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BIOLOGY OF THE SHAWNEE CAVE SPIDERS.

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General Introduction.

From September 7, 1908, to September 7, 1909, the author held the Speleological Fellowship in Indiana University with residence at the University's Cave Farm three miles east of Mitchell, Ind. The present paper embodies the results of the observations during this time on the habits of spiders in caves and in the laboratory.

The work has been carried on under the direction of Dr. C. H. Eigenmann, professor of zoölogy in Indiana University, to whom I am indebted for suggestions and the loan of his cave literature. I wish to express my thanks to Dr. Charles Zeleny, associate professor of zoölogy, for many helpful suggestions. I am indebted to Dr. Alexander Petrunkevitch for the identification of the specimens; to Dr. A. M. Banta, for the loan of his entire collection of cave spiders, and to Mr. Will Scott, for part of the map of this series of caves. He surveyed and mapped the cave from "1" to "37" or the Upper Dalton (see map, page 321) in the autumn of 1907; the author assisted by Mr. Frank Green surveyed and mapped the Upper Dalton from "37" to "64" in October, 1908.

Previous Work.

Published observations on the habits of cave spiders are limited to a few scattered papers which give lists of species and localities.[1] The best studies published are those of Packard[2] and Banta.[3]

[1]Banks ('06) and Blatchley ('96) give lists of Arachnids from Indiana Caves.

[2]*Mem. Nat. Acad. Sci.*, IV., 1888.

[3]"Fauna of Mayfield's Cave," 1907.

THE SPECIES STUDIED.

Two species of spiders permanently live in the Mitchell caves. One, *Troglohyphantes* (*Willibalda*) *cavernicola* Keyserling, a linyphid[1] is a true cave form; the other, *Meta menardi* Latreille, is an epeiridid and also lives outside of caves. According to Emerton (1902, 190–) the latter arachnid "lives in caves and similar cool and shady places in various parts of this country and also in Europe."

Banta (1907, 65) reports *Erigone infernalis* Key. from the Twin Cave at Mitchell, Ind. I have been unable to find it here, but have taken it in Mayfield's Cave at Bloomington, Ind.

Troglohyphantes has been observed in detail in order to get as far as possible the life history of a typical cave spider. The distribution, food and results of the experiments of *Meta* are given in order to show how an outside form is able to adapt itself to a subterranean life. All notes unless otherwise stated refer to *Troglohyphantes.* The numbers in quotation marks refer to localities in the caves (see maps, pages 321 and 323).

In *Troglohyphantes* there are all degrees of differences in coloration, and in the degeneration of the eyes. The abdomen varies in color from black, dark brown, light to white. The cephalothorax varies from dark, pinkish, light to a white color. The most common combination of colors is a light brown abdomen with a pinkish cephalothorax. The adult females range in length (cephalothorax and abdomen) from 2.4 mm. to 3.7 mm., while the adult males vary from 2.2 mm. to 3 mm.

In the adults the eyes range from eight in number, each with a maximum size of 0.036 mm. in diameter to no external signs of eyes. I have not seen Keyserling's description, but from his figure, which Packard[2] has copied, the eyes are small, and the front middle ones extremely minute.

PHYSICAL ENVIRONMENT.

These spiders are found only in total darkness, where the atmosphere is saturated, and in places suitable for the construction of snares. They are never found where the walls are perpendicular with water covering the entire floor; nor are they

[1]Banks, '06, classification.

[2]1888, Plate XV., Fig. 32.

found where the walls and floor are dry. Distance from the entrance does not necessarily limit the distribution if the three necessary conditions are present, nor does scarcity of food limit their distribution to a very great degree.

At "2" a few were collected last fall but none has been found since. This is 200 feet from the entrance in total darkness. At "9" a few more than at "2" have been found; at "10" a great many have been taken and "13" was my best collecting ground. This place is 600 feet from the mouth. On several occasions I have gathered two or three dozen individuals here and such wholesale collecting at one place seemed at the time to exhaust the supply, but a month after such a collection had been made, I have been able to duplicate this record. Many have been collected at "14" and at "19." The latter locality is the "Big Room," 1,700 feet from the entrance. Three were seen at "23" and only a few were observed in a branch at "31." This latter place is in total darkness 200 feet from the mouth of the Lower Twin Cave at "32." Not one has been observed between "33" and "36." A few have been collected in a branch at "38" in the Upper Dalton. This location is in total darkness 150 feet from the entrance. A number were taken from branches at "46" which is 1,024 feet from the entrance. This locality was my second best collecting ground, particularly for the cocoons. A few were taken at "50." One was caught in the "Big Room" at "57" and several snares were seen. At "63" almost a mile from the entrance of Upper Dalton, three were observed and several webs were among the rocks at a "cave-in."

Troglohyphantes is also quite abundant in Hamer's Cave one half mile west of these caves. None was found nearer than 300 feet from the entrance.

This archnid shares as wide a distribution as the blind beetle, *Anophthalmus tenus* Horn (Blatchley, '96). It far outnumbers the latter in individuals, but is less evenly distributed. By actual count there are twice as many females as males in all the collections made from the various caves.

Meta is found both in twilight and total darkness. In the Shawnee Cave they are quite abundant from the entrance at "1" to "4." The latter place is over 200 feet from the entrance in total darkness. Several were seen at "6," 100 feet from the mouth. An adult male was observed on the roof at "14"; nine days later, it was seen under a rock on the floor and had constructed a snare. One immature specimen was seen in a branch at "23." At "30," 200 feet from the entrance of Lower Twin, a few live, and at "32" and "33" they are quite numerous.

May 17, I collected eighteen *Metas* and placed them on the north wall by a large pile of rocks at "19" in the "Big Room." August 3, I saw six of them. They had scattered along the wall about 50 feet and among the rock pile. Each had built an orb-web and remains of small diptera were seen in the snares. August 17, after a brief search I saw only three of the eighteen. This absence does not mean that they had died, but that it was impossible to find them.

Locomotion.

This arachnid is very agile and is a good runner. Its long legs and slender body enable it to move from place to place, and to avoid an obstacle with much ease. When not irritated it moves along slowly and gently. When stimulated mechanically, it gives a quick jump, runs and dodges whatever obstacle may be in its way. However, it runs only a few inches and if stimulated a second or third time often drops in an instant and hangs to its web. Sometimes it climbs the web to the place from which it dropped, at other times it lets itself down to the floor and then runs off.

Several were placed on the roof among beads of water and other small obstacles. A pencil was used to stimulate and guide them so that they were obliged to run up against the obstacles. They use the first pair of legs as feelers. These are kept well in advance of the other legs and head so that they can detect an object in front of them the length of the body. While walking or running slowly, they are able to dodge an object every time. If caused to run swiftly, they run against the object, or if the object be a low bead of water, they run over it and pass on.

Webs and Snare.

This spider usually spins a web wherever it goes. It is impossible to see a single thread in the cave with a carbide bicycle lamp unless the thread is coated with water. Quite often on the roof in a slit between two strata of rocks, or in crevices in the walls are found collections of webs which are generally coated with water. These webs do not seem to be of any service to the spider after once spun. They, however, show how it wanders from place to place. It makes a flat sheet-like snare under which it lives. The snare is slightly curved downward and may lie in such a position as to form any angle between 0° and 90° with the floor. The threads are fine and the snare so transparent that it is difficult to see unless it is coated with water. The meshes are so minute that the snare turns water. The snare is supported by many fine threads from the sides, the length of these vary according to the surroundings. When insects fly into the snare they are taken through it by the spider which is on the under side.

Snares are most abundant in the older parts of the caves where the passages are blocked up with clay. At such places the clay banks are more or less perpendicular and the water has washed out many small crevices. Sometimes large blocks of clay tumble down into a heap. Among these heaps of clay blocks and in such crevices as the above the snares are very numerous. In a crevice five inches wide I once saw three snares built one above the other not more than three inches apart. All three were parallel with the floor.

In several places snares are quite conspicuous in the angle between the floor and wall. In such positions the spiders have better routes for travel from one snare to another than in the clay banks.

The third place where snares are found is among the rocks at "cave-ins." The rough cornered rocks appear to form good places for attachment and quite frequently dripping water is present which this species apparently enjoys.

Food.

While in captivity I have fed them small gnats, small flies and the spiderlings of *Meta*.

In the caves the following observations were made: At "13" while watching a male who was trying to court a female I saw a white-winged dipteron fly into the snare. In an instant the female seized the insect, then ran back to the male. The latter then ran to the other side of the snare. In a few minutes another white-winged dipteron flew into the snare near the male, and he lost no time in seizing it. Several other times these diptera flew against the snare but failed to be entangled in its meshes. In each case the spiders made a dash for the would-be victim while holding one insect in their mandibles. At an earlier date a spider at this same place was seen eating a white-winged dipteron. On various dates at "14" one was caught eating a myriopod; one, a small gnat; and several were caught under an old turtle's shell with thysanurans.[1] At "19" two or three were observed in a mouse trap with some cheese. At "40" one was caught under an old piece of meat with a small white thysanuran in its mandibles. At "43" one was eating a white-winged dipteron, this spider was running on the wall. At "50" one was seen in its snare eating a small myriopod.

This spider is usually very peaceful. Neither in the caves nor in captivity have I ever seen them to show the least signs of pugnacity when they came in contact with each other. Nevertheless it appears certain that they at times eat each other. A few times their remains have been found in the snares. A few remains were observed in the glass cases in which they were sometimes kept in the laboratory. Quite a number of times remains were found in the collecting vials the next morning when three or four were left in the same vial over night.

When bits of dirt were thrown into the snares, the spiders ran away quickly. Blind beetles were caught and tossed into the snares. At the instant when the beetles struck the snare, the spiders ran and with a jump seized the victim. Neither the web, nor spider, nor both together were strong enough to hold the beetle. Large flies were also thrown into the snare with the same results. The spiders always seized their prey and held on tenaciously until the last second. Small flies and mosquitoes were likewise tossed into the snares. In each case the spider made a quick run and with a jump seized the victims and held

[1]Here as elsewhere used in broad sense to include both *Thysanura* and *Collembola*.

on so firmly that both prey and spider were torn loose from the web by picking the prey up with forceps.

Not one specimen has even been seen drinking water. Since they always live in a saturated atmosphere all the water required is probably absorbed through the skin.

In captivity I have fed *Meta* flies, mosquitoes, gnats and various species of other arachnids smaller than themselves. When two or more of them are placed in the same case the largest invariably devours all the others in a short time.

In the caves *Metas* have been observed at various localities eating gnats, mosquitoes, flies and cave crickets. One was seen eating a small moth and another an old dried myriopod.

Enemies.

As far as my observations go, these spiders have no enemies besides themselves. It is very seldom that one can find the remains of a specimen in the webs and as mentioned above no case of fighting has ever been witnessed. At "63" almost a mile from the entrance the only other insect found was the blind beetle. Doubtless carefully repeated observations at this locality will prove that other insects are also present.

Temperature.

During the last three years a series of temperature records[1] have been taken at "19," or in the "Big Room." For 1907 the temperature is as follows: 11.5° C. for January, February, March, April and May; June 11.7°; July 11.9°; August and September 12.7°; October 12.2°; November 11.9°; and December 11.7°. Since food is more abundant and the three necessary physical conditions are evidently suitable at "2," "9" and "38," we can probably attribute the small number of specimens to the uneven temperature. Again, since food is extremely scarce a half mile from the entrance while the number of specimens is few, perhaps the small number of spiders is due to the scarcity of food. Midway between these two localities food is comparatively plentiful, the temperature is practically even throughout the year, and this combination is probably responsible for the great number of individuals.

[1]Eigenmann, '09.

Specimens have been kept in captivity in the laboratory throughout the year. In cold weather they are less active than in warm and are very fretful when the vials become too warm, and often die.

Courtship.[1]

November 16 two were seen copulating. In order to see them I got too close and my breath irritated the web. This caused them to separate. After an absence of five minutes I returned and found them together again. A second time they were disturbed. Returning after an absence of fifteen minutes, they were found close together. While copulating, they were lying one under the other with anterior and posterior ends reversed and with the ventral parts of their cephalothorax in contact. November 19, a pair was seen pairing. December 17, two were observed copulating, these were both under the snare, and the anterior and posterior ends of the cephalothorax were reversed. The dorsal surface of the cephalothorax of the male was pressed against the corresponding ventral part of the female. The male placed his palp on the epigynum once, this lasted only a few seconds, then they parted. December 14 and 22, two couples were seen copulating. Those on the latter date were first seen at 2:25 P.M. and then disturbed by breath. At 2:27 they were together again after the male had circled once around the female. This pair was on top of the horizontal snare all the time. The male used his palps alternatively three times in three minutes, each time lasted only a few seconds. They were disturbed at 2:30. January 4, two were observed copulating June 7, a male was seen courting a female. Both were under the snare within one and one-half inches of each other. They were first seen at 3:45 P.M. When the male tried to advance toward the female, she caused him to keep his distance, the result of which caused the male to circle completely around her clockwise in six minutes. Most of the time she kept the posterior end of her abdomen toward him, while he had his head facing her all the time. At 4:00 I left them and a half hour later upon my return they were still in the same position. They were placed in a vial, taken to the house and were put in a case. In this

[1] McCook, '93, describes only courtship of outside forms.

case they lived two weeks where they died. This pair like all others when in captivity had no inclination to mate.

Cocoons and Eggs.[1]

One cocoon was made in a glass case October 4. It contained six eggs. Another was made in a case December 11. January 21, one with five eggs was constructed in a vial. Other cocoons were made in vials on the following dates: April 28; May 5, 8, 22, 27 and 31; June 3, 25 and 28; July 8 and 27; August 6, 19 and 21.

On the following dates cocoons with eggs were collected in the caves: October 8, one with two eggs; one with eight eggs, January 20; January 26, one containing eight newly hatched spiders and one with seven eggs; another with seven eggs March 2; March 16, two cocoons, one with eggs and the other with newly hatched; May 24, one with four eggs; July 2, one with four eggs; July 19, at various localities collected seven cocoons, one of which contained eight eggs, and two others each held four young, at various localities in Upper Dalton August 22 collected seven cocoons. Some of these contained young just hatched, and others young ready to leave the cocoons.

The cocoons in the caves are usually constructed in secluded places and are difficult to find unless one examines every little crevice and looks under the ledges of rocks very carefully. Sometimes they are found attached to the underside of rocks lying on the floor, but more often under little ledges of rocks and in the acute angles of small crevices.

In color they are snow white and are disc-like in shape. The flat part of the disc is fastened firmly to the rocks. The average size is 6 mm. in diameter by 3 mm. in depth, although sometimes a cocoon containing the minimum number of eggs is as large as one containing the maximum number. I have never been fortunate enough to witness a female making her cocoon, but on examination, a coocon is composed of a more or less firm and closely woven circular base. The eggs are piled into a heap in the middle of this base and then the convex part is spun over them in such a crude and unsubstantial way that one can generally count the eggs through this covering. In detaching the

[1] Montgomery, '06, describes the cocoons and eggs of an allied outside form.

cocoon from the rock one must use precaution for fear the eggs fall through the covering.

In number the eggs vary from two to eight with five for an average cocoon. They are transparent whitish in color and are perfect spheres with an average diameter of 0.6 mm. During the embryological stages, they soon take on a yellowish color, become oblong in shape, and the outline of the embryos is discernible through the covering. Some of these embryos assume the shape of the profile of a man's head.

Young.

When hatched they remain for an indefinite period inside the cocoon and when strong enough emerge through a small circular hole.

March 22, three of the seven eggs in a cocoon collected March 2, hatched; April 3, two of these spiderlings were dead, they with the remaining eggs were covered with mold. June 4, two of the four eggs in a cocoon collected May 24, were hatched, one spiderling was dead and the other alive on this date. Neither one had any eyes. July 29, a cocoon collected July 19, was examined and contained three young. Each one was examined both alive and dead. All eyes, except the anterior middle ones, were discernible. Female no. 139 made a cocoon and laid four eggs May 5. On May 23 all four eggs were hatched, but the young were still inside the cocoon. Each spiderling had all eight eyes except the anterior middle ones. The eyes had a uniform diameter of 0.018 mm. While alive under the microscope their little eyes shone like small electric lights. Their mother had no signs of external eyes. Many other newly hatched spiderlings were observed both alive and dead. The anterior middle eyes are never discernible. In some, the other six eyes are present and in others no eyes can be seen. All the other eggs laid in the laboratory failed to hatch. Perhaps this was due to uneven temperature.

The young are much thicker-set than the old. The legs are thick and stubby. The cephalothorax and legs are transparent whitish while the abdomen is light cream in color. The latter has a few longitudinal rows of hairs. The length varies from 0.6 to 0.8 mm.

Moulting.

While in captivity seven individuals moulted, three of which were found dead shortly after the skins were cast off. The deaths were probably partially due to an excess of water in the vials for immediately after the old skins were shed the spiders lay lifeless in the water. The skins were suspended by threads to the upper side of the vials. The moults show that the skin splits on each side of the cephalothorax at the dorsal side of where the legs are attached. Hence, the moulted skin of legs and mouth parts adhere to the ventral half of the moult, and the corneal cuticle belongs to the dorsal half. All the old hairs are shed along with the skin, new ones take the place of the old which causes the color to be perceptibly brighter. The moulted skins of the abdomen were either missing or rolled up into little wads so that one could not tell precisely how they were cast off.

Mortality.

In the caves one never finds dead specimens. In captivity mortality is not great. The most important requirement is to place them in a saturated atmosphere as soon as caught. Two thirds of the specimens were found dead in the collecting vials the following morning when left in the vials without a drop of water over night. It is impossible to keep them long in anything not air-tight, however careful one is to keep them supplied with water. The best device is small vials with air-tight cork stoppers. In such vials they may be kept for months without food. One caught September 10 was placed in a small vial containing two drops of water. On January 20 more water was added which almost drowned the specimen. On January 26 it died. During all this time it had had nothing to eat. Another individual was placed in a small vial January 7, and died April 19, due to lack of moisture or food.

In captivity they quite often die soon after moulting. In vials sunshine kills them in a few minutes. The heat from a student's lamp is also fatal.

Light Experiments.

In the caves one may throw the light from a carbide bicycle lamp on *Troglohyphantes* for a half hour or more without producing any effect. Such is not true with *Meta*. Just as soon as the light strikes their eyes, they run into the dark. If the light is repeatedly thrown on their eyes, they may be turned in any direction and often can be driven into places where the light cannot reach them.

The following apparatus was used in the laboratory: For the adult *Metas*, slender 10-inch bottles; for the medium sized *Metas*, 6-inch test-tubes; for the spiderlings of *Meta* and for *Troglohyphantes*, small 5-inch vials. The closed end and the lower half of each vessel were covered with black carbon paper. The open ends were securely closed with air-tight cork stoppers. One specimen with one or two drops of water were placed in each vessel. In a very short time the water forms a thin film of moisture all over the inner surface of the vessel. This saturated the air in both ends equally. The vessels were then placed on an inclined rack by a south window in order to give each an equal amount of light. Occasionally they were rotated so that the light always fell directly upon the spiders' eyes. At various times the carbon paper was transferred to the cork end, thus throwing the specimen into the light or dark as the case may be. Those that were strongly negatively phototropic never lost much time in finding the dark end, regardless of the number of times the carbon paper was changed. Such individuals often pass into the dark in three minutes. The few that were strongly positively phototropic always changed from the dark end to the light end whenever they were thrown into the dark. Some were thus experimented with for thirty days, but experience taught that their actions were reliable for only the first four or five days. Darkness and cloudy weather had much to do with the final results. Time was counted from the period when first placed in the vessel, and each morning when first observed until 6:00 P.M. each day for four consecutive days. When first placed in the vessels and for a short time after the carbon paper was transferred, they were noticed every few minutes, after that irregularly five times every day.

The adult *Metas* were always in the dark end during clear and cloudy weather, and always in the light end when it was dark. The medium sized *Metas* were always found in the dark end in clear weather, one half the time in the dark end during cloudy weather, and usually in the light end when dark. The spiderlings of *Meta* remained in the dark end one half the time in clear weather, one third the time in the dark end during cloudy weather and most of the time in the light end when dark.

All eight eyes in the *Metas* were present and presumably well developed. The anterior middle ones were generally a little smaller than the others and occasionally an eye was found among the others which was about one half size. In all these experiments forty *Metas* were used.

The following table gives the results of the light experiments for *Troglohyphantes*. On the left is entered the number of the specimen, the locality, the sex, age (whether mature or immature) and the four sets of eyes, AME stands for anterior middle eyes, PME for posterior middle eyes, ASE for anterior side eyes, and PSE for posterior side eyes. All measurements were made with a micrometer slide inside the two inch ocular with two thirds or low objective. When the eyes were scarcely discernible the one-inch ocular was substituted for the two-inch. As a unit of measurement for the eyes one fifty-fifth of a millimeter (0.018 mm.) is employed. The fractional parts of this unit are only approximate. The +'s are used when the eyes are joined together, if separate −'s are employed. P stands for pigment speck. The remainder is self-explanatory.

The thirty examples included in the table were selected, not on a phototropic basis, but to represent the various localities, the age, size, degeneration of the eyes, and coloration. If another table were made from the specimens not included in this one, the results would be similar. If a correction could be made for cloudy weather and for the time occupied in going into the dark, the total per cent. of 49 for those in the dark column would be considerably larger than the total per cent. of 51 for those in the light column. In all these experiments 225 specimens have been used and I am positively certain that the results as given in the table are correct.

Summarizing the following table and other data not included therein we have the following statements:

Twenty-six per cent. of all the individuals examined had no

LIGHT EXPERIMENTS FOR TROGLOHYPHANTES CAVERNICOLA KEY.

No.	Loc.	Sex.	Age.	Size.	AME.	PME.	ASE.	P.S.E.	Color Abd.	Color Ceph.	Light, Hrs. and Min.	Dark, Hrs. and Min.	Light, Per Cent.	Dark, Per Cent.
397	9	♂	Im.	2.2	.5+.5	.7—.7	.7—.7	.7—.7	light	pink	11.40	24.45	38	62
712	9	♀	Mat.	2.8	.5—.5	1—.5	1—1	1.5—1.5	brown	"	15.20	21.05	42	58
322	10	?	Im.	1.0	0—0	0—0	0—0	0—0	light	light	10.00	25.15	28	72
324	10	♂	"	2.5	.5+.5	1—1	0—0	0—0	"	pink	15.15	20.00	43	57
327	10	♀	Mat.	2.6	0—0	0—0	0—0	0—0	brown	"	13.00	22.15	37	63
714	10	♀	Im.	2.7	.5+.5	1—1	1—1	1—1	"	light	8.25	28.00	23	77
325	13	♀	Mat.	2.8	1—1	2—2	1.5—1.5	1—1	"	pink	30.15	5.00	85	15
326	13	♀	"	2.5	1+1	2—2	1—1	1—1	light	"	18.00	17.15	51	49
399	13	♀	"	2.8	.5+.5	.5—.7	1—1	1—1	"	"	17.55	18.30	45	55
705	14	♂	"	2.7	.7+.7	1—1	1—1	1—1	"	"	23.10	13.15	63	37
747	14	♀	Im.	2.0	0—0	2—2	2—2	2—2	"	"	2.45	33.35	8	92
729	14	♂	Mat.	2.8	.7—.7	1—1	1—1	1.5—1.5	"	"	22.05	14.15	60	40
741	14	♀	"	3.0	0—0	0—1	.7—1	0—1	"	"	15.50	20.30	44	56
709	19	♀	"	3.0	0—0	0—0	0—0	0—0	"	"	16.05	20.20	45	55
731	19	♀	"	3.0	.7—1	1—0	1—1	1.5—1.5	brown	"	30.30	5.50	83	17
735	19	♀	"	3.1	1—1	1—1	0—1	0—1.5	dark	"	30.50	2.30	91	9
736	19	♀	"	3.0	.7—1	1—1	0—1	1.5—2	light	"	36.20	0.00	100	00
359	38	♀	"	2.8	.5—.5	P—1	0—0	0—1	brown	"	13.05	21.40	38	62
374	38	♀	"	2.9	.5—.5	.7—.7	.7—0	.7—.7	"	"	29.30	9.00	76	24
356	38	♀	?	?	.5—.5	0—.7	0—0	0—0	?	"	28.05	6.40	81	19
355	40	♀	Mat.	2.8	.5—1	.5—.5	1—1	1—0	brown	"	15.10	19.35	43	57
371	40	♀	"	3.0	0—0	0—0	0—0	0—0	light	"	2.25	32.20	7	93
375	43	♀	Im.	3.0	0—0	0—0	0—0	0—0	dark	"	16.30	22.00	43	57
753	43	♀	Mat.	3.2	.5—1	1—1	.7—.7	0—0	"	"	33.40	0.00	100	00
755	43	♀	"	2.4	1—1	1—1	0—0	1—1	"	light	25.45	7.55	76	24
725	46	♀	"	3.0	.7—.7	1—1	.7—0	1—1	brown	pink	12.40	23.00	35	65
726	46	♀	"	2.9	0—0	1—1	1—0	1—1	black	"	10.25	25.15	29	71
721	50	♀	"	3.2	.7—.7	1—1	1—1	1—1	dark	"	14.55	21.20	41	59
722	50	♂	Im.	2.3	0—0	0—0	0—0	0—0	light	light	12.05	24.10	33	67
331	57	♂	"	2.0	0—0	0—1	0—0	0—0	black	pink	17.45	17.15	51	49
										Total	549.25	522.30	51	49

[? Abdomen was lost.]

external eyes. Sometimes the eyes are not in their natural position. Often black pigment specks are found where the eyes are absent. The largest eyes are two fifty-fifths millimeter (0.036 mm.) in diameter, being twice as large as those of the newly hatched, but such individuals are comparatively rare. Hence as a rule, the eyes do not grow larger after birth, while the specimens more than thribble themselves in size. Neither locality nor size of the specimen determines the degree of degeneration in the eyes, or the shade of coloration. Generally, the lighter colored the individual, the more degenerated the eyes, and vice versa. Specimens totally devoid of eyes always stay in the dark more than fifty per cent. of the time; those with one or more eyes may stay either in the light or dark more than fifty per cent. of the time, the per cent. depending on the amount of degeneration.

Humidity.

Apparatus.—Glass tubes with one-half-inch bore and twelve inches long were used. The opening and three inches of one end were covered with black carbon paper. The other end was closed with a cotton cloth. A spider and two drops of water were placed in the light end of each tube and the tubes were placed in the light the same as in the light experiments. When first placed in the tubes the specimens wandered from one end to the other. In just a few moments they ceased their wandering and remained within reach of the drops of water. As it was impossible to watch these experiments all the time, quite frequently the drops of water evaporated before new ones could be added. Sometimes when the tubes became dry, the spiders were found in the dark end, other times in the light end. Under such conditions some were able to live only one or two days, some four or five days while others survived ten days. Out of two dozen individuals used not one at any time was ever found in the dark end when the light end was wet. Each specimen was examined, some had eyes and others were devoid of eyes. Judging from the preceding experiments on light the specimens devoid of eyes should have been found in the dark end at times, providing there was no other factor stronger than negative phototropism. Since these specimens remained near the drops of water all the time instead of going into the dark, we conclude that humidity is a stronger factor than negative phototropism.

The same experiments were prosecuted with the spiderlings and medium sized specimens of *Meta*. At times these were found in the dark end when the light end was wet, therefore probably humidity with them is not greater than negative phototropism.

Change of Humidity.

Apparatus.—The same tubes as used in the preceding experiments for humidity, also a hygrometer was employed. A specimen was placed in each tube and was observed several times each day. The following results show the relative humidity and the number of hours and minutes various individuals lived.

No. of Specimens.	Relative Humidity.	Hrs.	Min.
4	38—36	3	15
2	70—66—59	5	30
1	38—36—44	8	15
4	63—93	8	15
1	95—82—84—88— 92—78	23	35
1	81—60—76—73—100—75—89	31	45
1	100—65—55—60— 72—66—60	33	45

On various dates at the entrance and at the different localities in the caves the relative humidity was recorded. At the entrance it varied considerably on different days, but in the caves, the hygrometer always stood at 100 (saturation point).

These arachnids always live in a saturated atmosphere and it is impossible for them to survive long outside the caves where the variation in the degree of humidity is great. As a general rule the higher the relative humidity (with but a gradual and small amount of variability), the longer they live. Since the above experiments were prosecuted from May 18 to June 8, when the change in temperature was not such as to materially affect these spiders, we must attribute their deaths to the hygrometric conditions.

Summary.

1. *Troglohyphantes cavernicola* Keys. is found everywhere in these caves, where the three following necessary conditions exist—total darkness, a saturated atmosphere, and a suitable place for the construction of snares.

2. The first pair of legs are used as tactile organs.

3. All small winged insects, thysanurans and small myriopods serve as food. Scarcity of food does not entirely limit their distribution.

4. They have no known enemies other than themselves.

5. While temperature outside the caves does not materially affect the adult spiders themselves, it is probable that to the even temperature at localities between 600 and 1,700 feet from the entrance is due the great number of specimens found at this place.

6. Courtship is similar to that of some outside forms.

7. Cocooning is rudimentary. The eggs are few and comparatively large.

8. The young are white and are thicker set than the adults. Some are hatched with eyes, while others are entirely blind.

9. Moulting is comparatively rare and is often fatal. There are all shades from white to black in coloration.

10. In size the eyes vary from a small pigment speck to 0.036 millimeter in diameter. As a rule, after birth the eyes cease to grow while the specimens more than thribble themselves in size. Twenty-six per cent. of all the individuals are entirely devoid of eyes.

11. The degree of degeneration in the eyes and the shade of coloration are not determined by either locality or size of the specimen.

12. The lighter colored the specimen the more degenerated the eyes.

13. The more degenerated the eyes the greater the negative phototropism, and vice versa.

14. Humidity is a stronger factor than negative photropism in determining the location of specimens in the experimental tubes.

15. Change of relative humidity is fatal in a few hours.

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Explanation of Map.

Shawnee Cave (the outlet). Sec. I., No. 1.

Closed chamber caused by collapse of roof at Sec. I., Nos. 2–3.

Cascade. Sec. I., No. 6.

Double passage. Sec. I., Nos. 7–8.

Old cross cave. Sec. I., Nos. 9–10.

New passages. Sec. I., Nos. 1–8 and 11–13.

Opening in roof leading to *upper older* levels of cave. Sec. I., No. 14.

"Big Room." Sec. I., Nos. 15, 16, 17, 18, 19, 20, 21, 22.

"Fallen Rock." Sec. I., No. 31.

Lower Twin Cave. Sec. I., No. 32.

Upper Twin Cave. Sec. I., No. 33.

Roof too low for passage of boat. Sec. I., No. 34.

Deepest water in cave, 10 feet 4 inches. Sec. I., No. 35.

Lower Dalton Cave. Sec. I., No. 36.

Upper Dalton Cave. Sec. I., No. 37.

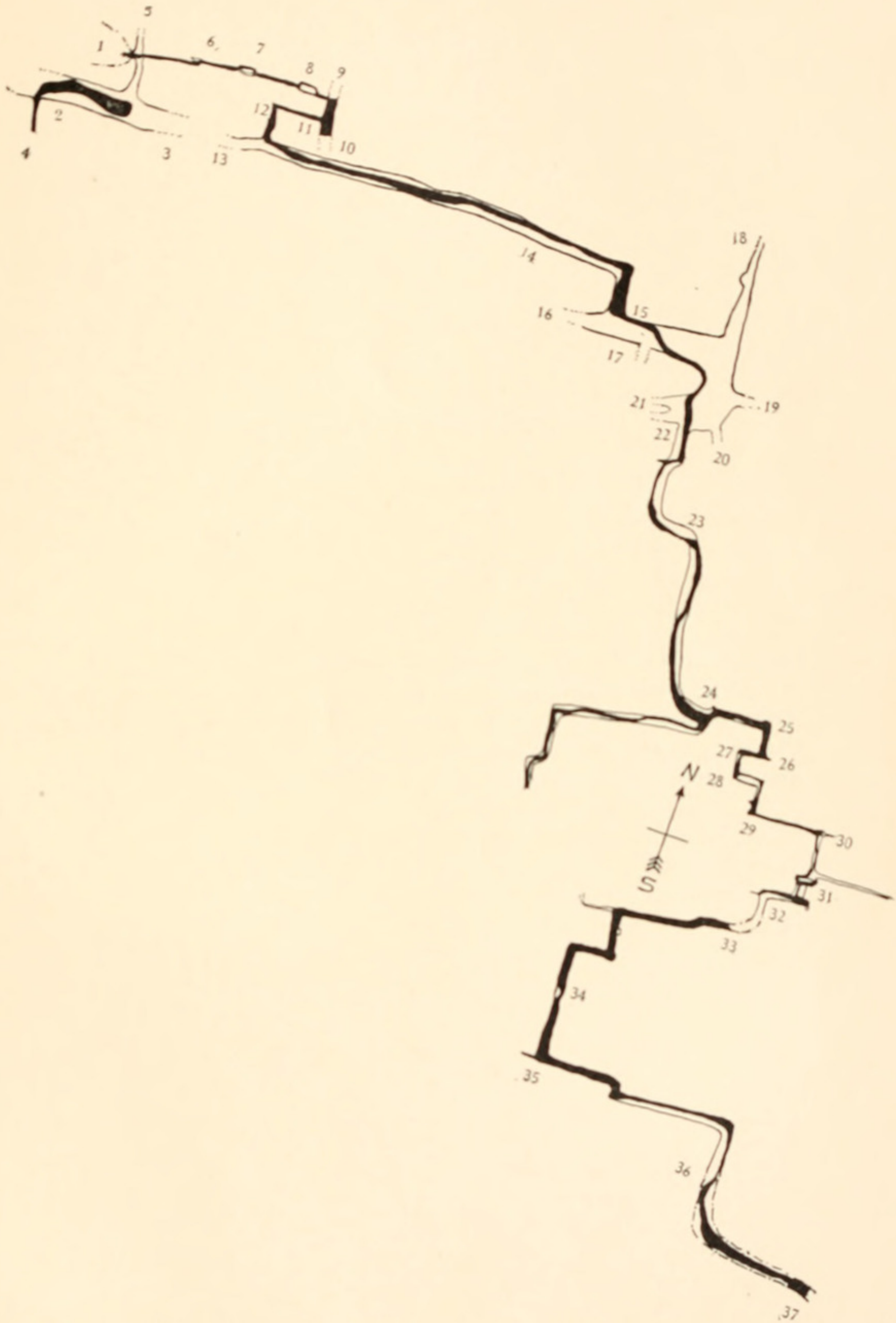

FIG. 1. Map of Shawnee Cave, section 1, from Shawnee to Lower Dalton. Length 4,453 feet. Scale 200 feet to the inch.

Explanation of Map.

Upper Dalton Cave. Sec. II., No. 37.
"Cross bedding" in limestone. Sec. II., Nos. 46–47.
"Old passages." Sec. II., Nos. 56–57.
Obstruction past which boat cannot be taken. Sec. II., No. 63.
End of exploration. Sec. II., No. 64.

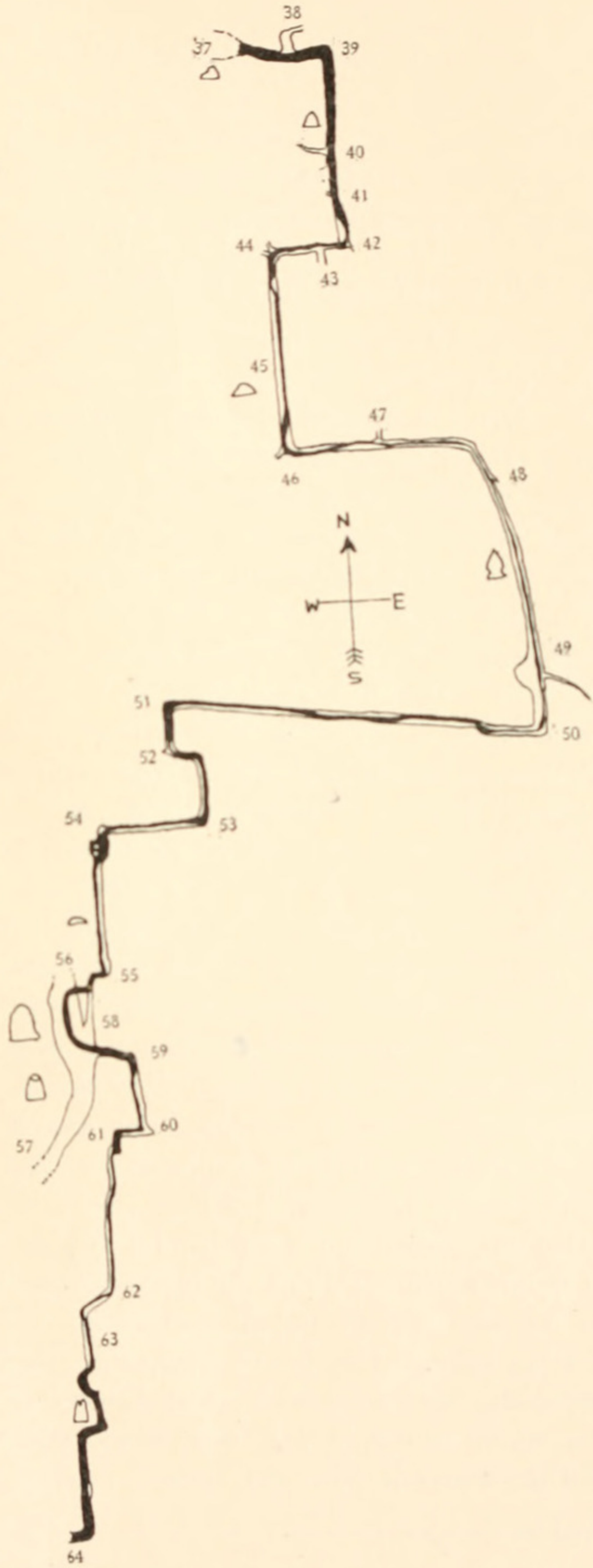

FIG. 2. Map of Shawnee Cave, section 2, from Lower Dalton to unexplored