No. 6. — *Cave Animals from Southwestern Missouri.* By SAMUEL GARMAN.

THOUGH a knowledge of their inhabitants would appear to be of the greatest importance in connection with the study of the cave life of Kentucky, Tennessee, Indiana, and elsewhere, up to the present time the caverns of Missouri have received little or no attention from the zoölogist. The existence of numerous and extensive caves west of the Mississippi has been well known to geologists for a long time. There is frequent mention of them in the various Geological Reports; but among the notices only a single one touches on their animal occupants. The cavernous belt of Missouri is a hundred and fifty miles or more in width, and extends diagonally quite across the State from northeast to southwest. On the Mississippi, roughly estimated, it reaches from Clark to St. Louis County, and at the opposite extremity it stretches at the least from Vernon to Howell County. The geological positions of the caves range from the St. Louis limestone of the Lower Carboniferous to the third Magnesian limestone of the Lower Silurian. To the northward the formations lie in a plane that nearly coincides with that of the horizon. In Clark County the Keokuk limestone is at the surface; in St. Louis, it is that known by the name St. Louis; and between these points it is mainly the Burlington group that appears at the top. In the southwest a section across the belt cuts from the Carboniferous to the Silurian, as if toward a centre of upheaval in the southeastern portion of the State.

Caves have been reported from some twenty different counties, and in a number of instances particular ones have been described at length. Among the better known are those of Ralls, Boone, Phelps, Greene, Christian, Ozark, and McDonald. Whatever the causes, whether differences in the strata, the inclinations, the amount of fall in the watercourses, or in the water itself, the caves appear to become more extensive and more numerous toward the southwestern portion of the State. Fisher's Cave, in Ralls County, has an opening of ninety feet in width by twenty in height, and more than four hundred feet from the entrance

it connects with the surface by means of a sink-hole. The statement is made that Conner's Cave, in Boone County, has been explored for a distance of eight miles. Friede's Cave, in Phelps County, according to report, has been traced for a number of miles. There are several large caves in Ozark County, in the third Magnesian limestone. The sink-holes, with which so many of the caverns are connected, prove the manner of forming to have been the same as that giving rise to the Mammoth and other caves of Kentucky; the rock, dissolved and disintegrated, has been gradually removed by the water from the sink-holes. There seems to be no reason to suppose the history of the majority of these caves goes further back than that of the later Tertiary deposits, if so far. Such a small amount of divergence as exists between the species peculiar to the caves and their allies outside is proof that the former have entered their subterranean dwellings at a comparatively recent period.

In one of his Reports, State Geologist Broadhead remarks that in Christian County there is a stream that disappears in a sink to come out again three quarters of a mile away by an opening ninety-eight feet wide by sixty feet high, from which "a very clear, cool stream passes out, in which by careful search crawfish without eyes can be found." This is the only notice our search has revealed of the animals inhabiting these caves.

An opportunity of adding something to our knowledge was recently afforded by the kindness of Miss Ruth Hoppin, of Jasper County. My attention was first directed to the matter by a note from her, accompanied by a specimen of *Typhlichthys subterraneus*, Gir., that had been taken from a well. She said that similar fishes had been taken from other wells in the neighborhood, and that the owners of the wells spoke of subterranean streams flowing through. Experience elsewhere satisfied me that there should be caves in the vicinity from which these streams escaped, and at once my correspondent was asked if she would kindly engage some one to explore any caves there might be near by, and also, if possible, to get more specimens from the wells. She took up the matter, engaged help, and, at great personal risk and inconvenience, herself made explorations of a number of the caves, which, as was suspected, were not at all rare in the district, the southern part of Jasper County. Numerous specimens of Batrachians, Fishes, Crustaceans, Mollusks, and Insects were collected and forwarded from time to time, among them several new to science. Abstracts from the letters accompanying them give a very fair idea of their surroundings.

In one letter Miss Hoppin says: —

"I took a boy with me and went to Wilson's Cave. The catch was not large, but I was much encouraged by what I learned while there. The cave is about fifty feet long, nearly as wide, oven-shaped, and high enough to stand erect except around the sides. The farmer had enlarged the entrance to use the place as a creamery. A small very clear stream flowed along the left side, having a width of two feet and a depth of three, with a temperature of +54° F. About ten feet from the entrance the light struck the stream in such a manner that we could see everything in the water without a lantern. The first things that caught the eye were a lot of white crayfish, a dozen in all, like those I took from the wells. It seemed as if I might take every one of them. But though blind, they have one or more of the other senses very keenly developed. I am very sure they, as well as the white fishes, have the tactile sense developed in an unusual degree. At the least touch upon the water they dart away. As the net cautiously follows, they escape adroitly, making no blunders as to the direction of the approaching enemy, and hide in crevices of the jutting rocks or in the muddy bottom of the stream. The mud was easily stirred so that nothing could be seen. These creatures, fish and crayfish, are only to be secured by patient waiting and skilful management. The people at the cave say the fish never bite, and cannot be taken with hook and line. The crayfish were all found near the entrance, where there is considerable light. Following the stream back to a dark recess, reached by crawling on the slippery rocks, the light of the lantern revealed a school of little white fishes, such as I secured from the wells. All were very small. I saw half a dozen or more, but secured only one. I concluded the crayfish liked the light. Perhaps they remain near the entrance because they find there a supply of food. We found a few snails floating about, but saw none in the dark pool where the fish were. Miss Wilson, who was with me, thinks the crayfish devour the others. She has never seen them together, and says the latter keep away from the former, though she had not noticed the crayfish catching or eating them. There was nothing to prevent the crayfish ascending the stream to where the others were.

"An insect, a 'water spider,' common outside, is found inside near the light. I did not find it back where the little fishes stayed. By crawling back under the rocks one could see where the stream issues from the crevice. The passage is too low and too small to be followed, as the water occupies almost the whole of the opening. Beyond it, I think, one would find the home of the fish. The low opening is arched over by solid limestone, and could hardly be enlarged artificially, as the main entrance has been. Several feet to the right of the stream, having no visible connection with it, is 'the lake,' about fifteen feet in diameter. It is now a muddy bed. In no place could I see an inch of clear water. Just at the centre it has most water. When the water is high, the lake is full of fishes. What becomes of them when the water is low? I am ashamed that I did not look into that mud a little more carefully. There

must be some connection with the creek, either directly or back through the rocks. The lake is the place to catch the fish in high water. It is accessible, if one does not count the 'gumbo,' which makes an almost impassable sticky covering over the entire floor of the cave. This 'gumbo' forms the banks of the stream. It is difficult to keep one's footing there. With all our care it was constantly falling into the stream, roiling the water and scaring the crayfish. There was a small, dark-colored salamander near them. I brought home only one small fish and four small crayfish, the largest about two inches long. But I am much encouraged, for I feel sure that in time we can get all you want, and I realize there is ever so much that I can learn."

Samples of the "gumbo," or red mud, of the floors of the caves were sent with the collection. Experiments with it proved its excessive fineness and stickiness. Stirred about in the water at a depth only of two and a half inches, it was more than three hours before it had settled so that objects could be distinguished on the bottom. Twenty-four hours later, a cloudy substance, an inch and a half in depth, seemed to hang over the bottom, and it was more than two days before it had completely settled.

Miss Hoppin's first work was done in August; in September she made further efforts. In answer to questions, she states that the wells from which specimens have been taken are about half a mile from Centre Creek, the water level in wells and creek being nearly the same. The wells were nine or ten in number, from five to eighty rods apart, from eleven to thirty feet in depth, deeper in the higher ground, and having a depth of water varying from two to four feet. In some wells the rock at the bottom had been excavated. The water is what is commonly called hard, i. e. impregnated with lime. After rains, some of the wells have softer water than others, and the water stands higher in these wells, indicating closer connection with surface drainage. All the wells soon regain the common level. They become low in times of drouth, but never dry out entirely, as is the case with a cave spring near by, about twelve feet above the level of the creek. The temperatures taken in the wells at low water ranged from +52° to 54° Fahrenheit. During a storm, in the well having the highest water the temperature rose to +57°. When the mercury stood at 90° to 95° in the shade outside, the temperature was only 54° in Wilson's cave.

"After several days of a cold wave, the night temperature of the outer air being 45° and the noon reading at 60° to 70° in the shade, I found the temperature of the water in the cave had gone down about two degrees. . . . The level of this cave is ten or more feet above the creek, and it is not affected

by the rains until several days after the creek has begun its rise. This statement is from the people at the cave, and was not verified by me.

"From one well thirteen blind crayfish were taken by means of a net formed of mosquito bar spread on the bottom. The specimens became entangled in it. From the same well a few snails were taken. The owner reports, that at various times, a year or more ago, the surface of the water would be covered with 'little white lice or something of the kind.' Minnows were put in, after which the lice disappeared. A blind fish was also put into this well, but nothing had been seen again either of it or the minnows. From each of the other wells one crayfish was taken; from one of the three, a few minute centipedes. Earlier in the season these centipedes had been so numerous as to render the water unfit for use; they seemed to be inhabitants of the well. Some minnows were put in, and the centipedes vanished. I heard of them too late to make a satisfactory collection. From the Armstrong well two small blind fish were taken, and one from the Adams well. From the latter some snails were secured, also some large centipedes, these latter under circumstances indicative of accidental presence. Reports come from the country for miles around where fish and crayfish are taken. One well, an Artesian, went dry when a neighbor dug another farther down the hill. It was then found that the first well opened at the side directly into a small cave. All of these wells are in limestone; only in this formation is good water to be obtained hereabout. The larger caves in this vicinity are under the limestone cliffs and hills that skirt Centre Creek. The wells are usually walled with stones that leave spaces, through which the fishes may pass. There are probably many small subterranean springs and streams, not one large underlying lake or stream, as popular belief has it.

"Day's Cave, from which a small collection is sent, opens under the cliffs. After much digging the mouth was enlarged so that a small boy squeezed through. Wilson's Cave is not large; it is spanned by one limestone, and floored with the sticky 'gumbo.' This mud is utterly without grit. It forms a crumbling bank on the approachable side of the stream, and the minute particles are seen through the very clear water to be suspended in a thin swaying cloud at the bottom of the water. This mud-cloud is so light as to form no obstacle to the movement of the creatures which find it a ready hiding-place. It renders a study of the animals at the bottom very difficult, the water is so easily roiled. It required great care to catch the specimens; the stirring of the water frightened them away to their hiding places on the bottom, or among the dark nooks and crevices of the jutting rocks of the opposite bank, their movements at the same time stirring up the mud so that nothing could be seen. In the farthest corner of the cave, where the water comes in, would seem to be the home of the fishes; here they were most numerous and most active. When the water is low, they are found only here, though the stream below is equally cold and deep. Apparently, they avoid the light.

"On my first visit, the water being low, no crayfish were seen in the dark nook, the place favored by the fish. After the storm which had flooded the caves, a few were found there. Though I watched for some time, I never saw them pursue the fishes, as they might easily have done, guided by the stir in the water. Both creatures are very sensitive to the slightest ripple. During high water, a pool, 'the lake,' is formed, a little way from the stream in another dark part of this cave. In low water the pool is cut off from the creek. I found both species in it, the fish in the darkest part, and saw no signs of enmity. Most of the crayfish were found in the lower part of the stream, in the twilight; the fishes could not be found without the lantern. At the time of the floods, the cave is full, and the water rushes out furiously. . . . Another proof that the crayfish are more fond of the light is seen in the shallower wells. That from which most were taken was more exposed to the sun. At noon, when the light was more favorable, we could see them swimming about. No fishes have been taken from this well. They were taken in the narrower more shaded wells, of which the deep ones on the hills report fishes only.

"As to the food of the fishes, I discovered nothing. The mud where they were was not so deep as farther down. An examination of it the length of the cave brought to light many snails; the shells of the living ones are whiter and more nearly transparent than the floating dead ones. The largest crayfish are of a dirty rusty color, and very bristly, in caves and in wells. One large one is very soft and very white; no doubt it is newly moulted.

"Both fish and crayfish were less numerous after the freshet, and apparently less active. The disturbance of the flood may have caused them to retreat into their hiding places, only the weaker being left behind, or some may have been swept away by the torrent. The sensitive creatures would soon die in the light and heat outside, where the water is full of frogs and eyed-crayfishes. . . . The specimens become opaque when they are put into alcohol; they are almost transparent when alive, so much so that the action of their internal organs can be observed. Repeated tests assured me the animals were blind, though very sensitive to the sunlight. They died soon after catching, even in water frequently changed.

"The insects of the collection were taken in the lower part of the stream, near the mouth of the cave. They are similar to, if not identical with, others found in all the spring streams of this vicinity. They are very lively on the surface of the water, constantly rippling it. I think the crayfish eat them, but have no positive proof. On my first visit, insects and crayfish were very numerous at this place. The latter were darting up towards the former. We thought we could detect a faint odor about the insects (water spiders) that might help to guide their enemies, but the vibration of the water would be sufficient.

"Two aquatic and two terrestrial salamanders taken in this cave are in the collection; they are not peculiar to the cave. Some nearly a foot long are in the creek outside."

Some time near the middle of October Miss Hoppin visited Wilson's cave again, after some cold weather; the water was four degrees colder, and no fishes were to be seen. A couple of weeks later, after a week of warm days, the water had taken on its summer temperature of 54°, but there was nothing to collect. The water at this time was so low that the connection with the water of the inner cavern was broken, the water in the stream being below the fissure from which it poured earlier in the season. It appeared as if the fishes could not get out into the cave till the water rose again. The opening into the inner cavern would admit a small dog. There were no insects on the walls. Something was heard that was supposed to be a bat, but it could not be found. The neighbors said that after the floods white crayfishes were frequently found out of the cave in the creek.

Various caves were visited, at a considerable distance apart; the collections were in the main made from the wells and the two caves mentioned. It is evident from the notes that the caves are numerous, and similar to those in the same formations in other States. It is also evident, from what is found in the stomachs of the fishes, that there is more to be done in the way of collecting. A few fossils from the walls were sent. Though not peculiar to it, all are forms common in the Keokuk limestones, which lie at or near the surface in this district, known as the lead region of Southwestern Missouri. The greatest altitude is rather more than eleven hundred feet above the sea level. At the point under consideration the drainage goes to the westward. The waters afterward go south in the Grand River, then southeast in the Arkansas, and reach the Mississippi a little below 34° north latitude, two hundred and fifty miles or more below the mouth of the Ohio. Directly eastward, a considerable distance, the water is carried toward the mouth of the Arkansas, near which it meets the Mississippi. Northeastward it is less than twenty miles to points from which the drainage is carried through the Osage River to the Missouri, the mouth of which is about a hundred and fifty miles above that of the Ohio. Whether approached by the way of the Arkansas or by that of the Missouri, the caves of Jasper County and the neighboring counties are pretty effectually isolated from the caves east of the Mississippi, — a fact not to be lost sight of in discussing the distribution of the animals.

The collections contain a large number of specimens pertaining to a rather small number of species. Of these the fishes and the crustacea claim most of our attention, being the only ones we can with safety call peculiar to the caverns. As their testimony concerning the acquisition

of the species by the caves appears to differ somewhat, it will be well to consider them separately. The following is the entire list of species : —

Geotriton longicauda, from Wilson's Cave.
Plethodon sp., larvæ, " "
Cambarus virilis Hagen, from the wells, Wilson's Cave, and streams.
C. setosus n. sp., from the wells, Wilson's Cave.
Asellus Hoppinæ n. sp., from Day's Cave, in mud under stones.
Physa heterostropha Say, from caves and wells.
Scolopocryptops sexspinosa, from wells.
Plathemis trimaculata DeGeer, from mouths of caves.
Hygrotrechus remigis Say, from near mouth of Wilson's Cave.
Dineutes assimilis Aubé, " " "
Agabus sp., from Day's Cave, under rocks.
Ceuthophilus Sloanii Pack, from the water in Wilson's Cave.

FISHES.

Typhlichthys subterraneus GIRARD, the only blind fish in the collection, is represented by a large number of examples, the majority of them taken from the wells, the balance from the caves, with the exception of a single one from the creek outside. Compared with specimens from Kentucky and Tennessee, they agree so exactly as to raise the question whether the species was not originated in one of the localities and thence distributed to the others. The opinion generally held is, that the cave species of Indiana, Kentucky, and Tennessee originated in their respective localities. It is no doubt true for some of them. The idea is well supported by the insects and crustacea, the species in one section being unlike those of the others. It may be urged that the respect in which the fishes differ from them is more apparent than real, since these crustacea and insects were derived from a number of distinct species, while in all probability the same species of fish entered the caves in each district, and, being under the same influences in each, suffered the same modification in each. Reduced to its lowest terms the question, so far as the fishes are concerned, is this : Were the blind fishes distributed to the scattered localities where now found before or after they became blind? In favor of independent origins at distant points, it can be said that a species, distributed over the valley, possessed of habits such as would lead it to place itself under the modifying conditions of the cave in one place, would be most likely led to do so in the others. On the other hand, we have the more hesitation in accepting the conclusion that one and the same species originated independently in two or more different

localities, from knowing that exact parallels in the development of animals in nature, if they exist, are excessively rare. If our caution prevents ready acceptance of two apparently exact evolutionary parallels as really coincident, we become much more sceptical when the number of parallels or coinciding lines is increased. There is no doubt that the representatives of *Typhlichthys subterraneus* in the various caves were derived from a single common ancestral species. The doubts concern only the probability of the existence of three or more lines of development, in as many different locations, starting from the same species and leading to such practical identity of result. Such identical results would demand substantially similar modifying elements, — darkness, temperature, food, enemies, etc., — and the same length of time subjected to their influence. The likelihood of the existence of so many like elements in distant regions is inversely to the number demanded, though one cannot say it is impossible. To accept the conclusion favoring independent developments of the same species would involve acceptance of the idea that the caves in each of the districts had been occupied for about the same period of time. This, of course, would not furnish us with any clue to the time of formation of the caves.

As an alternative, the opinion is here advanced that these blind fishes originated in a particular locality, and have been, and are being, distributed among the caves throughout the valley. We are in the habit of looking upon great rivers like the Ohio or Mississippi as impassable obstacles to passage from cave to cave, rather than as thoroughfares. In this we have certainly assumed too much. Various instances are on record of the discovery of blind fishes that have strayed into the open streams from their caverns. If there were means of determining the frequency of the occurrence of such instances, it would undoubtedly much exceed what we are now inclined to credit. Persons acquainted with the streams of the Mississippi basin will agree that their undermined banks provide series of recesses or caverns, extending from the rills at the sources of the tributaries to the Gulf. The currents do not prove insurmountable to multitudes of fishes, no better provided with locomotive organs than the blind fishes, passing up the streams every season. Swept from the caves by the torrents in the flooded mouths, the blind species would find itself protected at once from light or enemies by the turbid waters. The temperature of the water at such times is low, and, should the light penetrate so as to prove detrimental, retreats exist on every hand in the excavations of the banks or the mud of the bottom. What migrations these fishes may make in

winter we can only imagine. Hiding places are so numerous and extensive as to suggest the possibility of the evolution of blind forms without the caves. The great essential would be the disposition to avoid the light, opportunities existing everywhere; the surroundings then would bring the organization into harmony with their demands, sooner or later as the creature was more or less plastic and yielding; disuse of the sense of sight being followed by its loss and atrophy of its special organ. Development of sightless forms in the holes and burrows of the banks, or in the mud of the bottom of the river, would here follow a similar course to that gone through at great depths in lake or ocean.

Crooked streams are not so impassable as one might suppose, even to floating objects, insects, mollusks, etc. A twig or leaf dropped into the current on the inside of the upper arm of a horseshoe curve in a stream is carried near to the opposite shore before it leaves the bend, and, especially if favored by the wind, often is carried completely across. The passage is much easier to animals that swim, however feebly. Taking everything into the account, it does not appear to be at all necessary to credit *Typhlichthys subterraneus* from Kentucky, Tennessee, and Missouri with more than a single point of origin. The same may be said of *Amblyopsis spelæus* of Kentucky and Indiana, and of the blind crayfish of the same States.

In an article entitled "Life in the Wyandot Cave," Ann. Mag. Nat. Hist., Ser. 4, VIII., 1871, p. 368, Professor Cope makes this statement concerning *Amblyopsis*: "If these *Amblyopses* be not alarmed, they come to the surface to feed, and swim in full sight, like white aquatic ghosts. They are then easily taken by the hand or net, if perfect silence is preserved; for they are unconscious of the presence of an enemy, except through the medium of hearing. This sense, however, is evidently very acute; for at any noise they turn suddenly downward and hide beneath stones, etc. on the bottom." The statement is repeated in Amer. Nat., 1872, p. 409. Such a development of this sense, in recesses where we are accustomed to think any sounds other than those made by the rippling or dripping water are almost unknown, is not what one would have expected. Having this in mind, I wrote to Miss Hoppin asking her to make experiments on *Typhlichthys*, and to determine what she could in regard to hearing, feeding habits, etc. The quotations here given are from her replies.

"For about two weeks I have been watching a fish taken from a well. I gave him considerable water, changed once a day, and kept in an uninhabited place subject to as few changes of temperature as possible. He seems perfectly

healthy, and as lively as when first taken from the well. If not capable of long fasts, he must live on small organisms my eye cannot discern. He is hardly ever still, but moves around the sides of the vessel constantly, down and up, as if needing the air. He never swims through the body of the water away from the sides, unless disturbed. Passing the finger over the sides of the vessel under water, I find it slippery. I am careful not to disturb this slimy coating when the water is changed. . . . Numerous tests convince me that it is through the sense of touch, and not through hearing, that the fish is disturbed: I may scream, or strike metal bodies together over him as near as possible, yet he seems to take no notice whatever. If I strike the vessel so that the water is set in motion, he darts away from that side through the mass of the water, instead of around, in his usual way. If I stir the water, or touch the fish, no matter how lightly, his actions are the same."

From the stomach of one specimen the remains of an *Asellus* were taken; from that of another, a young *Cambarus;* from a third, fragments of an insect resembling *Ceuthophilus;* and from others, portions of a crustacean, of which we have several specimens from Day's Cave, with well developed eyes, resembling *Crangonyx*, and from appearance the main food dependence.

The total length of the largest fish is two inches and a quarter. The eggs in the ovaries, August to September, are large, but with no traces of embryos.

CRUSTACEA.

In part, at least, the problem of the origin of the cave crustacea is simplified by the fact that they are so distinct in various caves as to leave no doubt that they are descended from ancestors already of different species at the time of entering the subterranean habitations. The blind crayfish of the Missouri caves is very distinct from any previously known; it is described below under the name *Cambarus setosus.* The common species of the neighborhood, *C. virilis*, is also found to enter the underground retreats, but it is not, of the outside forms, the nearest ally of the blind form. The latter bears so much affinity to *C. Bartonii* as to suggest derivation from it. A somewhat parallel condition exists in the caves of Missouri and those of Kentucky. In these last, with the blind *C. pellucidus* we find *C. Bartonii*, the nearest ally of the blind crayfish of Missouri, *C. setosus;* and with the latter again, in the Missouri caves, is found an eyed species, *C. virilis*, more nearly allied to the blind one in the Mammoth Cave. The relationship existing between the species *C. setosus* and *C. Bartonii* is much closer than that between *C. pellucidus* and *C. virilis.* A distribution of *C. Bartonii* covering so large a portion of

the Upper Mississippi valley to some extent favors the idea of a derivation from it of *C. setosus*. The greater differences between *C. pellucidus* and all the known eyed species point toward a longer subjection of that form to the spelæan influences. For comparison we give diagrams of details of structure, antennal lamina, epistoma, and the two forms of the anterior pairs of abdominal appendages of several species. These are taken from the specimens and from the drawings. The degrees of affinity are well indicated by the shapes of the first pairs of abdominal legs. The slighter approach of *C. pellucidus* toward *C. virilis* is shown by Figures 12 to 14 of the former, as compared with Figures 8 to 10 of the latter; and the nearness of *C. setosus* to *C. Bartonii* is apparent in Figures 1 and 2 of the first, and 4 and 5 of the second. Figures 11 and 15 represent *C. hamulatus*, from the Tennessee caves, a form which stands between *C. setosus* and *C. pellucidus*, nearer the former. Distributing the mentioned species into the groups arranged by Professor Hagen, we shall have the aberrant form *C. pellucidus* in the first group, nearest to the second, in which *C. virilis* belongs; while *C. Bartonii*, *C. setosus*, and *C. hamulatus* fall into the third group. Such close affinities as exist between *C. Bartonii* and *C. setosus* do not permit their separation into different genera, and the retention of the latter in the genus *Cambarus* cannot but be followed by the disestablishment of the genus *Orconectes* and the return to the older genus of the two species heretofore included in the later. Very young specimens of *C. setosus* correspond better with the adults of *C. Bartonii;* their eyes are more prominent in these stages, and appear to lack but the pigment; the rostrum also is less acuminate, and its blunt lateral angles are present. The gonopods of the very small ones agree with those of form ii. of *C. Bartonii*, the adult shapes approaching those of form i. According to Miss Hoppin, the young of *C. setosus* when alive are not so white as the older ones.

"At first, I attributed it to greater transparency, but now I am sure the color is in the shell, not that the internal organs can be seen because of the transparent shell. They are not so dark, however, as the brook species [*C. virilis*] of the same size."

In similarity to the case of *Amblyopsis*, the presence of the same species of blind crayfish in the caves of Kentucky and those of Indiana is an indication of distribution from a single point of origin.

The crustacea were placed in the hands of Professor W. Faxon for identification. He has kindly furnished the descriptions of the new species, which are given as they come from his pen. I have added on

Plate II. a hasty sketch of an adult female of *Cambarus setosus*, one half larger than natural size, and another of a specimen of *Asellus Hoppinæ*, three times the size of the specimen. On Plate II. Fig. 1, the outer two joints of each leg of the hinder two pairs are bent under, so that they appear one third shorter. The remainder of the collection, the insects, mollusks, and the like, was examined by Professor H. Garman, to whom I am indebted for identifications and notes quoted below.

Cambarus setosus Faxon.

"Carapace granulate on the sides, with scattered hair-like setæ ; cervical groove sinuate ; a small lateral spine just behind the cervical groove ; rostrum of moderate length, triangular, excavated, lateral margins convex, no lateral teeth (except in smaller specimens, which have a small, acute tooth on each side near the tip); post-orbital ridges slightly developed, without anterior spines; region behind the cervical groove relatively long; areola very narrow, punctate. Abdomen about the same length as the carapace, with scattered hairs; telson bispinose (occasionally trispinose) on each side. Anterior process of the epistoma broadly triangular, margins more or less notched or dentate. Eye-stalks and eyes rudimentary. Basal segments of antennules furnished with a sharp spine near the distal end. Antennæ longer than the body; scale very broad at the distal end, external border slightly convex, ending in a short, sharp spine. Third pair of maxillipeds bearded within. Chelipeds of moderate length; chelæ long, very hairy, toothed on the inner margin, granulate on the outer margin; fingers long, compressed, costate ; carpus toothed on the inner face, granulate on the outer side; upper surface of meros granulate, lower surface with two rows of sharp spines. Third pair of legs of the male hooked. First pair of abdominal appendages terminating in two recurved hooks (similar to those of *C. Bartonii*). Annulus ventralis of the female prominent, with a deep central fossa.

"Length of one of the largest specimens, $2\frac{1}{2}$ inches ; carapace, $1\frac{1}{4}$ in.; from tip of rostrum to cervical groove, $\frac{11}{16}$ in.; chela, $1\frac{1}{16}$ in.; fingers, $\frac{11}{16}$ in."

From the wells come also two very small specimens with well developed eyes, probably *C. virilis* Hagen. They are too young to determine with certainty.

Asellus Hoppinæ Faxon.

"Anterior margin of head with a median concavity, from the bottom of which projects a rostral tooth; external angles rounded; the head widens posteriorly, so that the hind margin is nearly as broad as the anterior margin of the first thoracic segment; eyes of moderate size, oval. Thoracic segments subquadrate, lateral margins convex, giving to the body with the head and

abdomen an even, long oval outline. Abdomen suborbicular, slightly excavated on the margin at the base of the caudal stylets. Basal segment of antennule subspherical, second segment cylindrical, forming with the first a well marked peduncle; flagellum composed of six or seven segments; the tip of the antennule does not reach the distal end of the penultimate segment of the antennal peduncle. Peduncle of antenna composed of three short, followed by two long segments; flagellum long, reaching, when bent backward, as far as to the abdomen. Mandible furnished with a tri-articulate palpus. First pair of thoracic appendages of male provided with a thick claw; on the palmary border are two long teeth and a small blunted tubercle; dactylus armed with a blunt tooth or tubercle near the middle. Caudal stylets with two subcylindrical branches, the inner of which is somewhat longer than the outer. Color, slaty brown mottled with lighter yellowish spots.

"Length, without caudal stylets, $\frac{3}{8}$ inch ; breadth, $\frac{3}{16}$ inch."

INSECTS, etc.

The following are Professor Garman's notes on the invertebrates sent him for examination.

"The invertebrates sent me for identification pertain to common species, for the most part aquatic, such as one would expect to find at the mouths of caves from which emerge streams of water. With the exception of a myriapod and a small grub, all have well developed eyes. One or two may be classed as shade-lovers, since in ordinary situations they commonly affect retreats from which direct sunlight is excluded. The myriapod is totally blind, but is not, so far as I know, an inhabitant of caves. It is one of a number of widely distributed species, which spend much of their time in moist earth. The absence of eyes in a dipterous larva of the lot has also no necessary relation to a life in caves, since larvæ probably identical with it as to species are frequently taken among rubbish in open ditches and rivulets. The value of the collection is therefore to be looked for in the direction of its remote bearing on the problem of the origin of cave life, — a problem which needs for its complete elucidation all details obtainable which may by any possibility throw light upon this subject.

"The single mollusk of the collection, represented by many specimens from Wilson's cave, is *Physa heterostropha* Say, a species which is extremely common in the weedy shallows of ponds, lakes, and streams of the Middle States. It does not ordinarily avoid light more than other small fresh-water snails, and had perhaps penetrated the cave in following up its food supply. The examples are quite typical of the species.

"A myriapod, *Scolopocryptops sexspinosa* Say, is represented by one specimen marked 'From Wells.' Though lacking ocelli, it can hardly be considered a cave species, inasmuch as it is found everywhere throughout the eastern

United States under wood and stones. Its occurrence in wells is of course accidental.

"Three dragon-flies, two males and one female, taken at the mouth of Wilson's Cave, represent the *Plathemis trimaculata* De Geer, a swift-flying, light-loving insect which is common about fresh water in most parts of the United States.

"Seven examples of *Hygrotrechus remigis* Say were collected in Wilson's Cave, probably at no great distance from the entrance. These bugs prefer shaded waters, and are commonly seen on the surface of pools under bridges and culverts. Their eyes are relatively large, and they probably do not voluntarily visit regions entirely destitute of light.

"From the mouth of Wilson's Cave are four examples of the common whirligig beetle, *Dineutes assimilis* Aubé, differing in no respect from examples collected in other localities on open water.

"A second beetle, also aquatic, is represented by one specimen labelled 'Day's Cave, under rocks and stones in the mud.' It is a fine black *Agabus*, probably *A. suturalis* Crotch, but without authentic examples of this species for comparison it is hardly safe to make this determination final. From the Californian *A. lugens* Le Conte, to which it bears a close general resemblance, it seems to differ chiefly in having the sides of the prothorax a little rounded, and in having the basal margin sinuate.

"The 'cricket' seems to be *Ceuthophilus Sloanii* Pack., of which its discoverer says in a recent paper: 'The species is at once known by the conspicuous pale dorsal band which extends from between the eyes to the fourth segment behind, dilating slightly on the front edge of segments 2 to 4; the brown portion has scattered pale dots on each side of the line,' etc. The specimens are labelled 'From the water in Wilson's Cave.'

"The remaining specimen is a fleshy, wrinkled dipterous larva, 7 mm. long and 3 mm. in diameter, which was taken from a well."

November 16, 1889.

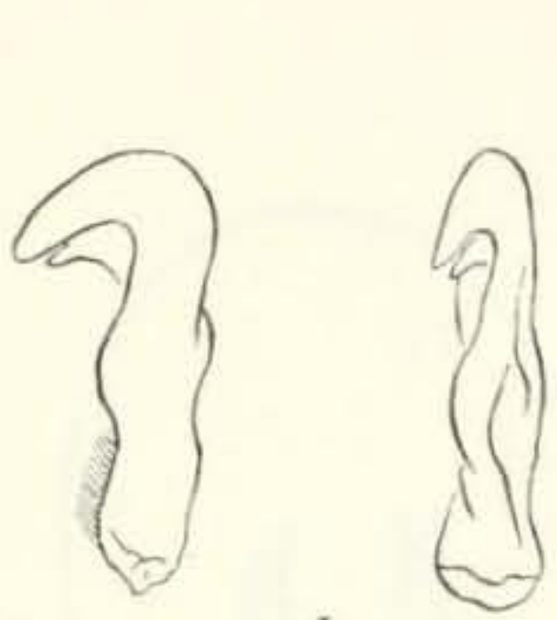
LIST OF DIAGRAMS.

PLATE I.

Fig. 1–3, 7. *Cambarus setosus* Fax.
Fig. 4–6. *C. Bartonii* Fabr.; Gir.
Fig. 8–10. *C. virilis* Hagen.
Fig. 12–14. *C. pellucidus* Tellk.; Gir.
Fig. 11, 15. *C. hamulatus* Cope; Fax.

PLATE II.

Fig. 1. *Cambarus setosus*, 1½ times nat., ♀.
Fig. 2. *Asellus Hoppinæ*, 3 times nat.



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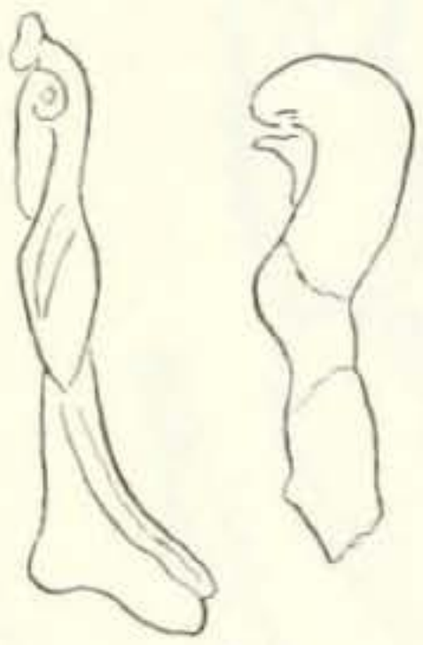

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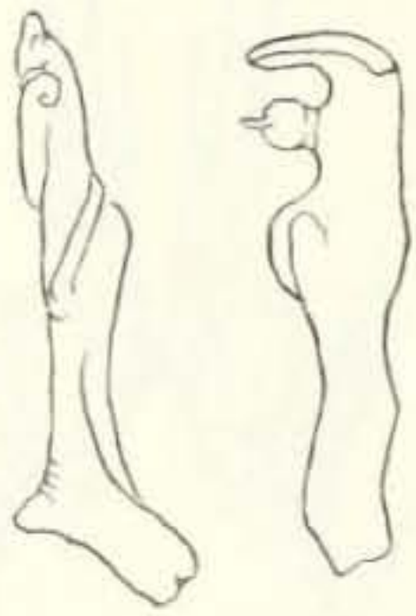

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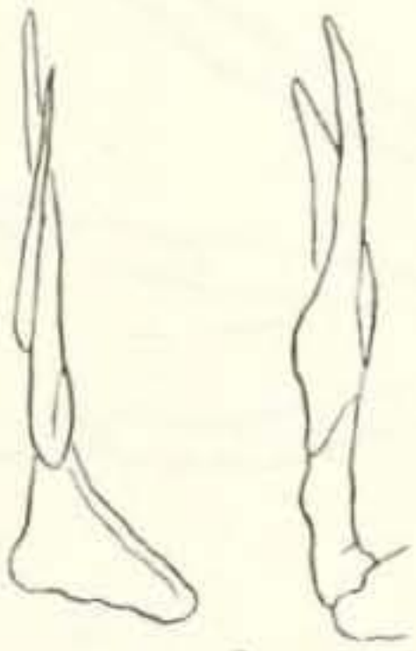

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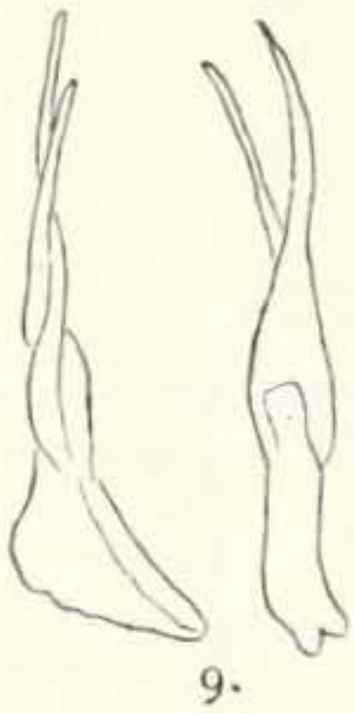

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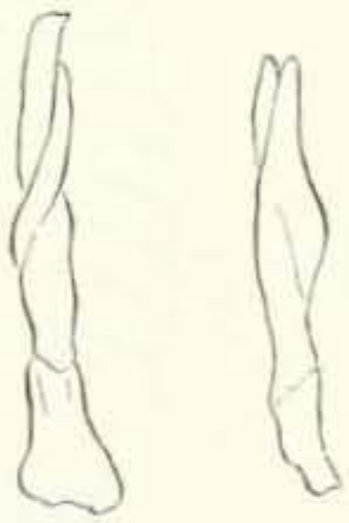

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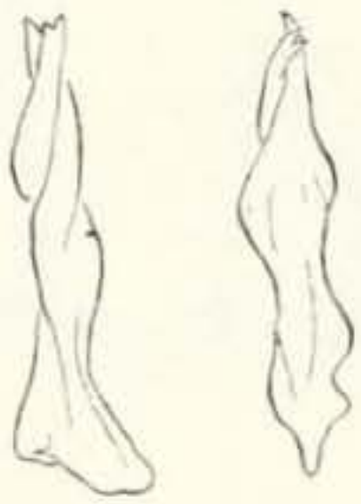

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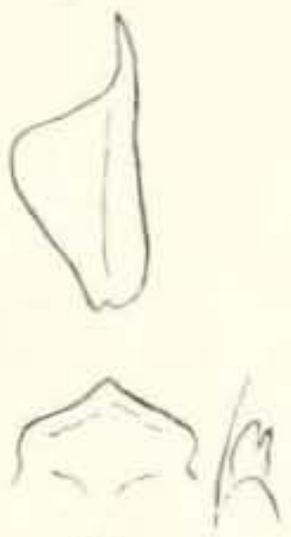

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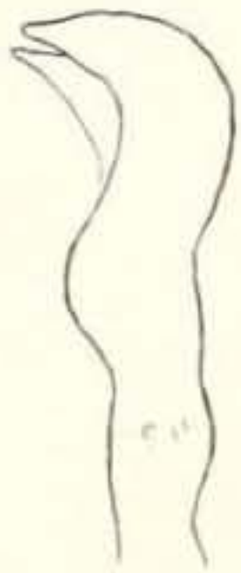

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Photo. Lith. of L. S. Punderson & Son, New Haven, Conn.

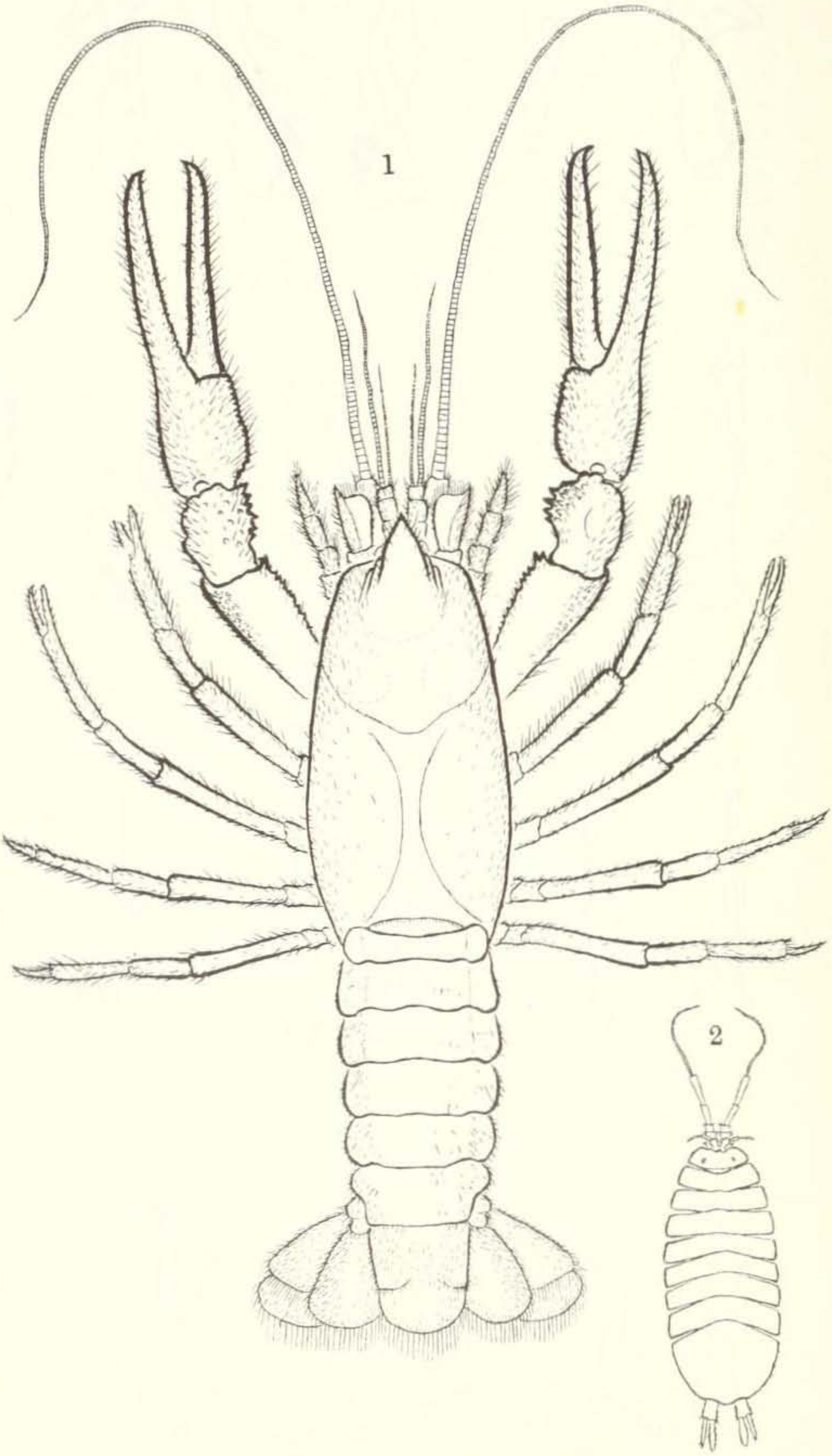

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Photo-Lith. of J. S. Pendleton & Son. New Haven, Conn.