

VII. THE CRAWFISHES OF WESTERN PENNSYLVANIA.

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Up to the present time, the crawfish fauna of western Pennsylvania was very incompletely known. Aside from the scanty records given in the monographic works on American crawfishes by Hagen (Ill. Catal. Mus. Harvard, 3, 1870) and Faxon (Mem. Mus. Harvard, 10, 1885), to which Faxon added a few other records (Proc. U. S. Mus., 20, 1898), we possess only a list of the species of crawfishes of Allegheny county, published by E. B. Williamson (Ann. Carnegie Mus., 1, 1901, 8-13). Unfortunately, this list was founded upon entirely insufficient material, and, consequently, later investigations have necessitated a number of changes and additions.

Hagen, in 1870, mentions two species from the State of Pennsylvania, of which one (*Cambarus affinis*) is said to be found also in the western part, at Pittsburgh (pp. 61 and 100, l. c.). This record, however, has not been substantiated by subsequent investigations; *Cambarus affinis* being restricted to the eastern portion of the state. Faxon, in 1885 (l. c., p. 165), mentions four species from the state, of which *three* are also recorded from the western part: *Cambarus bartoni*, *Cambarus diogenes*, and *Cambarus rusticus*. The latter species is said to come from Pittsburgh (p. 110), but, as the writer has ascertained now, this species is *not* found at Pittsburgh, and has not been found in any other part of the state, although it has been carefully searched for. Thus, the number of species actually known up to that date (1885) is only *two*, namely: *Cambarus bartoni* and *Cambarus diogenes*. In 1898 (l. c., p. 625) Faxon added a *third* species: *Cambarus obscurus*, from Westmoreland county.

Williamson, in 1901 (l. c.), gave the following *five* species from Allegheny county: *Cambarus bartoni* (and var. *robustus*), *Cambarus diogenes*, *Cambarus dubius*, *Cambarus propinquus*, *Cambarus rusticus*. Closer examination of the material preserved in the Carnegie Museum, that served as a basis for Williamson's paper, and its comparison with additional material, reveals the fact that only two of these species were correctly identified (*Cambarus bartoni* and *Cambarus diogenes*), while *C. dubius* turns out to be a new species, and *C. propin-*

quus and *rusticus* are really identical, belonging to one and the same species, which, however, is not to be called by either name, but is *Cambarus obscurus*. Consequently, Williamson's list of the crawfishes of Allegheny county really comprises only *four* species: *Cambarus bartoni*, *Cambarus diogenes*, *Cambarus nova species (monongalensis)*, *Cambarus obscurus*, and these four species are all that were known from western Pennsylvania up to the present time.

Extended collecting excursions undertaken by the present writer during the summer of 1904 have confirmed the presence of these four species in this region (or part of it), and have added two more species: *Cambarus propinquus*, from Erie and Crawford counties, and *Cambarus carolinus*, from Westmoreland, Fayette, and Somerset counties.

In studying the crawfishes of this region it was the special object of the writer to ascertain the exact boundaries of the distribution of each species, and, if possible, to correlate these boundaries with physical features of the country. The results obtained, although not yet complete in every respect, have proved to be highly interesting and apt to throw light upon the postglacial immigration of the freshwater fauna into this part of the state. At the same time, numerous observations on ecology, habits, and life-history of the different species have been made, which shall be set forth in a larger paper comprising the crawfish fauna of the whole state, since, at present, they are too fragmentary to be presented.

The present paper is to be regarded only as a preliminary account of the work done in the western portion of the state. This portion is sharply separated in its fauna from the central and eastern portions and comprises, generally speaking, the drainage of the Ohio River (Ohio, Monongahela, Allegheny), and consequently belongs to the Mississippi system. Only the northwestern corner of the state (parts of Erie and Crawford counties) does not belong here, draining into Lake Erie (St. Lawrence system), but it is included on account of its geographic situation, and the remarkable faunal conditions presented by it. Thus we may say that western Pennsylvania, as understood in the following pages, means that part of Pennsylvania that lies west of the divide between the waters that run to the Atlantic ocean (Delaware, Susquehanna and Potomac), and the waters that drain through the Ohio to the Mississippi and the Gulf of Mexico. This dividing line runs, roughly speaking, through Potter, McKean, Elk, Clearfield, Indiana, and Cambria counties, and thence along the main chain of the Alle-

gheny Mountains between Cambria and Somerset counties in the west, and Blair and Bedford counties in the east.

Within the region thus defined we have the following six species of *Cambarus*: (1) *Cambarus bartoni* (F.), (2) *Cambarus carolinus* Er., (3) *Cambarus monongalensis* nov. spec., (4) *Cambarus diogenes* Gir., (5) *Cambarus propinquus* Gir., (6) *Cambarus obscurus* Hag.

With the exception of *Cambarus monongalensis*, all these species are rather well known, although two of them (*C. carolinus* and *obscurus*) were considered as quite rare. To facilitate the identification of these species, the following key is offered.

- I. Species belonging to the third group of the genus (type: *C. bartoni*). Ischium (third segment) of third pair of legs of male hooked. First pair of abdominal appendages of male terminated by two thick, strongly recurved teeth. In all Pennsylvania species the rostrum has no lateral spines, and the lateral parts of the carapace, behind the cervical furrow, possess generally no spines (with occasional exceptions in *C. bartoni robustus*).
 - A. Areola wide. Form of carapace depressed. Color (in life) brownish or greenish olive. (Mountain brook species.) C. BARTONI.
 - B. Areola narrow or obliterated. Form of carapace compressed. (Burrowing species.)
 1. Areola narrow. Color in life remarkably bright, of tints unusual among crawfishes. Abdomen distinctly shorter than carapace.
 - a. Color bright red (chiefly so on chelæ and anterior part of carapace). Rostrum broad and short. (Mountain species.) C. CAROLINUS.
 - b. Color bright blue (chiefly so on chelæ and anterior part of carapace). Rostrum narrower, short. (Hill species.) C. MONONGALENSIS.
 2. Areola obliterated in the middle. Color of the usual tints in crawfishes: greenish or brownish olive. Abdomen about as long as the carapace. Rostrum rather long and narrow. (Bottom land species.) C. DIOGENES.
- II. Species belonging to the fourth group of the genus (type: *C. affinis*). Ischium of third pair of legs of male hooked. First pair of abdominal appendages of male terminated by two slender, styliform, nearly straight teeth. In the Pennsylvanian species, the rostrum has a lateral spine on each side, the carapace has a spine on each side behind the cervical furrow, and the areola is wide. Color green or brownish olive, with a reddish spot on each side of the anterior margin of carapace, below eye. (River and lake species.)
 - A. Rostrum with median keel. First pair of abdominal appendages of male at base of terminal teeth without prominent angle. Annulus ventralis of female flat. C. PROPINQUUS.
 - B. Rostrum without median keel. First pair of abdominal appendages of male at base of terminal teeth with a distinct, prominent angle on the anterior margin. Annulus of female with two tubercles in anterior part. C. OBSCURUS.

REMARKS ON THESE SPECIES AND RECORDS OF THEIR RANGE.

1. CAMBARUS BARTONI (Fabricius). The Common or Barton's Crawfish.

This well-known species (for detailed description see Hagen, 1870, p. 75) is easily recognized by the characters given in the key. Aside from the group-characters (form of male organs), the broad rostrum without lateral teeth, and the wide areola distinguish it from any other species of western Pennsylvania.

It is found, as Williamson states, in springs and smaller brooks, rarely in larger streams. Here it scoops out shallow holes under stones, and very often makes quite deep burrows, piling up the mud, sand, or gravel at the entrance in more or less regular piles, often assuming the shape of "chimneys." Wherever there are favorable localities in our region, this species is found, as it seems to be present all over the state. The older records mention *C. bartoni* only from a few places in western Pennsylvania: Foxburg, Clarion county (Girard); McKean county (Faxon, 1885); Westmoreland county (Faxon, 1898). Williamson records it as common in Allegheny county. According to the collections in the Carnegie Museum (made by E. B. Williamson, Dr. D. A. Atkinson, and the writer), it is found in the following counties: Greene, Fayette, Somerset, Washington, Beaver, Allegheny, Westmoreland, Butler, Clarion, Mercer, Crawford, Erie, McKean, Potter. According to material preserved in the collections of the Academy of Natural Sciences, Philadelphia, it is also found in Warren county. This renders it a certainty that it is to be looked for everywhere in the western part of the state. In Erie county, the typical *C. bartoni* is not very abundant, although present, and is largely replaced by the variety *robustus*. (See below.)

In the larger rivers this species is lacking, or found only occasionally, and the writer has observed that in large rivers it is found chiefly, where there are springs along the banks. These springs contain, in summer, generally much cooler water, and it is in this cooler water where *C. bartoni* is found, this species apparently disliking the warmer water of the large streams. In the Allegheny and Ohio Rivers, below Butler Junction in the northeastern corner of Allegheny county, it is exceedingly rare, only stragglers occurring there. In the upper Youghiogheny and Casselman Rivers, above Indian Creek in Fayette county, this species is found regularly, although not very plentiful,

and it is, in this region, the only species that inhabits the rivers, *C. obscurus*, the typical river-species, being absent here.

Cambarus bartoni goes far up into the mountains: the highest elevation at which it was collected is at Sand Patch, Somerset county, about 2,300 feet above sea level; here it was abundant in little mountain streams above the western entrance of the B. & O. R. R. tunnel.

This species attains, in the southwestern section of the state, a considerable size. Hagen (1870) gives 3.6 in. = 91 mm. as maximum size; according to the writer's observations, specimens from eastern Pennsylvania rarely grow beyond 60 mm. (largest male in Carnegie Museum, from near Valley Forge, Chester county, 61.5 mm.; largest female, from Wissahickon, Philadelphia county, 64 mm.), while in western Pennsylvania much larger specimens are not rarely met with; the largest male of the first form in the Carnegie Museum collections is from North Versailles township, Allegheny county (opposite Stewart, Westmoreland county), and measures 83.5 mm.; the largest female is from Hill, Westmoreland county (opposite Leechburg, Armstrong county), and measures 89 mm. (A male of the first form from Cheat River, West Virginia, is 92 mm.)

The color of *C. bartoni* is more or less brownish olive, in young specimens often rather greenish, in old ones frequently with coppery or bronze hue. The shade of color is quite variable, but generally it is more brownish than in other species. Rarely there are individuals of a bluish hue, but this blue is never bright and brilliant (as in *C. monongalensis*) but rather dull, like blue slate or clay. Often the shell is rendered more or less blackish by the deposit of a mud incrustation upon it.

1a. CAMBARUS BARTONI ROBUSTUS (Girard).

As has been done by most writers, I regard this form as a variety of *C. bartoni*. It differs chiefly in the shape of the rostrum, which is more elongate and narrower than in the typical form. Hagen, who mentions this form as a good species, gives the following additional characters: the large chela has a distinct impression near the outer margin of the hand, both above and below; the inner margin of the hand has a double row of tubercles; and the carapace has a spine on each side behind the cervical furrow. These characters, however, are not always distinctly developed, and, among the specimens from Allegheny county, the lateral spine is generally wanting, although we

possess a few in which it is present. In specimens from Erie and McKean counties, this spine is found more frequently, but not always. The impressions of the hand, and the double row of tubercles of its inner margin are often very indistinct, and chiefly so in young specimens, so that it is sometimes hard to tell whether a particular individual belongs to this variety or not, since also the shape of the rostrum shows transitions to the typical form, and very young individuals of the latter generally have a more elongate rostrum. Nevertheless, old and full-grown examples of this variety are easily recognized.

This form was first reported from western Pennsylvania by Williamson, who says that a few specimens of it have been taken in Squaw Run, near Aspinwall, Allegheny county. Additional material in the Carnegie Museum collected by Dr. D. A. Atkinson comes from Pine Creek, below Bakerstown Station and from Chartiers Creek, Carnegie, Allegheny county. The writer has collected this variety in Squaw Run, and further in McKean county, in the Allegheny River near Larabee, and in French Creek at Union City, Erie county. He has found it abundantly in Erie and Crawford counties in the drainage of Lake Erie: at Conneautville Station, Crawford county, in a small tributary of Conneaut Creek; in Temple and Conneaut Creeks near Albion, Erie county; in Elk Creek near Girard, Erie county; in Walnut Creek at Swanville, Erie county. There are a large number of specimens in the Philadelphia Academy collections from a tributary of the Allegheny River near Port Allegheny, McKean county.

In Allegheny and Crawford counties this variety was found with the typical form, and was comparatively rare. The specimens from Port Allegheny in the Philadelphia Academy were associated with a much smaller number of typical *C. bartoni*. At Larabee, the writer found only this form in the Allegheny River (associated with *C. obscurus*), but the typical form was abundant in small streams. In Erie county in French Creek, as well as in the lake drainage, this variety prevails, the typical *C. bartoni* being very rare there in the larger creeks, but the latter may be more abundant in small streams, which have not been examined. In Erie county it was always associated with either *C. propinquus* or *C. obscurus*. According to Williamson, this form is generally found in that part of the streams where *C. bartoni* and *propinquus* (correctly *obscurus*) come together, and this is quite right. However, there are many streams where this variety is not found at all, and the writer has never seen it in the southwestern

section of the state (Washington, Greene, Westmoreland, Fayette, and Somerset counties).

C. bartoni robustus attains a very large size, even larger than the typical form. The largest male of the first form is from Albion, Erie county: 94 mm.; a male of the second form from the same place is 95 mm. The largest female is from Squaw Run, Allegheny county, and measures 94 mm. Hagen gives 3.2 in. = 81 mm., and Faxon 86 mm.

2. CAMBARUS CAROLINUS Erichson. The Red Crawfish.

As Hay (Proc. Biol. Soc. Washington, 15, 1902, p. 38) has pointed out, *C. carolinus* Erichson is identical with *C. dubius* Faxon.

This species is easily recognized in the field by its color. It is of a vivid red, chiefly so on the anterior part of the carapace and on the chelæ, the color being hardly subject to any variation, except that it is more brilliant in newly molted individuals. But even in old shells, the bright brick-red of the anterior part of the body is very striking. The sides and abdomen possess often a more or less brownish (leather-brown) tint, and frequently old shells are covered by a black or brown coat of dirt, but even then the chelæ and parts of the carapace remain clean and red.

The morphological characters of this species have been well brought out by Faxon (1885, as *C. dubius*). The compressed shape of the carapace is similar to the following species, while in the wide rostrum it resembles *C. bartoni*. In the shape and the armature of the chelæ, aside from the shape of the rostrum, are found the chief differences from *C. monongalensis*: in *C. carolinus* the outer margin of the hand is serrated, this serration being produced by a series of pits (punctations) forming a regular longitudinal row along this margin. The carpopodite of the chela has a single strong spine on the inner side, all other spines on this side being absent. Lower side of meropodite of the chelipeds armed with two rows of spines, the inner row being longer consisting of about 6 spines, the outer one being shorter, and consisting of only 3 or 4 spines.

There is some variation in the shape of the rostrum. Pennsylvania (and Maryland) specimens never have the rostrum as wide as in Faxon's figure (l. c., pl. 4, fig. 3), and generally the margins converge a little. But there are specimens in which they are "subparal-

lel," as Faxon states. The lateral corners of the margins, where they pass into the short, triangular acumen, are generally quite sharp.

The type-locality of this species is Tiger Hall Farm, Greenville, Green county, South Carolina (*C. carolinus* Er., see Faxon, 1885, pp. 9 and 56). The type of Faxon's *C. dubius* is from Cranberry Summit (called now Terra Alta), Preston county, West Virginia, on the divide between the upper Youghiogheny and Cheat Rivers. Additional localities, recorded previously, are: Pennington Gap, Lee county, Virginia; Cumberland Gap, Claiborne county, Tennessee (Faxon, 1885); "among the Cherokees," Indian Territory (Faxon, Proc. U. S. Mus., 12, 1890, p. 624), and Hay says that it is found in southwestern West Virginia. I have collected this species, outside of the state of Pennsylvania, at Selbysport, Garrett county, Maryland (Youghiogheny valley). In Pennsylvania, it has never been found before, but is quite abundant in the mountain region between Chestnut Ridge and the main chain of the Allegheny Mountains, in Somerset, Fayette, and the southern extremity of Westmoreland county. Special localities are the following: Somerset county: Rockwood, at about 1,900 feet elevation; Meyersdale, about 2,000 feet; Listie, 1,900-2,000 feet; Fayette county: Dunbar, abundant on Chestnut Ridge at 1,260 feet elevation; stragglers associated with *C. diogenes* at 1,070 feet elevation; Indian Creek, 1,900 feet; Ohiopyle, in Rainier Park, 1,250 feet. In Westmoreland county, I found this species only in the southern extremity, in the region of the headwaters of Indian Creek at Jones Mills, about 2,000 feet elevation.

Thus it appears that this is a true mountain species, being found generally at an altitude from 1,200 to 2,000 feet above sea level (in Pennsylvania). The Chestnut Ridge forms its boundary toward the northwest, the Allegheny Mountains toward the southeast. It belongs chiefly to the drainage of the upper Youghiogheny and Casselman Rivers, but at Listie, Somerset county, it has crossed the transversal divide in the longitudinal valley between the Laurel Hill and Allegheny Mountains, and is found in the headwater region of Stony Creek that runs to the Conemaugh. How far it extends north here is unknown, but it is surely not present in the neighborhood of Cresson, Cambria county.

The new locality at Selbysport, Maryland, connects the Pennsylvania range with the type-locality of *C. dubius* in Preston county, West Virginia.

Cambarus carolinus is, as has been first reported by Faxon, a burrowing species, and makes holes in swampy and springy ground on the mountains. Favorite localities are swampy meadows on the top of the hills or on the hillsides, often apparently dry at the surface, but containing at the depth of one to two feet a supply of fresh spring water, generally with a substratum of stiff clay. The holes of this species are very complex, having very often several openings, each of which is crowned by a more or less regular "mud-chimney." At Ohiopyle, I have dug them out of holes, two or three feet deep, the holes forming, at this depth, a very intricate system of caverns and tunnels, branching off more or less horizontally in various directions. In certain parts of Somerset county, and in Garrett county, Maryland, this species is a real pest, seriously interfering with farming on account of its burrows and mud chimneys.

Faxon gives 62 mm. as the maximum size for this species. I have a male of the first form from Dunbar, Fayette county, which is 63.5 mm. long, and a female from Ohiopyle, Fayette county, which measures 80 mm. There is no doubt that adult males also attain a similar size, but it is hard to take them on account of the depth to which the holes of old individuals go down.

3. *CAMBARUS MONONGALENSIS* species nova. The Blue Crawfish.

Diagnosis. — A species belonging to the third group (*C. bartoni*), being most closely allied to *C. carolinus*, but differing in the following characters:

1. Rostrum narrower, a little variable in shape, but generally with margins more convergent, and the lateral angle at the base of the acumen less well defined.

2. Armature of chelæ different. Outer margin of hand not serrated, being swollen and evenly rounded, the pits (punctuations) never forming a regular longitudinal row on the edge. Carpopodite with more than one spine on the inner side. Generally, one spine is the largest (the one corresponding to the spine of *C. carolinus*), but there are always several other small spines or spine-like tubercles. Lower side of meropodite only on the inner edge with a row of spines, the outer edge is smooth, with a single tubercle at its distal end.

3. Color blue. It is most brilliant on the anterior part of the carapace and on the chelæ, being of a deep ultramarine hue, shading to sky-blue on the sides. Distal part of the fingers of chelæ orange or

reddish-brown. Margins of rostrum generally purple. Tubercles of chelæ whitish or reddish.

Description. — Carapace compressed. Abdomen shorter than carapace. Rostrum short, not very wide, triangular, margins convergent, suddenly contracted to the triangular, short acumen; lateral angles at base of acumen not sharp, more or less rounded. Upper surface of rostrum slightly concave. Postorbital ridges short, often indistinct, without spines. No lateral spines on carapace, but sides slightly granulated. Areola narrow, with one or two irregular rows of dots. Suborbital angle indistinct, rounded. Anterior part of epistoma subquadrangular. Anterior segment of telson with one spine on each side. Antennæ shorter than body, scale small. Large chela ovate, surface punctate. Inner margin of hand serrated by a single row of tubercles. Outer margin rounded and entire, without any serrations. Fingers conical, slightly down-curved, gaping at base, with teeth at their cutting edges. Outer margin of movable finger with deep pits, but without tubercles. Carpopodite with a strong spine on the inner margin, and a smaller spine proximally of it, and further, there are two or three more spine-like tubercles on the lower inner side. Meropodite with the superior border almost smooth, only with one or two indistinct distal tubercles. Lower side with a row of spines on inner edge, outer edge smooth, with one single distal tubercle. Hooks on third pair of legs of male; shape of male copulatory organs of the type of the third group. Color always with more or less brilliant blue, tubercles of chelæ whitish or reddish, finger tips reddish or orange.

Largest male of the first form, from Gordons Valley, Edgewood Park, Allegheny county, 67 mm.; largest female from same locality, 76 mm. (Another female from Monaca, Beaver county, has the same size.)

The above characters are constant. The blue color is very striking, and is always present on the anterior part of the body. Posterior part of carapace and abdomen sometimes of a purplish hue, and very often there is a blackish or brownish mud deposit on old shells. Shape of rostrum very variable, but always narrower than in *C. carolinus*, and with more convergent margins. The armature of the chelæ varies slightly with respect to the number of spine-like tubercles of the carpopodite, but the spines are always more numerous than in *C. carolinus*.

This species is geographically entirely isolated from *C. carolinus*, and never found associated with it. The boundary between them is

formed by the northwestern slope of the Chestnut Ridge, and *C. monongalensis* is found distributed on the hills lying on the west and northwest of this ridge. The range of this species comprises the northwestern part of Fayette county, Washington county and parts of Westmoreland, Allegheny and Beaver counties. It has not yet been found in Greene county, but is undoubtedly also present there. In Beaver and Allegheny counties, the valley of the large rivers, Ohio and Allegheny, apparently forms the northern boundary of this species: in fact, it has been found north of these rivers only at a single locality near Squaw Run, Allegheny county (by Dr. D. A. Atkinson), while it is very abundant on the hills south of these rivers. In Allegheny county, south of the Allegheny River, whence it has been reported by Williamson under the name of *C. dubius*, it is present everywhere, in swampy places on the hills, generally at an elevation from 900 to 1,100 feet, rarely going farther down (in Schenley Park and Fern Hollow, within the city line of Pittsburgh, it descends to a little below 800 feet). It is especially abundant on the hills east of Wilkinsburg and Edgewood Park, and specimens from the latter locality (head of Gordon's Valley, Edgewood Park, elevation 1,000-1,100 feet) have been taken as the *types* for the above description. The oldest specimen in the Carnegie Museum collections is from Moon township, Allegheny county, and was collected by A. T. Shafer in 1898 (Cat. no. 74.20),

In Westmoreland county this species has been found at Braeburn, on hills above the Allegheny River, at Jeanette, and it reaches the valley of the Kiskiminetas at Hill (opposite Leechburg, Armstrong county). In Beaver county it is abundant on Doctor Heights, Monaca, south of the Ohio.

In Washington county it has been found at Monongahela City, at Francis Mine (near Burgettstown), and near Taylorstown.

In Fayette county it is present near Smithfield and Cheat Haven.

Thus it has been traced from the southern state line in Fayette county (Cheat Haven) to the northernmost point of the Ohio River (Monaca), and almost to the point of the triangle formed by the Kiskiminetas and Allegheny Rivers (Hill and Braeburn); and from the foot of the Chestnut Ridge to near the western state line in Washington county (Taylorstown and Francis Mine), and very likely occupies all of the state that is included between the Chestnut Ridge to the east, the Ohio-Allegheny Rivers to the north, and the southern and western

state lines to the south and west respectively. The exact location of the northeastern boundary in Westmoreland county has not yet been ascertained, possibly it is formed by the Loyalhanna or Conemaugh.

Like *C. carolinus*, this species is a burrowing species and a chimney builder. The holes are made in a similar way as those of *C. carolinus* but generally are not quite as complex, although more so than those of *C. diogenes*. Swampy pastures and fields on the hillsides, with a permanent supply of spring water, are the favorite localities, and such places are often entirely undermined by the burrows, and thickly studded with chimneys of *C. monongalensis*.

There is no doubt that this species has a close genetic connection with *C. carolinus*, but it is certainly specifically different. I never met with a case in which I was in doubt about these two species, the peculiar color distinguishing them at once, and moreover, their mutual geographic separation supports their specific validity. They never have been found associated at the same place, the northwestern escarpment of the Chestnut Ridge forming a sharp boundary between them.

The specific name *C. monongalensis*, has been suggested by the fact that most of the range of this species belongs to the drainage system of the Monongahela River.

4. CAMBARUS DIOGENES Girard. The Mud Crawfish.

From the allied species, *C. carolinus* and *monongalensis*, this one is at once distinguished by the shape of the rostrum and the areola, aside from the color. The rostrum is more elongate and narrower, often being lanceolate without a trace of an angle or sinus at the base of the acumen, the latter being not at all marked. In other cases, the acumen is distinguishable. The areola is "obliterated," that is to say, the two lines confining the branchial regions are in actual contact in the middle of the carapace for a certain distance. Sometimes however the areola is not quite obliterated, there being a narrow space left between the two lines: this is chiefly the case with specimens from Fayette county. For the rest, this species is easily recognized by the tubercles of the inner margin of the hand, which always form more than one row, generally two, often with traces of additional rows, while in *C. carolinus* and *C. monongalensis* there is always one row only.

The color of *C. diogenes* differs entirely from that of either of the

two last named. It is more or less of the usual pattern among crawfishes, namely brownish or greenish olive. In well-developed, adult individuals, there is generally (in western Pennsylvania) a beautiful verdigris-green present on the base of the fingers, which, together with the orange-red finger-tips and the reddish margin of the rostrum, renders the coloration of such specimens rather vivid and attractive. But there are great variations in color: a specimen found in the fall of 1903 in Fern Hollow, Pittsburgh, in a puddle of yellowish-brown mud had assumed entirely this yellowish-brown mud color. A remarkable variety was found at Dunbar, Fayette county: a large male of a prevailing red color, similar to *C. carolinus*, but less brilliant. This apparently is to be regarded as a case of albinism; although found associated with *C. carolinus*, this specimen possesses all the typical morphological characters of *C. diogenes* and moreover, typically colored individuals were abundant at the same place.

C. diogenes is a well-known species occupying a wide range in the United States. In Pennsylvania it was recorded hitherto only from Derry, Westmoreland county (Faxon, 1885), and from Pittsburgh, Allegheny county (Williamson). The investigations of the writer, and additional material in the Carnegie Museum, collected by others, have shown that it is quite abundant in the southwestern section of the state. In Allegheny county it is common, being found chiefly in the bottom lands along the rivers, but it also goes up to the elevation of about 900 feet (200 feet above the rivers), apparently following upwards the valleys and ravines that empty into the large rivers. In Westmoreland county it is abundant at Derry (already recorded by Faxon), and has also been taken at Blairsville Intersection. In Washington county it has been found at Francis Mine (near Burgettstown); in Greene county, near Waynesburg; in Fayette county, near Smithfield and Dunbar, at the foot of the Chestnut Ridge. East of Chestnut Ridge, in Fayette, Somerset and Westmoreland counties, it is positively wanting: careful search for it in Ligonier Valley and the drainage of the upper Youghiogheny and Casselman Rivers has been unsuccessful. Its northern boundary is at present not well known: the most northern point is just below Bakerstown Station, Richland township, Allegheny county, but it may pass into Butler and Armstrong counties, which have not yet been examined satisfactorily.

It may be mentioned here that *C. diogenes* is also present in east-

ern Pennsylvania, whence it has never been reported before, although it is known from New Jersey (Trenton); the writer discovered it at Ridley Park and Marcus Hook in Delaware county.

The distribution of this species is quite puzzling; the curious fact that it is found both east and west of the Allegheny Mountains, but that it is clearly missing in the high plateau between Chestnut Ridge and Allegheny Mountains (at least in Pennsylvania), and that it is also absent from the region lying to the east of the main mountain chain, and does not appear till we reach the lowlands on the Delaware River, is not easily explained, unless there is a connection across the mountains somewhere south of the southern state line. It has been reported by Faxon from Deer Park, Garrett county, Maryland, but this record needs confirmation, since we rather ought to expect here another species, *C. carolinus*. A closer investigation of western Maryland, and eastern and northern West Virginia will probably throw light upon this question.

Cambarus diogenes is the best known of the "chimney builders." It prefers the bottom lands along the large rivers, but goes quite regularly up the valleys, where it often comes into contact with *C. monongalensis* or *C. carolinus*. Generally, if *C. diogenes* is found at a given locality, *C. monongalensis* or *carolinus*, if found associated with it, are less abundant, but become more frequent, and finally are exclusively found, if we go higher up on the hillsides. The holes of *C. diogenes* are decidedly less complex than those of the other two species; very often they consist only of a single shaft, generally going down in a slanting direction, that ends in a pocket; rarely there are lateral branches.

Western specimens of *C. diogenes* attain a very considerable size (4.5 in. = 115 mm., Hagen). The largest individuals from Pennsylvania represented in the Carnegie Museum are: a male of the first form from Nine Mile Run, Pittsburgh, 92 mm., and a female from Dunbar, Fayette county, 95 mm.

5. CAMBARUS PROPINQUUS Girard. The Lake Erie Crawfish.

This species is easily recognized when adult males of the first form and adult females are at hand. Young and undeveloped specimens are rather hard to distinguish from *C. obscurus*. It differs from all the preceding species by the characters of the fourth group, the form of the male appendages, and further, by the rostrum, which possesses a

lateral spine on each margin, by the presence of a lateral spine on the carapace, and by the wide areola. All these characters, however, are common to the next species (*C. obscurus*). It differs from the latter in the shape of the copulating organ of the male of the first form, which has no prominent angle on the anterior margin below the base of the terminal teeth, and in the shape of the annulus ventralis of the female, which is flat and has no prominent tubercles. Besides, I have been able to discover, in living specimens, a difference in color. While generally the color of both species is very similar (greenish-olive, with some brown on the abdomen, and a reddish spot on the anterior margin of the carapace below the eye),¹ there is a difference in the color of the finger-tips; in *C. propinquus* the tips are brownish, preceded by a pale or yellowish band, while in *C. obscurus* there is, proximally of the brown tips, a dark green or even blackish band, often followed again by a pale yellowish band.

There are a few other differences. In *C. propinquus* the rostrum possesses a median keel, which is wanting in *C. obscurus*, but in Pennsylvania specimens of *C. propinquus* this keel is sometimes very indistinct. The chelæ in *C. propinquus* are generally more swollen and less broad and flattened than in *C. obscurus*, and, except for punctations, are smooth with a double row of small tubercles on the interior margin of the hand. The fingers are straight, in old males they are very slightly gaping at the base, and the outer margin of the dactylopodite is only very slightly curved.

In *C. obscurus* the chelæ of old males are more flattened and broader, the fingers are widely gaping at the base, and the dactylopodite is strongly curved, the curve being S-shaped, with a distinctly and strongly concave outer margin. The palm possesses tubercles on the upper side besides the double row on the inner margin; generally there is a row of tubercles running parallel with the margin toward the middle of the base of the dactilopodite; sometimes there are additional scattered tubercles between this latter row and the inner margin.

As has been said, young specimens are not easily identified, since these characters, chiefly the sculpture of the chelæ, are not well developed, but I am able to distinguish young males of the second form by the shape of the copulatory organs. Here in both species the prominent angle at the base of the terminal part is missing, but in *C.*

¹ This spot has been first observed by Williamson in *C. obscurus*, but by a misprint (p. 13) he states that this blotch is on the *posterior* margin of the carapace.

propinquus the tip of the internal part is pointed, while in *C. obscurus* it is blunt.

Cambarus propinquus is restricted, in Pennsylvania, to Lake Erie and the Lake Erie drainage. In the lake itself it has been found at Presque Isle (Dr. D. A. Atkinson coll.), and near Miles Grove (picked up alive on the beach by the writer). Of the tributaries of the lake, it is present in Conneaut Creek, associated with *C. obscurus*, at Albion, Erie county, but is exclusively found in some smaller creeks running to Conneaut Creek, Temple Creek at Albion, and in a small, nameless tributary below Conneautville Station, Crawford county. With *C. obscurus* it is found in Elk Creek, between Girard and Miles Grove, and it is found without *C. obscurus* in Walnut Creek at Swanville.

The largest specimens of *C. propinquus* in the Carnegie Museum collections are from Albion, Erie county, and measure: male of first form, 61.5 mm.; female, 69 mm. Hagen gives 2.3 in. = 66 mm. for this species.

6. CAMBARUS OBSCURUS Hagen. The River Crawfish.

The differences from *C. propinquus* have been set forth above, and are the following: (1) Lack of median keel of rostrum; (2) armature and shape of chela, which, however, is well developed only in large males of the first form; (3) shape of male copulatory organs; (4) shape of annulus of female; (5) color of finger-tips. (In old, dirty and soiled shells the color markings are largely obscured.)

Hagen gives 3.5 in. = 89 mm. for this species. The largest specimens in our collections are: male of first form from Ohio River, Stowe and Neville townships, Allegheny county, 86 mm.; female from Pucketty Creek, Allegheny county, 93 mm.

C. obscurus is the river form of western Pennsylvania, and prefers larger streams. Generally, the specimens are found under stones, where they scoop out a little hole for their accommodation. Rarely they dig short tunnels, and they do this chiefly on gravelly banks in the rivers, where there are no larger stones. If stones are lacking, they make short holes in muddy or peaty banks. These holes are very artless, running generally in a horizontal direction for a few inches, rarely more than a foot, just below the level of the water. The workings of this species are often indicated by insignificant mud or sand piles in front of their holes, generally more or less obliterated by the action of the water.

This species has been reported hitherto only from two localities: the type locality in the Genessee River at Rochester, New York (Hagen), and from Westmoreland county, Pa. (Faxon). Williamson mentions *C. propinquus* and *rusticus* from the Allegheny, Monongahela and Ohio Rivers in Allegheny county, but as the specimens in the Carnegie Museum show, his *propinquus* represents young specimens of *C. obscurus*, while his *rusticus* is founded upon full grown males and females of the same species.

C. obscurus is, aside from *C. bartoni*, the most abundant species in western Pennsylvania, and belongs, generally speaking, to the drainage of the three great rivers, Ohio, Allegheny and Monongahela. It is very numerous in the Ohio in Beaver and Allegheny counties, and has also been found in creeks running westward through the panhandle of West Virginia to the Ohio, for instance in Harmons and Buffalo Creeks in Washington county. It has been traced up the Allegheny River from Allegheny county through Clarion, Venango, Warren counties (specimens from Corydon are in the Academy in Philadelphia), then into New York state (Salamanca, Cattaraugus county, specimens in the Philadelphia Academy), and back into Pennsylvania, McKean county. Up the Monongahela River it has been traced to the Cheat River at Cheat Haven, Fayette county, and up the Youghiogheny as far as Connelsville, Fayette county, and the Indian Creek at Jones Mills, Westmoreland county. In the Kiskiminetas and Conemaugh, it goes as far as Blairsville Intersection, Westmoreland county, and up the Loyalhanna into Ligonier Valley. In the Beaver and Shenango Rivers it goes to Crawford county, and in French Creek at least as far as Union City, Erie county. Within the area thus outlined, it is found also in smaller streams up to a certain point, which cannot be defined in a general way, till it is replaced by *C. bartoni* occupying the rough and cooler waters near the source of each stream.

The presence of *C. obscurus* has been established in the following counties: Greene, Fayette, Washington, Westmoreland, Beaver, Allegheny, Butler, Clarion, Venango, Erie, Crawford, Warren, McKean; all these belong to the Ohio drainage. But there are a few additional remarkable facts. (1) The upper Youghiogheny and Casselman Rivers do not contain this species, and it is thus lacking in southeastern Fayette and in Somerset counties. This species goes up the Youghiogheny as far as Connelsville, and probably a little beyond,

since it enters the Indian Creek, but above the region where the Youghiogheny cuts through Laurel Hill and Chestnut Ridge it is not found any more. (2) This species is also found outside of the Ohio drainage, namely: (*a*) in Erie county, in the lake-drainage in Conneaut Creek at Albion, and in Elk Creek at Miles Grove; (*b*) in the Potomac drainage, in Wills Creek near Hyndman, Bedford county. This latter locality, although not properly belonging to western Pennsylvania, as defined above, is mentioned here, since it will give occasion to a very interesting zoögeographical discussion, for which, however, the investigations have not been finished.

REMARKS ON THE GEOGRAPHICAL DISTRIBUTION OF THE CRAW-
FISHES OF WESTERN PENNSYLVANIA.

Only a few points shall be mentioned here, in order to call attention to some remarkable facts of the distribution, which will be discussed more fully in a subsequent paper.

We may leave alone *C. bartoni*, which is found everywhere in the state, and its variety *robustus*, for which only slender material is at hand. *C. carolinus*, *monongalensis* and *diogenes* are restricted to the southwestern section of the state. The distribution of *C. carolinus* plainly indicates immigration from the south along the high plateau and longitudinal valleys included between Chestnut Ridge and Allegheny Mountains. In the valley between Chestnut Ridge and Laurel Hill, it managed to reach the cross divide between Indian Creek and the Loyalhanna River in Westmoreland county, without crossing it, while in Somerset county it has crossed the transversal divide between Casselman River and Conemaugh system. *C. monongalensis* very likely is its parallel form on the low plateau (Cretaceous peneplain?) northwest of the foot of the Chestnut Ridge: it has not yet been traced beyond the limits of the state, but reports are at hand that it is also found in West Virginia.¹ Northward, the Ohio-Allegheny-Kiskiminetas River seems to form the boundary of its distribution: this is highly interesting, in so far as a large river marks in this case a barrier to the further dispersal of an aquatic creature, but this is easily understood, if we take account of the peculiar habit of this species of living in springs on the hill-tops. Apparently, this species also came from the south, and migrated on the hills parallel with the gen-

¹ Such reports have been obtained from unprofessional people, and cannot be given, unless verified.

eral direction (south to north) of the Monongahela and Youghiogheny Rivers, and was stopped in its progress by the first large cross-valley encountered, that runs in an east-west direction.

The distribution of *C. diogenes* is not yet fully understood. Its area in western Pennsylvania somewhat resembles that of *C. monongahensis*, although it goes beyond the limits of the latter in a northerly and northeasterly direction, crossing the Allegheny River in Allegheny county, and the Loyalhanna in Westmoreland county. At present, no physical features of the country have been discovered that might furnish a barrier to the dispersal of this species northward, although it is certainly not found in the northern half of western Pennsylvania. Toward the east, the Chestnut Ridge limits this species. The presence of this species in eastern Pennsylvania further complicates this question.

With respect to the river-species, *C. obscurus* and *propinquus*, at the first glance, conditions appear simple, the first belonging to the Ohio drainage, the second to the Lake Erie drainage. We have seen, however, that parts of the Ohio drainage, namely, the upper Youghiogheny system, do not possess *C. obscurus*, it apparently finding its boundary where this river is rushing over falls and rapids through the narrow gorge of the Laurel Hill and Chestnut Ridge. This fact clearly proves that at least in the Youghiogheny the dispersal of this species was directed up stream. On the other hand, *C. obscurus* is found, together with *C. propinquus*, in certain parts of the Lake Erie drainage. Here, I think, we have to deal with a case of stream piracy, the capturing of the headwaters of one system by another one. In our case, we know, that the drainage features of Conneaut Creek and French Creek have entirely changed from what they were in pre-glacial times; but this part of their history does not bear upon the present case, the immigration of both river species into these parts undoubtedly belonging to postglacial times. Thus we are led to believe that quite recent changes of drainage have taken place here, which may be generally explained as a tapping of the drainage of French (and possibly also of Shenango) Creek by Conneaut and Elk Creeks cutting back through the original divide, which was formed by moraines. Together with the waters, certain elements of their fauna were thus deflected. In this respect it needs special attention, that, while *C. obscurus* has thus become a member of the fauna of the Lake Erie drainage, the opposite has not taken place with reference to *C.*

propinquus, and the latter species is strictly confined to the lake drainage; this is an important fact in so far as it demonstrates that no passive transport has played a part in the dispersal of these species, for, if it had been possible for *C. obscurus* to become colonized by transport (through water-fowl, etc.), in the Erie drainage, the same agents must have worked also in the opposite way, and should have been able to transport *C. propinquus* into the Ohio drainage. But this is not the case. Our material from the whole immense area occupied by the Ohio drainage contains not a single individual that shows the slightest approach to *C. propinquus*, although hundreds of specimens from various parts have been examined.

The peculiar presence of *C. obscurus* in the Potomac drainage at Hyndman is possibly due to similar causes and has a similar bearing; but since the solution of this question is to be sought for apparently in parts outside of our territory, we shall here refrain from discussing it.

It is hoped that the writer may be able to continue and enlarge the above studies, so that it will be possible, in a future memoir, to discuss the whole state of Pennsylvania. If this work is carried out, the distribution of the different species chiefly with regard to their post-glacial immigration into their present range will be elucidated, and, it is needless to say, very interesting results will be obtained, as is already indicated by the above short and preliminary sketch.