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A. S. PACKARD, JR., AND F. W. PUTNAM.

E. S. MORSE AND A. HYATT, ASSOCIATE EDITORS.

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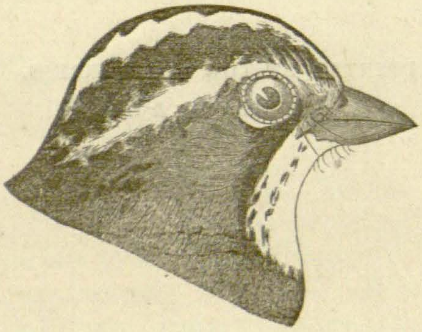

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THE MAMMOTH CAVE AND ITS INHABITANTS.

BY THE EDITORS.

AFTER the adjournment of the meeting of the American Association for the Advancement of Science, held at Indianapolis, in August last, a large number of the members availed themselves of the generous invitation of the Louisville and Nashville Railroad Company, to visit this world renowned cave, and examine its peculiar formation and singular fauna.

The cave is in a hill of the subcarboniferous limestone formation in Edmondson County, a little to the west and south of the centre of Kentucky. Green river, which rises to the eastward in about the centre of the state, flows westward passing in close proximity to the cave, and receiving its waters thence flows northwesterly to the Ohio.

The limestone formation in which the cave exists, is a most interesting and important geological formation, corresponding to the mountain limestone of the European geologists, and of considerable geological importance in the determination of the western coal fields.

We quote the following account of this formation from Major S. S. Lyon's report in the fourth volume of the Kentucky Geological Survey, pages 509–10.

" The sinks and basins at the head of Sinking creek exhibit in a striking manner, the eroding effect of rains and frost — some of the sinks, which are from forty to one hundred and ninety feet deep, covering an area of from five acres to two thousand. The rim of sandstone surrounding these depressions is, generally, nearly level; the outcropping rocks within are also nearly horizontal. Near the centre there is an opening of from three to fifteen feet in diameter; into this opening the water which has fallen within the margin of the basin has been drained since the day when the rocks exposed within were raised above the drainage of the country, and thus, by the slow process of washing and weathering, the rocks, which once filled these cavities, have been worn and carried down into the subterranean drainage of the country. All this has evidently come to pass in the most quiet and regular manner. The size of the central opening is too small to admit extraordinary floods; nor is it possible, with the level margin around, to suppose that these cavities were worn by eddies in a current that swept the whole cavernous member of the subcarboniferous limestone of western Kentucky; but the opinion is probable that the upheaving force which raised these beds to their present level, at the same time ruptured and cracked the beds in certain lines; that afterwards the rains were swallowed into openings on these fractures, producing, by denudation, the basins of the sinkhole country, and further enlarging the original fractures by flowing through them, and thus forming a vast system of caverns, which surrounds the western coal field. The Mammoth Cave is, at present, the best known, and, therefore, the most remarkable."

So much has been written on the cave and its wonders, that to give a description of its interior would be superfluous in this connection, even could we do so without unintentionally giving too exaggerated statements which seems to be the natural result of a day underground, at least so far as this cave is concerned, for after reading any account of the cave, one is disappointed at finding the reality so unlike the picture. As the Association party was accompanied by one,* who while a most enthusiastic collector and explorer, was also a calm recorder of statements made by the geologists of the party, we can not do better in conveying to our readers the general geological character and structure of the cave than to copy his account.

"As we expected to remain within the cave a long time, our trusty guide, Frank, had provided himself with a well-filled can of oil, to replenish our lamps, and with this strapped upon his back he led the way into the thick darkness. We shall attempt no description of the cave. Its darkness must be felt to be appreciated, and no form of expression, understood by mortals who have never descended to its cavernous depths, nor trod its gloomy

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*W. P. Fishback, Esq., of the Indianapolis Daily Journal.

corridors, can convey any thing like an adequate idea of the place. After spending fifteen hours within its chambers, it is absolutely nauseating to read the descriptions which have been current in the letters of newspaper correspondents for a quarter of a century, and even the vigorous and picturesque language of Bayard Taylor becomes tame and commonplace when it attempts to describe this subterranean wonder of the world.

How and when the cave was made, were the leading questions in the minds of the geologists. They do not believe that the cave was the immediate result of some violent upheaval of the strata, which left these vast crevices and chambers of which the cave is composed; neither do they share the popular belief that the rapid and violent action of some subterranean stream of water has worn these deep channels through the limestone; on the contrary, they find conclusive evidence that the same agencies are at work and the same changes in progress to-day that have been slowly, steadily and quietly, through vast periods of time, accomplishing the marvellous wonders that now astonish the beholder. The cave is wrought in the stratum known as the St. Louis limestone, which, in some places reaches a thickness or depth of four hundred feet. This stone is dissolved whenever it is subjected to the influence of running or dripping water impregnated with carbonic acid gas. Water exposed to the air readily absorbs this gas, and surface water percolating through small fissures of the limestone, dissolves it. Another fact should be stated. When, during this process of solution, the water becomes thoroughly impregnated with lime, it loses its power to dissolve the stone. The following conditions, then, were essential to the productions of the cave, assuming what is not disputed by geologists, that the place where the cave now is, was once nearly solid limestone. First, that there should be fissures in the strata, allowing the ingress of the surface water. Secondly, there should be a place or places of exit for the water charged with limestone in solution. Without the latter, the water would become charged with lime, fill up the crevices, and the dissolving process would cease. These conditions are all present to-day, and have remained the same during the countless ages that have passed away while the work has been in progress. There have doubtless been times in the history of the cave, when, owing to a greater flow of water, the work has progressed more rapidly than at present, but that the results have been accomplished in the manner stated, rather than by the process of attrition by rapid currents of large volumes of water, seems to be the general opinion of scientific men. This theory is strengthened by the fact that where the cave attains its greatest heights, and reaches its lowest depths, the dripping waters have never ceased their labors, and are busily at work to-day. In the Mammoth Dome, for instance — rarely seen by visitors, on account of the dangers and fatigue incident to the journey — where the chasm attains a height and depth of more than two hundred and fifty feet, a cascade falls from a great height, and keeps the entire surface of the rocks covered with dripping water. This, falling into a deep pit below, finds an exit through which it bears away a portion of the lime composing the rock. After a walk of thirteen hours, our guide informed us that he would conduct us to the Mammoth Dome if we felt able to bear the fatigue of the journey. Foot-sore and weary, we were not in a favorable condition for so arduous an undertaking, but Mr. Thomas Kite of Cincinnati, who had visited the locality thirty years ago, urged us to go, and told us the sight of this Dome was worth all the rest. Provided with magnesium and calcium lights, we crawled and climbed our way to the brink of the pit, the bottom of which was reached by a rickety ladder, slippery and dripping with water. A portion of the party descended, and when all were ready the lights were ignited, and the immense dome was revealed to us in all its majestic beauty. Upon our return, three hearty cheers were given to the good friend at whose earnest solicitation we undertook this part of our journey.

We are indebted to Professor Alexander Winchell, of the University of Michigan, for the following abstract of his views concerning the formation of the cave.

'The country of the Mammoth Cave was probably dry land at the close of the coal period, and has remained such, with certain exceptions, through the Mesozoic and Cænozoic ages, and to the present. In Mesozoic times, fissures existed in the formation, and surface waters found their way through them, dissolving the limestone and continually enlarging the spaces. A cave of considerable dimensions probably existed during the prevalence of the continental glaciers over the northern hemisphere. On the dissolution of the glaciers, the flood of water which swept over the entire country, transporting the materials which constituted the modified drift, swept through the passages of the cave, enlarging them, and leaving deposited in the cave, some of the same quartzose pebbles which characterize the surface deposits from Lake Superior to the Gulf of Mexico. Since the subsidence of the waters of the Champlain epoch, the cave has probably undergone comparatively few changes. The well one hundred and ninety-eight feet deep, at the further end of the cave, shows where a considerable volume of the excavatory waters found exit. The Mammoth Dome indicates probably, both a place of exit and a place of entrance from above. So of the vertical passages in various other portions of the cave.'

We believe that the views of Professor Winchell are in harmony with those of the other eminent geologists of the party, and when it is considered that the geologists of this excursion stand in the front rank of the most eminent scientific men of the world, their views upon this interesting subject are well worthy of attention. Before dismissing this branch of the subject, we will take occasion to correct a popular error concerning the formation of the beautiful structures that adorn the ceilings of some portions of the cave. In the drier localities, where the floors are dusty and everything indicates the prolonged absence of moisture, the ceiling is covered with a white efflorescence that displays itself in all manner of beautiful shapes. It requires no stretch of the imagination to discover among these, the perfect forms of many flowers. The lily form prevails, and the ceilings of many of the chambers are covered with this beautiful stucco work, surpassing in delicacy and purity the most beautiful workmanship of man. These are not produced, as many suppose, by the dripping of water, and the gradual deposit of sulphate of lime upon the outer portions. The stalactite is formed in this manner, but these are neither stalactiform, nor are they produced in a similar way. Dripping water is the agency that forms the stalactite, while the efflorescence in the dryer portions of the cave cannot take place where there is much moisture. The growth of these beautiful forms is from within, and the outer extremities are produced first. They are the result of a sweating process in the limestone that forces the delicate filaments of which they are composed through the pores upon the surface of the rock, their beautiful curved forms resulting from unequal pressure at the base, or friction in the apertures through which they are forced. Mr. L. S. Burbank, of Lowell, Mass., has kindly furnished us with the following abstract of his opinions upon this interesting subject.

'The rosettes, wreaths, and other curved fibrous forms of gypsum, in the Mammoth Cave, occur only in particular strata of the limestone which do not appear in the first part of the long route.

Their formation may be explained in this way: that portion of the rock where they are found consists of carbonate of lime, with some impurities, and contained originally the sulphide of iron, or iron pyrites, disseminated in small grains or crystals, and also in rounded nodules or concretions, sometimes of considerable size.

By exposure to air and moisture, oxygen unites with both the sulphur and the iron, producing sulphuric acid and oxide of iron, which combined, form a sulphate of iron. Then a double decomposition takes place; the sulphuric acid unites with the lime to form the gypsum; the carbonic acid of the limestone combines with the oxide of iron, forming a carbonate of iron, and this, on further exposure, parts with the carbonic acid, and leaves the brown coating of oxide, which is seen in many places on the surface of the rock.

The gypsum is thus constantly forming in the rock, and, being soluble, is carried by the water to the exposed surface where it crystallizes.

The crystals appear to grow out from the rock by additions from beneath, which continue to push the ends first formed, and if these do not become attached to other parts of the rock, straight needlelike fibres are often produced. Very commonly, however, the crystals begin to form when a small nodule of the iron ore is exposed at the surface; the parts first formed become attached to the surface around the edges, and as the chemical action proceeds towards the centre of the nodules successive leaf-like layers are thrown out, and the rosette form is the result. Along lines of fracture in the surface of the rock, the crystals are curved in opposite directions.

The wreaths and other figures formed by the chains of the rosettes, may be caused by the chemical action described taking place around the edges of large masses or concretions of the iron ore.

These crystalline forms occur only in the dryer parts of the cave. Where there is more moisture, as in the 'Snow-ball room,' the gypsum merely forms white, rounded concretions, originating from nodules of the iron ore on the roof and sides of the cave.'"

With these general remarks on the cave we give a brief account of its interesting fauna, comprising representatives of the Fishes, Insects, and Crustaceans. No Mollusks or Radiates have as yet been discovered, but the lower forms of life have been detected by Tellkampf, who collected several species belonging to the genera *Monas*, *Chilomonas*, and (?) *Chilodon*.

ON THE BLIND FISHES OF THE CAVE. BY F. W. PUTNAM.

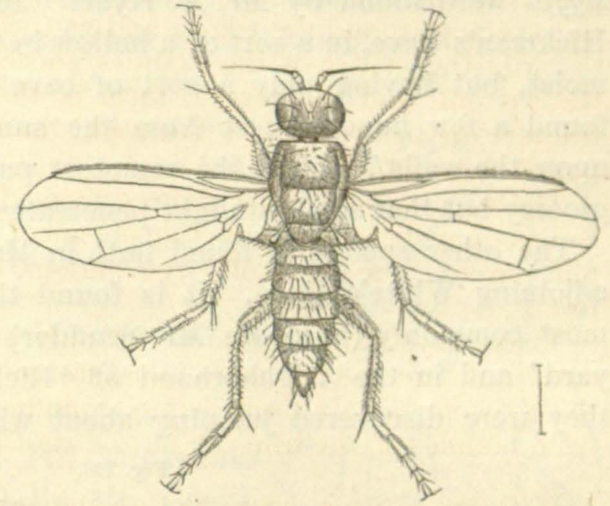
[This part of the article is unavoidably postponed till the January number, as it was found necessary to illustrate it with two steel plates which could not be engraved in time for the present number.]

ON THE CRUSTACEANS AND INSECTS. BY A. S. PACKARD, JR.

Representatives of all the grand divisions of the Insects and Crustaceans have been found in this cave, and if no worms have yet been detected, one or more species would undoubtedly reward a thorough search.

We will enumerate what have been found, beginning with the higher forms. No Hymenoptera (bees, wasps, and ants) or Lepidoptera (moths) are yet recorded as being peculiar to caves. The Diptera (flies) are represented by two species, one of Anthomyia (Fig. 122), or a closely allied genus, and the second belonging to the singular and interesting genus Phora (Fig. 123). The species of Anthomyia usually frequent flowers; the larvæ live in decaying vegetable matter, or, like the onion fly, attack healthy roots. It would be presumptuous in the writer to attempt to describe these orms without collections of species from the neighborhood of the cave, for though like all the rest of the insects they were found three or four miles from the mouth, yet they may be found to occur outside of its limits, as the eyes and the colors of the body are as bright as in other species.

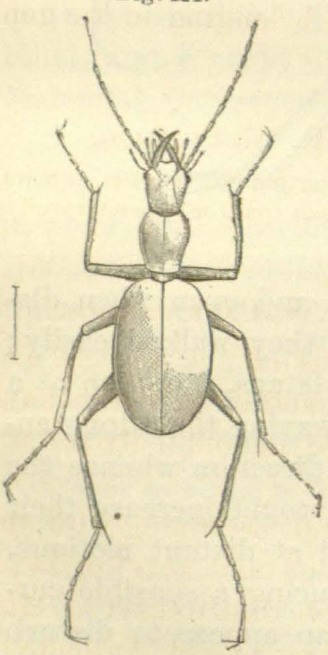
Fig. 122.



Anthomyia.

Among the beetles, two species were found by Mr. Cooke. The *Anopthalmus Tellkampfii* of Erichson, a Carabid (Fig. 124), and *Adelops hirtus* Tellkampf (Fig. 125) allied to Catops, one of the Silphidæ or burying beetle family. The Anopthalmus is of a pale reddish horn color, and is totally blind; * in the Adelops, which is greyish brown, there are two pale spots, which may be rudimentary eyes, as Tellkampf and Erichson suggest. No Hemiptera (bugs) have yet been found either in the caves of this country or Europe. Two wingless grasshoppers (sometimes called crickets) like the common species found under stones (*R. maculata* Harris), have been found in our caves; one is the *Raphidophora subterranea* (Fig. 126 nat. size) described by Mr. Scudder, and very abundant in Mammoth Cave. The other species is *R. stygia* Scudder, from Hickman's cave, near Hickman's landing,

Fig. 124.



Anophthalmus Tellkampfii

Fig. 123.

Phora.

Fig. 125.

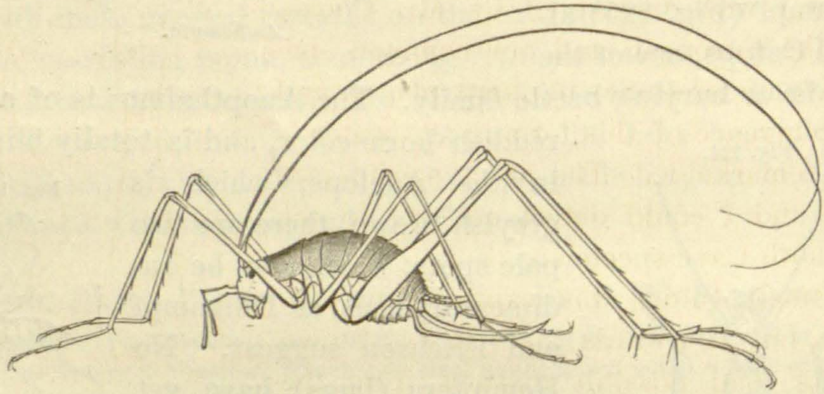
Adelops hirtus.

* In Erhardt's cave, Montgomery Co., Virginia, Prof. Cope found "four or five specimens of a new Anopthalmus, the *A. pusio* of Horn, at a distance of not more than three hundred feet from its mouth. The species is small, and all were found together under a stone. Their movements were slow, in considerable contrast to the activity of ordinary Carabidæ." Proc. Amer. Phil. Soc. 1869. p. 178.

upon the Kentucky river. It is closely allied to the Mammoth Cave species. According to Mr. Scudder, the specimens of *R. stygia* were found by Mr. A. Hyatt "in the remotest corner of Hickman's Cave, in a sort of a hollow in the rock, not particularly moist, but having only a sort of cave dampness. They were found a few hundred feet from the sunlight, living exclusively upon the walls." Even the remotest part of that cave is not so gloomy but that some sunlight penetrates it.

The other species is found both in Mammoth Cave, and in the adjoining White's Cave. It is found throughout the cave, and most commonly (to quote Mr. Scudder) "about 'Martha's Vineyard' and in the neighborhood of 'Richardson's Spring' where they were discovered jumping about with the greatest alacrity

Fig. 126.



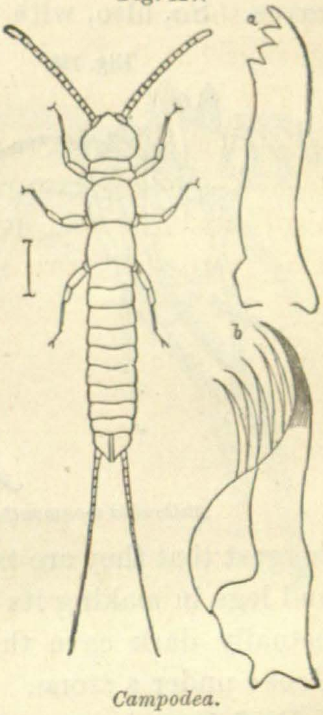
Rhaphidophora subterranea.

upon the walls, where only they are found, and even when disturbed, clinging to the ceiling, upon which they walked easily; they would leap away from approaching footsteps, but stop at a cessation of the noise, turning about and swaying their long antennæ in a most ludicrous manner, in the direction whence the disturbance had proceeded; the least noise would increase their tremulousness, while they were unconcerned at distant motions, unaccompanied by sound, even though producing a sensible current of air; neither did the light of the lamp appear to disturb them; their eyes, and those of the succeeding species (*R. stygia*) are perfectly formed throughout, and they could apparently see with ease, for they jump away from the slowly approaching hand, so as to necessitate rapidity of motion in seizing them."

The Thysanurous Neuroptera are represented by a species of Machilis, allied to our common *Machilis variabilis* Say, common in Kentucky and the middle and southern states. So far as Tellkampf's figure indicates, it is the same species apparently, as I have received numerous specimens of this widely distributed form from Lexington, Kentucky, collected by Dr. Josiah Curtis.

It was regarded as a crustacean by Tellkampf, and described under the name of *Triura cavernicola*.* He mistook the labial and maxillary palpi for feet and regarded the nine pairs of abdominal spines as feet. The allied species, *M. variabilis* Say, is figured in vol. v. pl. 1, fig. 8, 9 (see also p. 94 of this journal).

Fig. 127.



Campodea.

An interesting species of Campodea† of which the accompanying cut (Fig. 127) is a tolerable likeness, though designed to illustrate another species (*C. staphylinus* Westw.) was discovered by Mr. Cooke. Both the European and our common species live under stones in damp places, and the occurrence of this form in the water is quite remarkable. The other species are blind, and I could detect no eyes in the Mammoth Cave specimen.

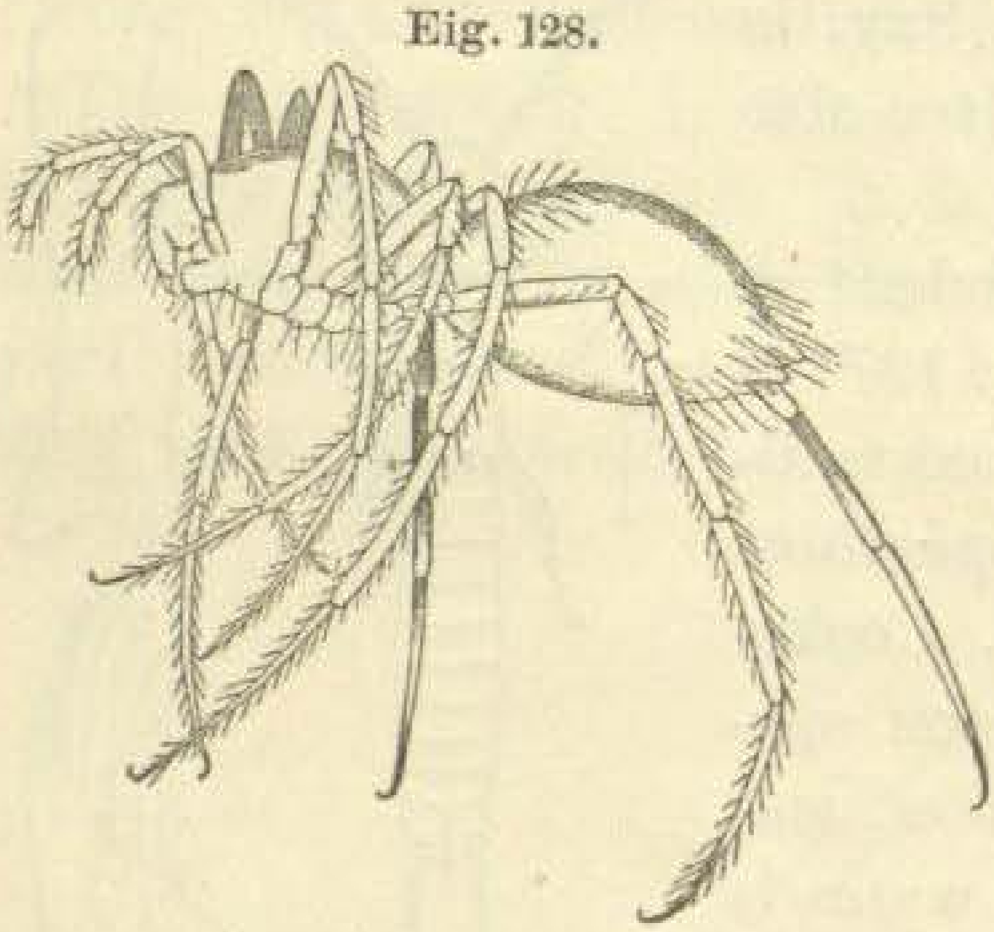
A small spider was captured by Mr. Cooke, but afterwards lost; it was brown in color, and possibly distinct from the *Anthrobia monmouthia* Tellkf. (Fig. 128) which is an eyeless form, white and very small, being but half a line in length. The family

* Professor Agassiz in his brief notice of the Mammoth Cave animals, does not criticise Tellkampf's reference of this animal to the crustacea; and so eminent an authority upon the articulates as Schiödte remarks that while "Dr. Tellkampf's account affords us no means of forming any conclusion as to its proximate relations," that, however, it "appears to belong to the order of Amphipoda, and to have a most remarkable structure." Tellkampf's figure of Machilis is entirely wrong in representing the labial and maxillary palpi as ending in claws, thus giving the creature a crustacean aspect; and indeed he describes them as true feet!

† *Campodea Cookei* n. sp. Closely allied to *C. Americana*, but it is much larger; the antennæ are 24-jointed instead of 20-jointed as in *C. Americana*, and reach to the basal abdominal segment, while in *C. Americana* they reach only to the second thoracic; the terminal joints are much longer than in that species, the penultimate joint being one-third longer. Last three abdominal segments unequal (equal in *C. Americana*) the penultimate very short, not half as long as the terminal, which is longer and slenderer than in *C. Americana*, while the three are much narrower in proportion to the rest of the body than in the other species. Hind femora longer than in *C. Americana*. Entirely white and pilose. Length .25 inch, the largest *C. Americana* being .15 to .20 inch. (Anal stylets broken off.) Several specimens were seen by Mr. C. Cooke, but only one was captured in a pool of water, two or three inches deep, in company with the Cæcidotea.

of Harvest men is represented by a small white form, described by Tellkampf under the name of *Phalangodes armata* (Fig. 129) but now called *Acanthocheir armata* Lucas. The body alone is but half a line long, the legs measuring two lines. It should be borne in mind that many of the spiders, as well as the Thysanura, live in holes and dark places, so that we would naturally find them in caves. So, also, with the Myriopods, of which a most remarkable form * (Figs. 130, and 130 *a* front of head) was found by Mr. Cooke, three or four miles from the mouth of the cave. It is the only truly hairy species known, an approach to it being found in *Pseudotremia Vudii* Cope. It is blind, the other species of this group which Professor Cope found living in caves having eyes. The long hairs arranged along the back, seem to suggest that they are tactile organs, and of more use to the Thousand legs in making its way about the nooks and crannies of a perpetually dark cave than eyes would be. It was found by Mr. Cooke under a stone.

Eig. 128.



Anthrobia monmouthia.

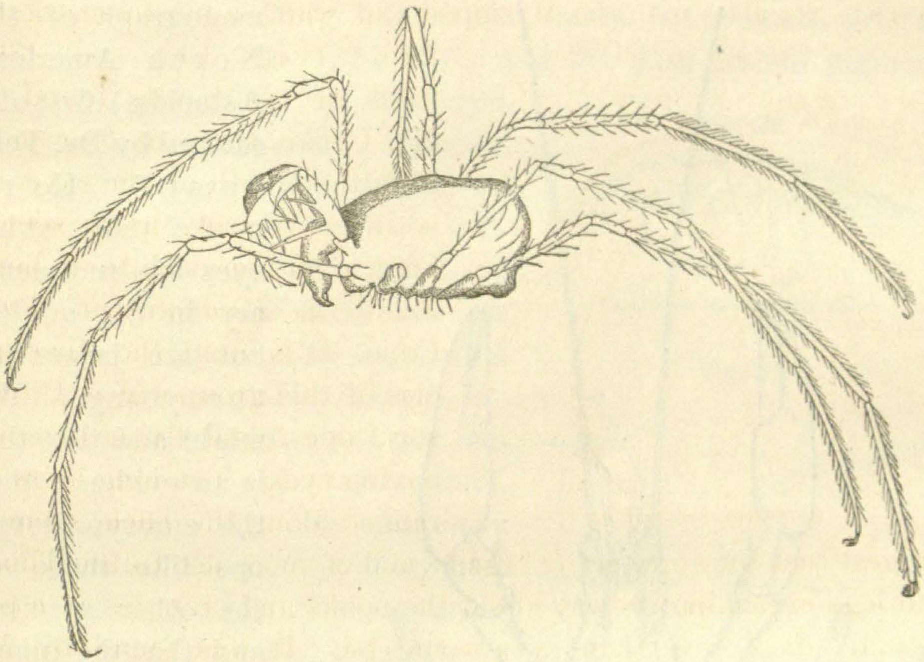
Prof. Cope has contributed to the "Proceedings of the American Philosophical Society" (1869, p. 171) an interesting account of the

* *Spirostrephon (Pseudotremia) Copei* n. sp. Head with rather short, dense hairs; no eyes, and no ocular depression behind the antennæ, the surface of the epicranium being well rounded to the antennal sockets; behind the insertion of the antennæ the sides of the head are much more swollen than in *S. lactarius*. Antennæ slender, with short thick hairs; relative length of joints, the 6th being longest; 6th, 4th, 5th, 3d, 8th, 7th, 1st, the 7th joint being much thicker than the 8th. Twenty-eight segments besides the head; they are entirely smooth, striated neither longitudinally nor transversely; a few of the anterior segments rapidly decrease in diameter towards the head. The segments are but slightly convex, and on each side is a shoulder, bearing three tubercles in a transverse row, each giving rise to a long stiff hair one-half to two-thirds as long as the segment is thick; these hairs stand up thickly all over the back, and may serve at once to distinguish the species. No pores. Feet long and slender, nearly as long as the antennæ, being very slender towards the claws. Entirely white. Length of body .35 inch; thickness .04 inch.

It is nearly allied to *Pseudotremia Vudii* of Cope. It will be noticed that Professor Cope characterizes the genus Spirostrephon as having "no pores"; though we find it difficult to reconcile this statement with that of Wood who describes *S. lactarius* as having "lateral pores." Cope separates Pseudotremia from Spirostrephon for the reason that the segments have "two pores on each side the median line." The present species has no pores, but seems in other characters to be a true Spirostrephon, and we are thus led to doubt whether Pseudotremia is a well founded genus.

cave mammals, articulates and shells of the middle states. He says that "myriopods are the only articulates which can be readily found in the remote regions of the caves [of West Virginia] and they are not very common in a living state." The *Pseudotremia cavernarum* which he describes, "inhabits the deep-

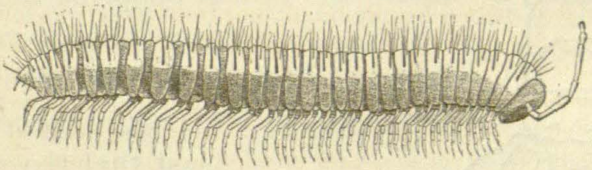
Fig. 129.

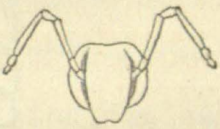


Acanthocheir armata.

est recesses of the numerous caves which abound in Southern Virginia, as far as human steps can penetrate. I have not seen it near their mouths, though its eyes are not undeveloped, or smaller than those of many living in the forest. Judging from its remains, which one finds under stones, it is an abundant species, though

Fig. 130. Fig. 130*a*.



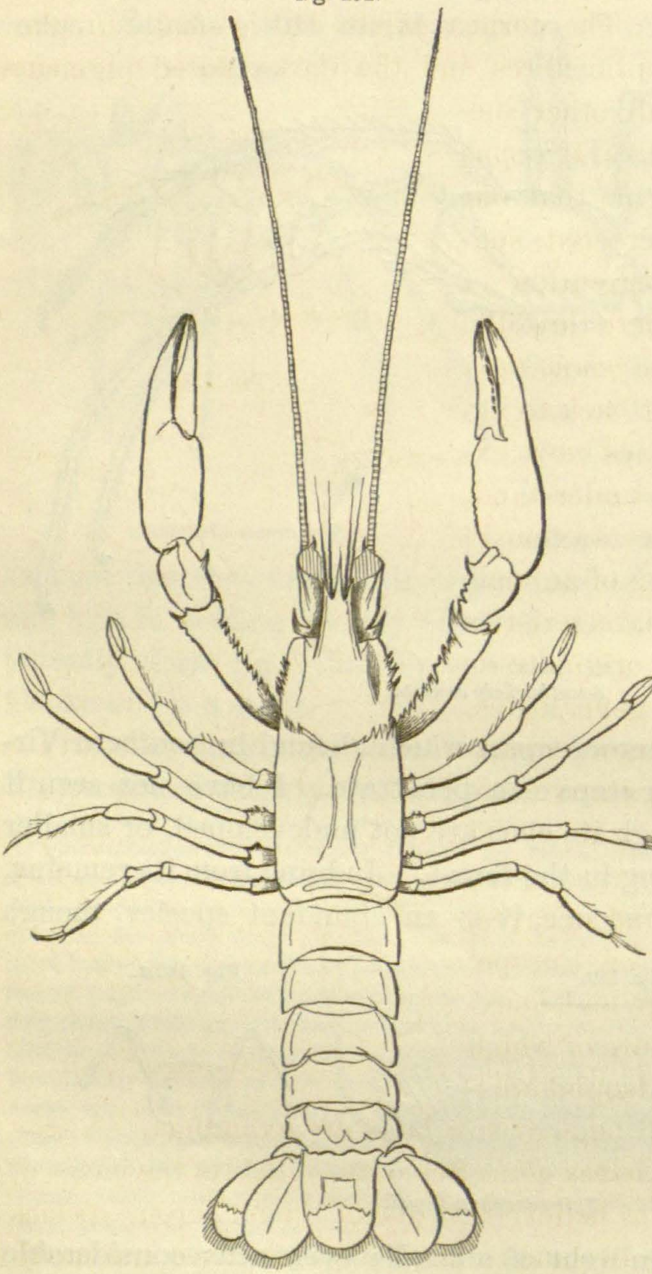


Spirostrephon Copei.

rarely seen by the dim light of a candle even after considerable search. Five specimens only were procured from about a dozen caves." The second species, *P. Vudii* Cope, was found in Montgomery Co. and he thinks it was not found in a cave. Professor Hyatt informs me that he saw near the "Bottomless Pit" in Mammoth Cave, a brownish centipede-like myriopod, over an inch in length, which moved off in a rapid zigzag motion. Unfortunately, he did not capture it.

Next to the blind fish, the blind crawfish attracts the attention of visitors to the cave. This is the *Cambarus pellucidus* (Fig. 131, from Hagen's monograph of the North American Astacidæ) first described by Dr. Tellkampf. He remarks that "the eyes are rudimentary in the adults, but are larger in the young." We might add that this is an evidence that the embryo develops like those of the other species; and that the inheritance of the blind condition is probably due to causes first acting on the adults and transmitted to their young, until the production of offspring that become blind becomes a habit. This is a partial proof at least that the characters separating the genera and species of animals are those inherited from adults, modified by their physical surroundings and adaptations to changing conditions of life, inducing certain alterations in parts which have been transmitted with more or

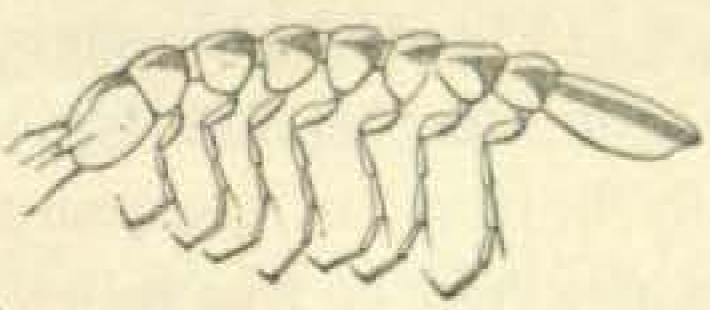
Fg. 131.



Cambarus pellucidus.

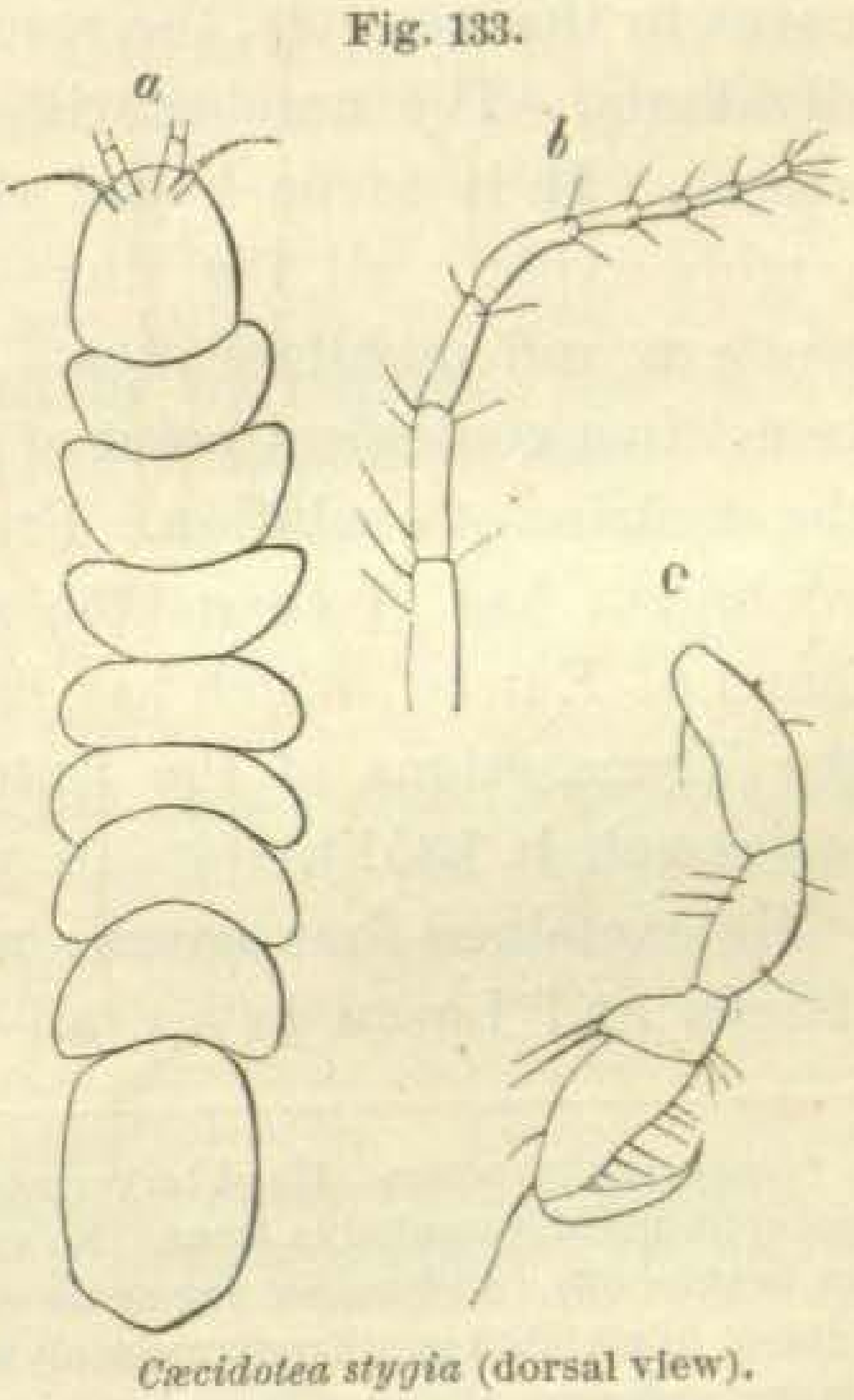
less rapidity, and become finally fixed and habitual. Prof. Hagen has seen a female of *Cambarus Bartonii* from Mammoth Cave, "with the eyes well developed," and a specimen was also found by Mr. Cooke. Prof. Hagen remarks that "*C. pellucidus* is the most aberrant species of the genus. The eyes are atrophied, smaller at the base, conical, instead of cylindrical and elongated, as in the other species. The cornea exists, but is small, circular, and not faceted; the optic fibres and the dark-colored pigments surrounding them in all other species are not developed." It seems difficult for one to imagine that our blind craw fish was created suddenly, without the intervention of secondary laws, for there are the eyes *more perfect in the young than the adult*, thus pointing back to ancestors unlike the species now existing. We can now understand, why embryologists are anxiously studying the embryology of animals to see what organs or characteristics are inherited, and what originate *de novo*, thus building up genealogies, and forming almost a new department of science: comparative embryology in its truest and widest sense.

Fig. 132.



Cæcidotea stygia (side view).

Fig. 133.



Cæcidotea stygia (dorsal view).

Of all the animals found in caves, either in this country or Europe, perhaps the most strange and unexpected is the little creature of which we now speak. It is an Isopod crustacean, of which the pill bugs or sow bugs are examples. A true species of pill bug (*Titanethes albus* Schiödte) inhabits the caves of Carniolia, and it is easy to believe that one of the numerous species of this group may have become isolated in these caves and modified into its present form. So also with the blind *Niphargus stygius* of Europe, allied to the fresh water Gammarus so abundant in pools of fresh water. We can also imagine how a species of Asellus, a fresh water Isopod, could represent the Idoteidæ in our caves, and one may yet be found; but how the present form became a cave dweller is difficult of explanation, as its nearest allies are certain species of Idotea which are all marine, with the exception of two species: *I. entomon*, living in the sea and also in the depths of the Swedish lakes, as discovered by Loven, the distinguished Swedish naturalist, while a species representing this has been detected by Dr. Stimpson at the bottom of Lake Michigan. Our cave dweller is nearly allied to Idotea, but differs in being blind, and in other particulars, and may be called *Cæcidotea stygia.** (Fig. 132 side view, enlarged; Fig. 133 dorsal view; *b*, inner antenna; *c*, 1st leg.) It was found creeping over the fine sandy bottom, in company with the Campodea, in a shallow pool of water four or five miles from the mouth of the cave.

This closes our list of known articulates from this and other caves in this country, the result of slight explorations by a few individuals. The number will be doubtless increased by future research. It is to be hoped that our western naturalists will thoroughly explore all the sinks and holes in the cave country of the western and middle states. The subject is one of the highest interest in a zoological point of view, and from the light it throws on the doctrine of evolution. Professor Schiödte, the eminent Danish zoologist, has given us the most extended account of the cave fauna of Europe, which has been translated from the Danish into the Transactions of the Entomological Society of London (new series vol. 1, 1851).

He examined four caves; namely, that of Adelsberg, the Magdalena and Luege caves, all in the neighborhood of Adelsberg,

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*Generic characters. Head large, much thicker than the body, and as long as broad; subcylindrical, rounded in front. No eyes. First antennæ slender, 8-jointed (2d antennæ broken off). Abdominal segments consolidated into one piece. Differs chiefly from Idotea, to which it is otherwise closely allied, by the 8-jointed (instead of 4-jointed) 1st (inner) antennæ, the very large head, and by the absence of any traces of the three basal segments of the abdomen usually present in Idotea.

Specific characters. Body smooth, pure white: tegument thin, the viscera appearing through. Head as wide as succeeding segment, and a little more than twice as long. Inner antennæ minute, slender, the four basal joints of nearly equal length, though the fourth is a little smaller than the basal three, remaining four joints much smaller than others, being one-half as thick and two-thirds as long as either of the four basal joints; ends of last four joints a little swollen, giving rise to two or three hairs; terminal joint ending in a more distinct knob, and bearing five hairs. Segment of thorax very distinct, sutures deeply incised; edges of segments pilose; abdomen flat above, rounded behind, with a very slight median projection; the entire pair of gills do not reach to the end of the abdomen, and the inner edges diverge posteriorly. Legs long and slender, 1st pair shorter, but no smaller than the second. Length .25 inch.

and the Corneale cave at Trieste. The only plant found was a sort of fungus, *Byssus fulvus* Linn. The only vertebrate is the singular salamander, *Hypochthon* (Proteus) *anguinus*, found in the Magdalina river. No shells were found. Regarding the articulates he writes:

"On searching along the walls within the entrance of the caves, among the rubbish and the vegetable debris along the sides of the river, we meet with a considerable number of Insecta, Myriopoda, Arachnida and Crustacea, of various families which shun daylight; being such species only as inhabit promiscuously other places, provided they are moist and feebly illumined. We find species of Pterostichus, Pristonychus, Amara, Quedius, Homalota, Omalium, Hister, Trichopteryx, Cryptophagus, Atomaria, Ptinus, Ceraphron, Belyta, a grasshopper of the Locust family, probably the *Raphidophora cavicola* Fischer, as it was only seen in the larva state, Trichoptera, Sciara, Psychoda, Phora, Heteromyza, Sapromyza, Tomocerus, Linyphia, Gamasus, Cryptops, Julus, and Asellus. In proportion as we recede from the entrance the number of species as well as individuals greatly decreases, and at the distance which entirely excludes the light, only single individuals are found. In the deepest recesses these species are entirely wanting, except some few which have been transported by the current; only a few Diptera are found; namely, a species of Phora, very near *P. maculata* Meig., *Heteromyza flavipes* Zett., and *Sapromyza chrysophthalma* Zett., extending also very far into the caves, even to the remotest accessible places in Adelsberg cave, more than half an hour's walk from its entrance. Dead moths are occasionally found far in the caves, being left there by the bats; and likewise accidental specimens of the parasites of the latter. Of the five earlier known animals which inhabit these caves, I found *Pristonycha elegans* Dej. rather frequently, and *Homalota spelæa* Er. in considerable numbers. Besides these are *Anopthalmus Schmidtii*, which is very rare, and the wood louse, *Titanethes alba*. The new forms he found were a beetle (*Bathyscia byssina*) allied to our Adelops;* *Stagobius troglodytes*, an aberrant genus of Silphids; a Podurid, *Anurophorus Stillicidii;* and the two blind arachnidans, one a spider allied to Dysdera, the *Stalita tænaria*, and a false-spider, *Blothrus spelæus*. Among the crustacea he found *Niphargus stygius*,†

* Ludwig Müller enumerates four other species of Adelops from these caves, and three species from France, and *Machærites spelæus*, in Verhandl. Zool. Bot. Vereins, Wien, 1855, p. 505. See also Heller's Beitrage zur österreich. Grotten-Fauna. (Myriopoda and Crustacea.) Vienna, 1858. He describes a myriopod with rudimentary eyes (*Trachysphæria Schmidtii*) allied to Glomeris, and another blind species (*Brachydesmus subterraneus*) allied to Polydesmus; also a new *Tithanethes* (*T. graniger*), and notices *Monolistra cœca* Gerst. Wankel (1861) also found a new Phalangid (*Leiobunum troglodytes*) with distinct eyes and four species of mites in the caves of Eastern Austria. The mites are *Scyphius spelæus*, *Linopodes subterraneus*, *Gamasus loricatus* and *G. niveus*, and an additional species of Trachysphæria (*T. Hyrtlii*). See also Ehrenberg's list of cave insects (Monabsberichte der Akad. Berlin. 1861.)

† Several species of Niphargus occur in the wells and hot springs in Europe. Accord-

allied to Gammarus, which lives in small pools of water and is white and blind; and the cave pill bug, *Titanethes albus* (Koch.)."

In conclusion Schiödte remarks that:—

"We may with propriety apply the collective term *Subterranean Fauna* to those animals which exclusively inhabit caves, and are expressly constructed for such habitations. Still there is nothing in this name which would indicate that these animals have any claim to be considered as a separate group, beyond the mere peculiarity of their common place of abode. While a few of them possess such an extraordinary structure as to stand in no comparison with those animals which inhabit the light, there are others, forming only more characteristic links in the groups of animals more or less shy of light, of which many are found common in the localities of the caves; and some belong to genera having a wide local, as well as geographical, extension. We are accordingly prevented from considering the entire phenomenon in any other light than something purely local, and the similarity which is exhibited in a few forms (Anophthalmus, Adelops, Bathyscia) between the Mammoth Cave and the caves in Carniola, otherwise than as a very plain expression of that analogy, which subsists generally between the fauna of Europe and of North America. Besides, it is clear to me that the fauna of the caves of Carniola consists of two divisions, of which the essential character is referable on the one hand to the dark locality, and on the other to the additional confinement to stalactitic formations; as yet we are not

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ing to Bate and Westwood (British Sessile eyed Crustacea) "the British examples have been obtained from artificially excavated wells connected with houses for domestic purposes. In some instances the wells have been old, in others but recently dug. In their geological condition the habitats have been equally various. At Corsham the well exists in the Oolite formation, at Ringwood in chalk-flint gravel, at Mannamead in slate. At Corsham and Mannamead they are found on a hill, at Ringwood they lie low. The appearance of some of these animals in a well soon after its being excavated, raises a question of considerable interest. Thus they were found at upper Clafford, near Andover and at Mannamead, near Plymouth, but not a trace of them was to be found in the surrounding streams; in fact they perish in the light. It is impossible to regard them as an extreme variety, or modification of our only fresh water Amphipod, *Gammarus fluviatilus*, since various parts not only differ in form, but some are altered in character; for example, the extraordinary elongation and slenderness of one of the branches of each of the last pair of caudal appendages seem to be a special structure, having for its object the antenna-like use of a delicate apparatus at the extremity of the body. . . . . Although we can find no fresh water ally to this genus in the rivers and streams of Europe, yet Bruzelius has taken in the deep sea, near Bohusia, a form which he has described under the name *Eriopis elongata*, approximating so nearly to it that it appears to be scarcely generically distinct.

We are inclined to think that *Gammarus pungens* of Milne Edwards, from the warm springs of Cassini in Italy, also belongs to this genus." Of Niphargus these are the following species known besides *N. stygius*; *i.e. N. aquilex* Schiödte (*Gammarus puteanus* Koch, the embryology of which has been studied by V. St. George) *N. fontanus* Bate, *N. Kochianus* Bate. Another generic form is *Crangonyx* founded by Bate, which also belongs to the subterranean fauna. "A single species as yet is all that has been found in England; but we have little doubt but that *Gammarus Ermanni* of Milne Edwards which was found by M. Ermann in the warm springs of Kamtschatka belongs also to this genus. It is curious that we should have to record that while the animals of this genus, as in the preceding (Niphargus) inhabit the deep artificial wells, without being known to exist in our rivers and streams, its nearest allied form is to be found in a marine genus, Gammarella."

able vigorously to discriminate between the two. We shall accordingly look upon the subterranean fauna, or more properly faunas, as small ramifications which have penetrated into the earth from the geographically-limited faunas of the adjacent regions; and which, as they extended themselves into darkness, have been accommodated to surrounding circumstances. Animals not far remote from the ordinary forms, prepare the transition from light to darkness. Next follow those that are constructed for twilight; and last of all those destined for total darkness, and whose structure is quite peculiar. Among these some are adapted for special localities, those which inhabit dry localities or detached little reservoirs being totally blind, while others, destined for running streams, have eyes of imperfect construction, so as to receive the impression of rays of light, but no proper image of illuminated objects. We may therefore with tolerable precision arrange the inhabitants of caverns under the following heads:—

Shade animals.—Extensive genera and species inhabiting caverns near their entrance, and, generally, all cool, shady and moist localities. Of these, those that fly occasionally enter far into the caverns (Diptera).

Twilight animals.—They belong to widely spread genera, but are peculiar to the caves, and distinguished by their small eyes. They are principally found near the entrances to the caves, but proceed deeper into, the darkness than the shade-animals, and although wingless, they penetrate often the whole extent of the dark space.—(*Pristonychus elegans*, *Homalota spelæa*.)

Cave animals.—They form, at least in part, peculiar genera, are wingless and colorless, as far as the consistency of their integuments will admit, and exist exclusively in total darkness. The terrestrial division is blind; the aquatic has a perception of light. To this group belong all the animals in the Mammoth Cave, and among those of the caves of Carniola, Anophthalmus, Bathyscia, perhaps likewise Anurophorus and Hypochthon, which, however, may belong to the following group.

Stalactite cave animals.—Insects, Arachnidans and Crustaceans appertaining to peculiar genera, wingless, blind, brightly colored according to the nature of their integuments, either light brown, yellowish white, or snow white, perhaps according to the preponderance of the chitine; living in total darkness, peculiar to stalactite caves, in part occupying the columns and constructed accordingly, either for ascent or hovering over them. Here belong most of the animals treated of in this memoir—Stagobius, Blothrus, Stalita, Niphargus, and Titanethes." *

A pertinent question arises as to the time of the formation of these caves and when they became inhabitable. As previously stat-

*In a note appended he adds to the list "a new cave crustacean, *Palomon anopthalmus* Kollar, said to serve as food for Hypochthon [the Salamander], of which last genus he discriminates six species."

ed, the caves of the western and middle States are in lower Carboniferous limestone rocks, though the Port Kennedy cave explored by Wheatley and Cope† is in the Potsdam limestone. They could not have been formed under water, but when the land was drained by large rivers. This could not have occurred previous to the Triassic period. Prof. Dana in his "Manual of Geology" shows that the Triassic continent spread westward from the Atlantic coast "to Kansas, and southward to Alabama; for through this great area there are no rocks more recent than the Palæozoic." "Through the Mesozoic period [comprising the Triassic, Jurassic, and Cretaceous periods] North America was in general dry land, and on the east it stood a large part of the time above its present level." Though at the close of these periods there was a general extinction of life, yet this was not probably a sudden (one of months and even years), but rather a secular extinction, and there may be plants and animals now living on dry land, which are the lineal descendants of mesozoic and more remotely of Carboniferous forms of life. So our cave animals may possibly be the survivors of Mesozoic forms of life, just as we find now living at great depths in the sea remnants of Cretaceous life. But from the recent explorations in the caves of Europe and this country, especially the Port Kennedy cave, with its remarkable assemblage of vertebrates and insects, we are led to believe from the array of facts presented by Prof. Cope that our true subterranean fauna probably does not date farther back than the beginning of the Quaternary, or Post pliocene, period. We quote his "general observations" in his article on the Port Kennedy fauna.

"The origin of the caves which so abound in the limestones of the Alleghany and Mississippi valley regions, is a subject of much interest. Their galleries measure many thousands of miles, and their number is legion. The writer has examined twenty-five, in more or less detail, in Virginia and Tennessee, and can add his testimony to the belief that they have been formed by currents of running water. They generally extend in a direction parallel to the strike of the strata, and have their greatest diameter in the direction of the dip. Their depth is determined in some measure by the softness of the stratum, whose removal has given them existence, but in thinly stratified or soft material, the roofs or large

†A notice of the animals found in this cave will be found in the Proceedings of the American Philosophical Society, April, 1871. The insects there enumerated would probably not come under the head of cave insects.

masses of rocks fall in, which interrupt the passage below. Caves, however, exist when the strata are horizontal. Their course is changed by joints or faults, into which the excavating waters have found their way.

That these caves were formed prior to the postpliocene fauna is evident from the fact that they contain its remains. That they were not in existence prior to the drift is probable, from the fact that they contain no remains of life of any earlier period so far as known, though in only two cases, in Virginia and Pennsylvania, have they been examined to the bottom. No agency is at hand to account for their excavation, comparable in potency and efficiency to the floods supposed to have marked the close of the glacial period, and which Prof. Dana ascribes to the Champlain epoch. An extraordinary number of rapidly flowing waters must have operated over a great part of the Southern States, some of them at an elevation of fifteen hundred feet and over (perhaps two thousand) above the present level of the sea. A cave in the Gap Mountain, on the Kanawha river, which I explored for three miles, has at least that elevation.

That a territory experiencing such conditions was suitable for the occupation of such a fauna as the deposits contained in these caves reveal, is not probable. The material in which the bones occur in the south is an impure limestone, being mixed with and colored by the red soil which covers the surface of the ground. It is rather soft but hardens on exposure to the air.

The question then remains so far unanswered as to whether a submergence occurred subsequent to the development of the postpliocene mammalian fauna. That some important change took place is rendered probable by the fact, that nearly all the neotropical types of the animals have been banished from our territory, and the greater part of the species of all types have become extinct. Two facts have come under my observation which indicate a subsequent submergence. A series of caves or portions of a single cave once existing on the southeast side of a range of low hills among the Alleghany mountains in Wythe Co., Virginia, was found to have been removed by denudation, fragments of the bottom deposit only remaining in fissures and concavities, separated by various intervals from each other. These fragments yielded the remains of twenty species of postpliocene mammalia.* This denudation can be ascribed to local causes, following a subsidence of uncertain extent. In a cave examined in Tennessee the ossiferous deposit was in part attached to the *roof* of the chamber. Identical fossils were taken from the floor. This might, however, be accounted for on local grounds. The islands of the eastern part of the West Indies appear to have been separated by submergence of larger areas, at the close of the period during which they

* See Proceed. Amer. Phil. Soc. 1869, 171.

were inhabited by postpliocene mammalia and shells. The caves of Anguilla include remains of twelve vertebrates,* of which seven are mammalia of extinct species, and several of them are of large size. These are associated with two recent species of molluscs *Turbo pica*, and a *Tudora* near *pupæformis*.† As these large animals no doubt required a more extended territory for their support than that represented by the small island Anguilla, there is every probability that the separation of these islands took place at a late period of time and probably subsequent to the spread of the postpliocene fauna over North America."

I think the reader will conclude from the facts Prof. Cope so clearly presents, that the subterranean fauna of this country does not date back of the Quaternary period. These species must have been created and taken up their abode in these caves (Mammoth Cave and those of Montgomery County, Virginia) after the breccia flooring their bottoms and containing the bones of Quaternary animals had been deposited; or else migrated from Tertiary caves farther south, which is not probable, as it has been previously shown that those blind animals inhabiting wells immediately die on being exposed to the light. (British Sessile-eyed Crustacea, i, p. 313.)

The case becomes much simpler when we consider the age of the rocks in which the Adelsberg and other caves mentioned by Schiödte are situated. The Alps were under water in the Middle Eocene; consequently the caves could not have been formed until the close of the Tertiary. Hence the species of the cave fauna were evidently created either at the close of the Tertiary, or more probably the beginning of the Quaternary, as "even in the later part of the Pliocene era there was an elevation of three thousand feet in a part of the Island of Sicily" (Dana). We are therefore led to conclude that the species of the subterranean fauna the world over are recent creations, probably not older than the extinct mammals associated with man.

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*Loc. cit. 1869, 183; 1870, 608. A fourth species of gigantic Chinchillid has been found by Dr. Rijgersma, which may be called *Loxomylus quadrans* Cope. It is represented by portions of jaws and teeth of three individuals. It is one of the largest species, equalling the *L. latidens*, and has several marked characters. Thus the roots of the molars are very short, and the triturating surface oblique to the shaft. The roots of the second and fourth are longer than those of the first and third. The last molar has four dental columns instead of three as in the other *Loxomyli*, and is triangular or quadrant-shaped in section; the third is quadrangular in section, and has three columns. The second is the smallest, being only .6 the length of the subtriangular, first. Length of dental series m. .063 or 2.5 inches. Palate narrow and deeply concave. There is but little or no lateral constriction in the outlines of the teeth; the shanks are entirely straight. In its additional dentinal column, this species approaches the genus *Amblyrhiza*.

The large Chinchillas of Anguilla are as follows, *Loxomylus longidens*, *L. latidens*, *L. quadrans*, and *Amblyrhiza inundata*.

†See Bland, Proceed. Amer. Phil. Soc., 1871, 58.

Assuming on the principles of evolution that the cave animals were derived from other species changed by migration from the outer world to the new and strange regions of total darkness, it seems evident that geologically speaking the species were *suddenly* formed, though the changes may not have been wrought until after several thousand generations. According to the doctrine of natural selection, by which animal species pass from one into another by a great number of minute variations, this time was not sufficient for the production of even a species, to say nothing of a genus. But the comparatively sudden creation of these cave animals affords, it seems to us, a very strong argument for the theory of Cope and Hyatt of creation by acceleration and retardation, which has been fully set forth in this journal. The strongly marked characters which separate these animals from their allies in the sunlight, are just those fitting them for their cave life and those which we would imagine would be the first to be acquired by them on being removed from their normal habitat.

On introducing the wingless locust, *Rhaphidophora maculata*, into a cave, where it must live not under stones, but by clinging to the walls, its legs would tend to grow longer, its antennæ and palpi would elongate and become more delicate organs of hearing as well as touch,* and the body would bleach partially out, as we find to be the case in *R. subterranea* and *stygia*. The Carabid beetle, Anopthalmus, extending farther into the cave, would lose its wings (all cave insects except the Diptera have no wings, elytra excepted) and eyes, but as nearly all the family are retiring in their habits, the species hiding under stones, its form would not undergo farther striking modification. So with the blind Campodea, which does not differ from its blind congeners, which live more or less in the twilight, except in its antennæ becoming longer. The blind Adelops, but with rudiments of eyes, does not greatly depart in habits from Catops, while on the other hand the remarkable Stagobius of the Illyrian caves, which according to

* After writing this article, and without knowledge of his views, we turned to Darwin's Origin of Species to learn what he had to say on the origin of cave animals. He attributes their loss of sight to disuse, and remarks:—"By the time an animal has reached, after numberless generations, the deepest recesses, disuse will on this view have more or less perfectly obliterated its eyes, and natural selection will often have effected other changes, such as an increase in the length of the antennæ or palpi, as a compensation for blindness." 5th Amer. Edit., p. 143. We are glad to find our views as to the increase in the length of the antennæ and palpi compensating for the loss of eyesight, c onfirmed by Mr. Darwin.

Schiödte spends its life in crawling ten to twenty feet above the floor over the columns formed by the stalactites, to which unique mode of life it is throughout perfectly adapted, is remarkably different from other Silphids. Its legs are very long and inserted far apart (the prothorax being remarkably long), with surprisingly long claws, while the antennæ, again, are of great length and densely clothed with hairs, making them most delicate sense organs.* So also are the limbs of the false scorpion, and the spider and pill bug (Titanethes) of remarkable length.

But the modifications in the body of the Spirostrephon are such that many might deem its aberrant characters as of generic importance. It loses its eyes, which its nearest allies in other, but smaller, caves possess, and instead gains in the delicate hairs on its back, which evidently form tactile organs of great delicacy; the feet are remarkably long, as also the antennæ. These are not new formations but simply modifications apparently, by use or disuse of organs present in the other species. The aberrant myriopod and Stagobius are paralleled by the blind fish, an animal so difficult to classify, and so evidently adapted for its abode in endless darkness. And as an additional proof of the view here taken that these cave animals are modified from more or less allied species existing outside of the caves, we have the case of the craw fish, whose eyes (like those of the mole), are larger in the young than adult, indicating its descent from a species endowed with the faculty of sight, while in the adult the appendages are modified as tactile organs so as to make up for its loss of eyesight, in order that it may still take its prey.

We thus see that these cave animals are modified in various ways, some being blind, others very hairy, others with long appendages. All are not modified in the same way in homologous organs; another argument in proof of their descent from ancestors

*Schiödte remarks that "it is difficult to understand the mode of life of *Stagobius troglodytes;* or how this slow and defenceless animal can escape being devoured by the rapid, piratical Arachnidans, or find adequate support on columns, for inhabiting which it is so manifestly constructed. We are led in this respect to consider the antennæ. Whatever significance we attach to those enigmatical organs, we must admit that they are organs of sense, in which view an animal having them so much developed as Stagobius, must possess a great advantage over its enemies, if these be only Arachnidans. Its cautious and slow progress, and its timid reconnoitring demeanor, fully indicate that it is conscious of life being in perpetual danger, and that it endeavors to the utmost to avoid that danger. Darkness, which always favors the pursued more than the pursuer, comes to its aid, especially on the uneven excavated surface of the columns."

whose habits varied as their out-of-door allies do at present. Had they been specially created for subterranean life, we should have expected a much greater uniformity in the organs adapting them to a cave life than we actually find to be the case.

Another fact of interest in this connection is the circumstance that these cave species breed slowly, being remarkably poor in individuals; they are nearly all extremely rare. Did they breed as numerously as their allies in the outer world the whole race would probably starve, as the supply of food even for those which do live is wonderfully limited.

It is now known that animals inhabiting the abysses of the sea are often highly colored: light must penetrate there, for we know that were the darkness total they would be colorless like the cave insects.

In view of the many important questions which arise in relation to cave animals, and which have been too imperfectly discussed here, we trust naturalists the world over will be led to explore caves with new zeal, and record their discoveries with minuteness, and the greatest possible regard to exactness. The caves of the West Indian Islands should first of all be carefully explored. Also those of Brazil, those of the East Indies, and of Africa, while fresh and most extended explorations of our own Mammoth Cave should be made, perhaps by a commission acting under government or State authority, in order that the most ample facilities may be afforded by the parties owning the cave.

A SINGING HESPEROMYS.

BY REV. SAMUEL LOCKWOOD, PH. D.

Some twenty years ago, it was, that the "London Charivari" shot its shafts of ridicule at a singing mouse on exhibition in the metropolis. Thus put upon the scent, the firm of Pooh, Pshaw & Co., whose merciless power is alike feared by philosopher and peasant, "went for" the showman and his "phenomenon."

And so hard was the *punch*-ing,
And such was the fuss,
That it quite put an end
To that musical *mus!*