comes into contact with them. I have collected them from stagnant sewage offering a minimum of conditions favorable to respiration and other physiological life processes. According to Ortman ('06) in the case of *C. diogenes*, it is chiefly in mid-summer that the young begin to build their own holes. However, in other species this may take place at any time, from spring to fall and consequently the new and often very irregular chimneys of small specimens may be seen at any time during the warm season. Some valuable studies have been made on the burrows of this species by Faxon ('85), Girard ('52), Tarr ('84), Holder ('86) and Schiufeldt ('96), and others. Quoting from Hay ('96), "The subterranean tunnels may sometimes be found to extend for several feet and, as the animal frequently excavates them at some distance from the water, they must reach a depth great enough to supply moisture sufficient for the need of the animal. During the dry months of the summer, however, they seem to live in the end of their burrows in a sort of stupor. I have often seen them fall from the end of an excavation, apparently lifeless, capable of moving when put in water.

In the early spring, when they go forth to breed, is the only season when they are a noticeable number of our fresh water fauna. They move about chiefly at night though I have frequently taken numbers of them from ditches and small streams on bright sunny days."

Cambarus (Faxonius) limosus Rafinesque.

LOCALITY—The distribution of this species in West Virginia is very limited being reported by Ortman from the Potomac River and Cherry Run, Morgan County.

HABITAT—*C. limosus* is primarily a river species and belongs to the rivers, ponds and canals of the lowlands of the Atlantic Coastal Plain and the Piedmont region.

Cambarus putnami Faxon.

LOCALITY—MacDowell County, Barrenche Creek near Perryville; Mingo County, Horsepen Creek; MacDowell County, War Creek. Specimens closely resembling *C. putnami* were collected in 1900 by Hay.

NEW LOCALITY—Mineral County, Patterson's Creek, two miles north of Burlington; Boone County, near Uneeda, five miles from Madison, West Virginia.

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