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THE SENSE OF SIGHT IN SPIDERS WITH SOME OBSERVATIONS ON THE COLOR SENSE.

GEORGE W. AND ELIZABETH G. PECKHAM.

But few observations have been made upon spiders to determine their range of vision. According to Plateau, the German physiologist Müller credited them with distinct vision at a short distance, and so also did Lacordaire. Among modern naturalists, M. Eugène Simon speaks of the genus *Lycosa* as possessed of good powers of sight,¹ and as Simon has passed very many years in the study of this group his opinion is entitled to great weight. Dahl believes that a jumping spider (*Attus arcuatus*), saw a small fly, eight inches away.² Hentz, from a study of *Marptusa familiaris*, says that the sight of spiders, though acute, is not unerring.³ The Rev. Dr. McCook, who has made a special study of the habits of spiders says: "No one who has watched them (jumping spiders) stalking prey during the day could well fail to conclude that they were guided by a tolerably accurate sense of sight. * * * So also with Citigrades. I have seen young *Dolomedes sexpunctatus* leap from the side of a box and catch a fly on the wing, and return to its perch by the rebound of its drag line. Such an act not only shows ability to see but also some faculty to estimate distance, unless we suppose it to have been a chance shot."⁴

Also Bingley says of the jumping spider: "If it sees a fly at the distance of three or four yards, it does not run directly to it, but endeavors, as much as possible, to conceal itself till it can arrive near; and then creeping slowly up, and but seldom missing its aim, it springs upon the insect's back, and it is

¹Historie Naturelle des Araignées, First Edition, p. 364.

² Versuch einer Darstellung der psychischen Vorgänge in den Spinnen. Vierteljahrschrift f. Wissenschaftl. Philosophie, pp. 94, 95, IX, I, 1884.

³ Spiders of the United States, p. 57.

⁴American Spiders and their Spinning Work, Vol. II, p. 286.

then almost impossible for the fly to effect an escape. But if, before the spider gets to it, the fly takes wing, and fixes upon another place, it whirls nimbly about, and still keeps its eyes upon it, in order to commence a fresh attack.”⁵

It is not probable that a spider could see a fly at a distance of three or four yards, but Bingley could scarcely have spoken in this way if he had not been sure that it could see to a considerable distance.

In 1886 Forel published a paper on the sensations of insects. It is his conclusion that the sense of sight in spiders is so bad that if the flies were not so stupid and so imprudent they would never be caught. He says that the jumping spiders miss fifty flies to one that they catch.⁶ This author, however, speaks of his experiments in such a general way, giving no details, that they are of but little value in the solution of the problem. It is rash to draw positive conclusions from superficial observations. To an ordinary observer nothing could seem more senseless than the way in which ants run about on the ground. Even after an ant has found some choice morsel which it wishes to carry to the nest, it runs now this way and now that in what appears to be a perfectly aimless manner; and yet if a person has the patience to follow one of them through all its wanderings it will be seen to reach the nest at last. Another animal which might easily be misunderstood is a fish that inhabits our inland lakes (*Coregonus artedi*, var. *sisco*) that during a very short season of the year will bite at almost anything. After that time they may have their favorite fly dangled all around them and yet not take it under any circumstances, appearing perfectly blind.

To discover the limits of the special senses of an insect is a very difficult matter. Only a prolonged study of its life history, pursued through several years and during different seasons, on a number of different species and on many individuals of both sexes, is likely to lead to important conclusions; and in reporting their experiments all writers should remember Lange's words on the subject of scientific observations: “An

⁵Animal Biography, Vol. III, p. 455.

⁶Sensations des Insectes, premiere partie, Recueil Zoologique Suisse, T. IV, No. 1, p. 41.

exactly described procedure with an exactly described animal can always be repeated, by which means our interpretation, if it is due to variable by-conditions, is at once corrected, and at all events thoroughly cleared from the influence of personal preconception, which has so great a share in so-called self-observation."⁷

In 1887 Prof. Felix Plateau brought out a paper upon the sense of sight in Arthropods, and by 1888 he had published four more papers, covering the whole field of Arthropod vision. In the second of these papers he treats of the sight of spiders. M. Plateau is in accord with naturalists generally in the opinion that the question of the range of vision in insects is only to be determined by observation, and that, so far, morphology has been of but little use in solving the problem. He has, himself, followed the experimental method, but in working over so large a field as the Arthropoda he has very naturally drawn some conclusions that a more intimate acquaintance with the creatures in his hands would have taught him to avoid.

Thus he states, after experimenting with a small number (five) of species, that the sight of two large groups of spiders, the Attidae and the Lycosidae, is very bad, the limit of clear vision being about one or two centimeters.

The observations upon which he bases this conclusion were different for the two groups. In studying the Lycosidae he took from two females the cocoons which contained their eggs, and noted that although they sought for them eagerly they did not find them until they came very close. These experiments will be considered further on.

For *Dolomedes fimbriatus* and for two Attidae, M. Plateau pursued a different plan. He first noted, in numerous instances, that both free and captive spiders did not leap upon a fly until it came as near as two centimeters.

He found that *Epiblemum scenicum* turned from side to side to follow with its eyes the movements of a fly ten and twelve centimeters away, and that it ran after the fly from a distance of five centimeters; but this, he says, signifies only perception of movement and not perception of form, since it is at a much

⁷History of Materialism, Vol. III, p. 178.

shorter distance that *Epiblemum* sees its victim clearly enough to capture it. In other instances the spiders paid no attention to living flies which were not in motion, although passing at a distance of four centimeters.

M. Plateau remarks that the distance of two centimeters is not chosen because it is the limit of the spider's leaping powers, as it is able to jump twice as far.

Of *Marpissa mucosa* he says that at four centimeters the spider perceives the movements of a fly, but that it is only the movements that are noticed, since at this distance, and even at three centimeters, it seems to lose sight of its prey and to relapse into complete indifference if the fly becomes perfectly motionless.

It seems to us that these experiments and a number of similar ones performed by Plateau, show not how far the spider can see distinctly, but at what distance it usually seizes its prey. It is not safe to take for granted that if the spider does not try to catch the fly he therefore does not see it. As a matter of fact spiders will often let flies—which certainly are, as M. Forel has said, both stupid and imprudent—not only come within two centimeters of them, but climb upon them and walk all over them, practically putting their heads into the lion's mouth, and yet will seem unconscious of their existence. Perhaps they are not hungry. At any rate such are the facts. Dr. McCook says, "One of our largest indigenous Laterigrades, the Huntsman Spider (*Herterapoda venatoria*), received from Florida and kept in captivity, permitted a large fly placed in her cell to run between the legs, fly into the face, alight on the back, without any attempt to capture it. In the course of time, however, the fly lit on the side of the box a short distance in advance of the Huntsman. She perceived it, crouched, slowly moved her limbs, stealthily and by almost imperceptible advances approached, then swiftly shot forth her claws and secured her victim."⁸

M. Plateau tried another set of experiments with the same spiders in which all the conditions were the same except that instead of a fly he used three rude imitations of that insect,

⁸*Ibid*, p. 286.

consisting of a ball of blackened wax, of a little gray feather, and of a ball of black and white paper. As he made these things move about they were noticed, pursued, and in some cases were seized by the spiders, just as in the case of the true fly. Without doubt the spiders were to some extent deceived by the artificial insects. They did not necessarily take them for flies, but they probably hoped to find in them something edible. But this, after all, does not argue that their vision is very poor, since, in nature, they must be constantly meeting with new forms of life upon which they may prey. Spiders eat a great variety of things-caterpillars, beetles, bugs, walkingsticks, and, in fact, all manner of insects, as well as other spiders.

M. Plateau gives an example of very hasty reasoning in his remarks upon H. F. Hutchinson's statement that he has seen a jumping spider, *Epiblemum scenicum*, pursuing its own reflection in a mirror.⁹ He says that it would be difficult to imagine an experiment which would more fully prove that spiders distinguish form very badly, seeing movements rather than anything else.¹⁰ Does he then suppose that the spider mistook his reflection for some insect which would serve him as prey? Such an hypothesis is quite uncalled for, and is, indeed, untenable. We once owned a very intelligent dog that on several occasions nearly knocked down a large pier-glass by rushing at his own reflection and attempting to fight it. He became furious whenever he entered the room; and one of our boys, when two years and four months old, used to search eagerly behind the glass for the little boy that he saw in it, and it was several days before he gave up trying to find him. Mr. Hutchinson's spider, like the dog and the boy, mistook his reflection for another spider. may be that he wished to catch it and eat it, as is commonly done among spiders, even of the same species; or very probably, if it was in the mating season, he saw, in his reflection, a rival male, and was trying to give battle.

We find, by reference to some notes made in 1887, that when

⁹Nature, Vol. XX, 1879, p. 581.

¹⁰Recherches Experimentales sur la Vision chez les Arthropodes deuxième partie, p. 10.

a small looking-glass was placed before a male of *Astia vittata*, in the mating season, he would prance before his reflection in a most ludicrous fashion, throwing forward his first legs and advancing toward his supposed rival as the glass was slowly moved away, or retreating as it was moved toward him; and again, that both the male and female of *Phidippus morsitans* noticed their reflections in the mirror. The male raised his legs as they do upon seeing another male, while the female crouched, raised her first legs, and finally sprang upon the glass. She followed her reflection, at a distance of one inch, all around the box in which she was confined. The females of this species are exceedingly intolerant of each other as well as of the males. Two of them can not live in the same neighborhood; one is always killed and devoured by the other.

Let us now turn to M. Plateau's experiments upon the Lycosidae. The females, in this group, commonly carry the cocoon containing their eggs about with them, either attached to the under and hinder part of the abdomen or, as in *Dolomedes* and *Micromata*, held grasped in the falces, under the cephalothorax. Both Plateau and Forel having, at several different times, separated the spiders from their eggs, and having noted their difficulty in finding them again, have concluded that their sight is very poor and short.¹¹

It is indeed a well established fact that when the cocoon is taken away from one of these spiders she is very much disturbed by its loss, and searches eagerly about for it, and yet that she may run all around it without finding it, never recognizing it unless she comes very close. This is the truth but not quite the whole truth. As a matter of fact, she never recognizes it unless she touches it; but let her graze it ever so slightly, with any part of her body and she instantly seizes it and reattaches it to her abdomen.

The action is so sudden and rapid that one may easily make the mistake of supposing that the spider, in coming very near, recognizes the cocoon through the sense of sight, but close attention will prove that this is never the case. She always comes into actual contact with it before taking it. We feel very

¹¹Plateau, *Ibid.*, p. 21; Forel., *Ibid.*, p. 19.

confident that when the spider loses the cocoon she never looks for it but feels after it. This is not so strange as at first appears, for it is quite possible that the spider constructs the egg-sac, deposits her eggs in it, closes the aperture, and attaches it to her body without ever seeing it.

The pages of notes that we have collected on this point would be tedious reading, but we offer a few experiments in evidence of our view of the matter.

The cocoon was taken from a female of *Pirata montanus*. She seemed much disturbed and hunted for it, but though it was only a few inches away she did not find it. The cocoon was then placed one-fifteenth of an inch from her, and still she did not take it. She several times passed very close but until she touched it she did not notice it. The experiment was repeated upon another spider of this species with the same results. We next tried *Pardosa pallida*, and found that she also depended upon touch and not upon sight to recover her eggs. The same was true of *Pirata minuta*. No matter how anxious she was to find her eggs, and no matter how close they were brought to her, she never recognized them except by touch. We then changed the form of the experiment by suspending the cocoon of *Pirata montanus* at the end of a thread. As the spider searched anxiously about, it was lowered until she could barely pass beneath without touching it. This arrangement required some manipulation but we finally succeeded in suspending several cocoons at exactly the right height, and then watched the spiders as they passed and repassed without observing them. If, however, we allowed the cocoon to graze one of the posterior legs the spider instantly turned and seized it. The position of the eyes of these spiders is such that unless they were totally blind they must have seen these suspended cocoons, but they are as dependent upon touch for recognizing their eggs as thorough-bred bloodhounds are upon their sense of smell when hunting their game, or as English greyhounds upon sight.

Exactly the same experiments were performed upon *Dolomedes tenebrosus* and *Micromata carolinensis* with exactly the same results. Their distress at losing their eggs was great and their

search after them patient and persistent, but always unavailing until they touched the cocoon.¹²

We have also made experiments to determine what the powers of vision are in the Lycosidae. When at liberty, these spiders rush along so rapidly and seize their prey so suddenly that it is very hard to say at what distance they perceive an object. Even in confinement they are more difficult subjects than Attidae.

A male of *Lycosa nidicola* was placed in a narrow case of colored glass made up of plates each of which was four inches wide. The case was sixteen inches long. The spider was standing at one end when we put a green grasshopper in at the other. After a time he began to move down the case. When eight inches away from the grasshopper he appeared to see it, making a change in his movements, but whether this inference was correct or not he certainly saw it at four inches, since when separated from it by the width of one of the plates he leaped upon it and began to eat it. This experiment was repeated with three other spiders of the same species and all jumped upon grasshoppers or small spiders at from three to four inches; while *Lycosa nigroventris* leaped upon its prey when two inches away.

Further evidence concerning the powers of sight in the Lycosidae is given by W. H. Hudson in his very interesting work on the La Plata. He says:

“The king of the spiders on the pampas is, however, not a *Mygale*, but a *Lycosa* of extraordinary size, light grey in colour, with a black ring round its middle. It is active and swift, and irritable to such a degree that one can scarcely help thinking that in this species nature has overshot her mark. When a person passes near one—say, within three or four yards of its lurking place—it starts up and gives chase, and will often follow for a distance of thirty or forty yards. I came once very nearly being bitten by one of these savage creatures. Riding at an easy trot over the dry grass, I suddenly observed a spider pursuing me, leaping swiftly along and keeping up with my beast. I aimed a blow with my whip, and the point of the lash

¹²For a more complete discussion of this subject see our paper, Mental Powers of Spiders, *Journal of Morphology*, Vol. I, p. 399.

struck the ground close to it, when it instantly leaped upon and ran up the lash, and was actually within three or four inches of my hand when I flung the whip from me.¹³

In another place Hudson says: "The spiders I have spoken of up to now are timid, inoffensive creatures, chiefly of the *Epeira* family; but there are many others exceedingly high-spirited and, like some of the most touchy hymenopteras, always prepared to 'greatly quarrel' over matters of little moment. The *Mygales*, of which we have several species, are not to be treated with contempt. One is extremely abundant on the pampas, the *Mygale fusca*, a veritable monster, covered with dark brown hair, and called in the vernacular *arana peluda*—hairy spider. In the hot month of December these spiders take to roaming about on the open plain, and are then everywhere seen travelling in a straight line with a slow even pace. They are very great in attitudes, and when one is approached it immediately throws itself back, like a pugilist preparing for an encounter, and stands up so erect on its four hind feet that the under surface of its body is displayed. * * * * In the case of the hairy spider I do not think any creature, however stupid, could mistake its meaning when it stands suddenly up, a figure horribly grotesque; then, dropping down on all eights, charges violently forwards."¹⁴

When in Guatemala, some years ago, we frequently made these *Mygales* rise up on their hind legs, as is described by Hudson, by pointing the stick of a sweep-net at them, always keeping at a safe distance, since if excited they would jump a remarkable distance to reach the offending object.

M. Plateau criticises Eugene Simon's statement that *Lycosa* leaps upon its prey from a distance, saying that his judgment must be based upon very superficial observations.¹⁵ We trust that we have shown that it is rather venturesome for a critic who cannot have devoted more than a few weeks to the subject to so lightly dispose of the opinion of a naturalist who has studied spiders in many parts of the world, both in the closet and the field, for more than twenty-five years.

¹³*The Naturalist in La Plata*, p. 192.

¹⁴*Ibid.*, p. 191.

¹⁵*Ibid.*, p. 21.

One would naturally expect that the orbweavers would not be very far-sighted. Living as they do in webs, the vibration of the lines would seem to be sufficient both to enable them to capture their prey and to carry on the preliminaries to their mating. Still the evidence offered by Rev. Mr. O. P. Cambridge, and by Hentz, to some extent confirmed by our own experiments, renders it fairly probable that some of the sedentary species have distinct vision for stationary objects at from two to four inches. Cambridge, as quoted by Dr. McCook,¹⁶ "records that he has more than once seen an English Orbweaver, *Meta segmentata*, drop from her web upon an insect which it had espied on the ground a little way below it, and ascend again with its prize by means of the line drawn from its spinnerets in the descent." As Dr. McCook goes on to say, this is certainly a remarkable degree of keen sightedness for an Orbweaver, and especially for one that habitually affects a shadowed habitation.

We have confirmed the statement of Hentz,¹⁷ that *Eperia prompta* sometimes catches its prey by running and leaping upon it, like an *Attus*. We have also made some experiments upon the Therididae¹⁸ which showed that *Theridion blandum* and *Theridion frondeum* recognized their cocoons at three and at four inches, respectively. In these spiders, although the cocoon is not attached to the mother's body, she keeps guard over it and evidently knows it by sight.

The evidence that we have to offer upon the subject of sight in the Attidae is based upon a study of twenty species. This study has extended over eight successive summers and we have notes of many hundreds of observations. We have experimented more with the Attidae than with other families, both because the habits of these spiders make them especially available and because it was easy for us to carry on a double set of observations while we were studying their mating habits.

Unlike all the other families of spiders with which we are acquainted, nearly all of the Attidae, when shut into a box which

¹⁶*Ibid.*, p. 287.

¹⁷*Ibid.*, p. 112.

¹⁸Mental Powers of Spiders, *Journal of Morphology*, Vol. I, p. 401.

is supplied with light and air, seem entirely unconscious of the fact that they are prisoners. They catch flies and devour them, sun themselves, mate, lay their eggs, and indeed carry on all the affairs of their daily life in the most natural and unconcerned manner imaginable, passing a whole summer in confinement with an appearance, at least, of perfect contentment.

The movements and attitudes of the spiders of this group are wonderfully varied and expressive, and indicate very delicate shades of feeling. For example, a female of *Phidippus morsitans* stalks a fly with a stealthy, menacing air, but when she is about to pounce upon and devour a male of her own species, there is added to this an appearance of something so evil and malignant that one almost sympathizes with De Geer in the feelings of horror and indignation with which this sight filled him. The males in the mating season, throw themselves into one position when they catch sight of a female and into quite another at the appearance of another male. Indeed their attitudes express so many shades of excitement, tempered more or less by caution, and of jealousy of each other as to make a very dramatic performance for the observer.

This power of expression through different attitudes and movements is of great assistance in determining not only how far the spider can see but how much it recognizes of what it sees, or, in other words, its power of distinct vision, since it acts in one way when it catches sight of its prey, in another at the appearance of a male of its own species, and in still another when it sees a female. Dr. McCook says: "Their rapid and marked change of manner when prey is sighted, the mode of approach, like the action of a cat creeping upon a bird, the peculiar behavior displayed when the final spring is made, are not to be accounted for on any theory other than a keen sense of sight."¹⁹

Similar observations have been made by Hentz on *Marptusa familiaris*. Of this spider he says: "It dwells in cracks around sashes, doors, between clapboards, etc., and may be seen on the sunny side of the house, and in the hottest places, wandering in search of prey. It moves with agility and ease, but usually

¹⁹*Ibid.*, p 286.

with a certain leaping gait. The moment, however, it has discovered a fly, all its motions are altered; its cephalothorax, if the fly moves, turns to it, with the firm glance of an animal which can turn its head; it follows all the motions of its prey with the watchfulness of the falcon, hurrying its steps or slackening its pace, as the case may require. Gradually, as it draws near to the unsuspecting victim, its motions become more composed, until, when very near, its movements are entirely imperceptible to the closest observation, and, indeed, it would appear perfectly motionless, were it not for the fact that it gradually draws nearer to the insect. When sufficiently near it very suddenly takes a leap, very seldom missing its aim."²⁰

There is a considerable difference in the character of the different species as well as among individuals of the same species, but we have found nearly all of our Wisconsin Attidae very good subjects for experiment.

In the summer season it is our habit to keep from twenty to forty species in confinement for several weeks at a time. They are put into boxes of two sizes, the larger ones being 15 inches long by 11½ wide and three deep, and the smaller 7½ long by 5¾ wide and 2½ deep. The sides of each box are marked off into inches so that the distances of the spiders from each other and from the flies can be easily noted. The bottom is of cotton cloth and the top is a glass slide.

As may be easily imagined it is something of a task to feed so many prisoners. Our principal food supply is found in the gnats that settle upon the wire screen which encloses the porch of our cottage. These are well liked by all the smaller species, while the larger ones take house-flies, May-flies, and small grasshoppers.

When several gnats were put in at one end of a box containing six or eight spiders their attention was immediately excited and two or three of the gnats would be captured almost before they had settled on the sides of the box. Those that were not caught would settle at once and become motionless. As the bodies of these little gnats were white and nearly transparent they were very inconspicuous, whether resting upon the sides

²⁰*Ibid.*, p. 56

of the box, which were of yellow pine, upon the bottom, which was of white cloth, or upon the top which was of glass, and yet they were evidently recognized by the spiders at all distances up to five inches, as may be seen by the following observations which are taken from our notes.

A female of *Astia vittata* was standing with her back to a motionless gnat three and one-half inches away. On turning she caught sight of the gnat and at once began to approach it stealthily. She sprang upon it when one inch away and caught it.

A female of *Astia vittata* was walking about the box when she caught sight of a gnat five inches away. She showed her perception of it by a contraction of all the muscles of the body and by lifting her head and fixing her eyes upon the prey. After a moment, she began to advance, rapidly at first and then more slowly. She jumped when about one inch away.

Into a box containing a male of *Hasarius hoyi* we put eight gnats and four small flies. They all settled and became quiet. The spider, neglecting several gnats and flies which were close to him, fixed his eyes upon a gnat five inches away and approaching it by short jerks, from in front, pounced upon it, holding it tightly a moment and then letting it go. One of its legs was broken. It fluttered off to a distance of seven inches. After a moment the spider followed it and caught it again, still paying no attention to several nearer ones. This he repeated six times, letting it go each time. He then began to catch other gnats and flies at distances of from one to four inches. He made in all twenty-five captures, jumping always when about an inch away. His actions were exactly like those of a cat playing with a mouse. It seems remarkable that he could see clearly enough to follow the gnat which he had at first singled out among a number of others which were almost identical in appearance.

A mosquito alighted four inches from the nest of a male of *Philaeus militaris*. The spider crept out, approached cautiously, and when one inch away jumped, but the mosquito escaped. A moment later it flew back and settled two inches from the spider. This time he ran quickly up, leaped, and caught it.

A tiny black fly approached to within two inches of a male of *Habrocestum splendens*. The spider advanced very slowly facing the fly, which seemed to be fascinated, gazing into the spider's eyes, but backed slowly away moving its abdomen up and down in a peculiar manner. They moved along in this way for two and one half inches, when a gnat flying by, distracted the attention of the spider.

Again, a hungry male of this species was put into a box where there were several small flies. He at once began to stalk a motionless fly which was standing five inches away, but lost it. He then fixed his attention upon another fly four inches away but before he approached it the fly began to move and walked slowly away from him around the corner of the box and then up on to the glass cover. The spider followed the fly with his eyes, moving his head around to keep it in view. The same spider afterward stalked a fly which was standing quiet three inches from him.

A female of *splendens*, being dropped into a box, at once saw a motionless gnat full four inches away, lifting her head and drawing her legs together as she approached it. Another female of the same species noticed motionless gnats fifteen different times at distances of from two to five inches.

A female of *Epiblemum scenicum* being put into a box containing flies lifted her head and drew herself together on see- a motionless gnat five inches away. This was repeated with a fly at three and one-half inches.

A male of *Anoka mitrata* followed a moving gnat at distances of two, of four and of six inches.

A male of *Phidippus rufus*, standing in a corner of his box turned around and brought into view a small green grasshopper which was standing quiet two and one-half inches away. He at once began to creep forward as they do when approaching prey and soon seized it. There can be no doubt that he saw it at once. He had before made several half-hearted moves toward some small flies which were walking about from one-quarter to one-half an inch from him, but only when they actually intruded themselves upon him. At another time this spider saw a motionless grasshopper three and one-half inches away and jumped

at it. The grasshopper threw him off and hopped five inches away where it stood still. He at once ran toward it, jumped at it and caught it.

A gnat often brought destruction upon itself by flying across the box, although it immediately settled and became quiet, as the motion would attract the spiders at any distance up to fourteen inches. A spider having once caught sight of a gnat had no difficulty in finding and capturing it after it had ceased to move.

One of our little ant-like species, *Synemosyna formica*, seems to have the weakest vision of the whole family. A male of this species saw flies in motion four inches away, but if they were quiet did not show that he noticed them further off than one and one-half inches. They never eat any but living creatures, but they often seem to be deceived by dead flies and gnats, leaping upon them when one-quarter of an inch away, and then relinquishing them.

By far the most interesting experiments on vision, however, are those that have to do with Attidae in their mating season. Here we have evidence that spiders not only see, but see clearly at considerable distances.

Thus we had a male of *Saitis pulex*, which we put into a box containing a female of the same species. The female was standing perfectly motionless, twelve inches away, and three and a half inches higher than the male. He perceived her at once, lifting his head with an alert and excited expression, and went bounding toward her. This he would not have done if he had not recognized her as a spider of his own species. When four and one-half inches from her he began the regular display of this species, which consists of a peculiar dance. This he would not have done had he not recognized her sex. A male of this species, on the floor of the box, caught sight of a motionless female on the glass, nine inches away and four and one-half inches above him. He raised his body almost vertically and gazed alternately at her and at a male, which was five inches away in another direction. At other times the males recognized the females at eight, nine and eleven inches, and the females recognized the males at six, seven, nine and one-half and eleven inches.

A male of *Hasarius hoyi* was dropped into a box with another male, which was standing seven inches away. He at once threw up his first legs, this being a challenge to battle. The other male responded by throwing up his first legs. The two advanced upon each other slowly and when only two inches apart began to circle about each other, waving their legs. The same male when put into the box with a female, saw her as she stood quite eleven inches away and at once lifted his first legs, not straight up, as in the case of the other male, but obliquely, and began to move with a rapid gliding gait, from side to side, this being the characteristic display, before the females, in this species. At other times we saw the males of this species challenge each other at two and one-half, at three, at four, at five, at six and at six and one-half inches, and saw the males display before motionless females at two, five, eight and ten inches. The females of this species gave evidence of recognizing males which were perfectly quiet, raising the head with a comprehensive glance and then turning and running in an opposite direction, at four, five, six and eight inches, and one female followed with her eyes the movements of a male, as he walked about the other end of the box, at least ten inches away.

A male of *Anoka mitrata* saw another male which was not moving when eight inches away, and at once threw out his long plumy first legs. As he takes this attitude both in courtship and in fighting, he may not have been able to distinguish the sex of the other spider, but he certainly recognized it as being of the same species, as he would otherwise have remained quite indifferent.

Another male of this species saw a motionless female nine inches away. He raised himself high on the first pair of legs and eyed her attentively. After a moment he ran toward her, and when four inches away he extended the first pair of legs at a right angle to the cephalothorax, and turned his abdomen first to one side and then to the other, this being his characteristic display. They frequently saw at from six to eight inches when both were standing still, one of them often bending far to one side to see the other more distinctly. It was a common thing for two males, or for a male and a female to back

against each other, not aware of their proximity to each other until in actual contact, when they would turn around very quickly.

A male of *Philaeus militaris*, on being put into a box, at once noticed a female that was quietly eating a fly seven inches away. He looked at her, raising himself on his first legs to see better, and after a moment ran toward her with his palpi outstretched. At two inches he threw up his legs and began his display. Two males of this species challenged each other to battle when standing twelve inches apart, and both males and females repeatedly recognized each other at all lesser distances.

Dendryphantès capitatus noticed a quiet female eight inches away and ran toward her, beginning his display at five inches.

Icius hartii began his display before the female, showing recognition of sex, at three inches.

A male of *Zygoballus bettini* noticed a female six inches away, raising his head and then turning it to see her better as she walked around him.

A male of the little antlike spider *Synageles picata*, began his display before a motionless female when four inches distant.

A male of *Habrocestum splendens*, upon being put into a box with a quiet female, became wildly excited, beginning to show off like a peacock when five and one-half inches from her.

In *Icius elegans* the males and females gave evidence of recognizing each other at all distances up to seven inches.

The males and females of *Phidippus morsitans* showed that they recognized each other at all distances up to thirteen inches, when quiet or moving slowly. The male danced before a motionless female at six inches.

A male of *Epiblemum scenicum* noticed a female that was sucking the juices of a fly seven inches away. He raised himself high on his first legs to see her better, and after a moment ran toward her with outstretched palpi.

Phidippus rufus, put into a mating box, seemed to see a female seventeen inches away—at any rate he advanced directly toward her. At nine inches he showed signs of excitement,

and at six inches he made his display, raising himself high upon his six back legs, while he lifted the first pair obliquely forward and upward, crossing the tips and widely extending his palpi, while his abdomen was dropped so that it dragged on the ground. He advanced with a swaying motion. When he was close to her she ran rapidly away, leaving him in her corner, and taking up her position fifteen inches away remained quiet for some time with her eyes fixed upon him. Later on he noticed her when she was quiet, eleven inches away, and she followed him with her eyes, moving her head, as he walked all around the box, at a distance of from ten to fifteen inches.

A female of *Marptusa familiaris* standing four and one-half inches lower than the male and thirteen inches away followed him with her eyes as he moved slowly back and forth in a semicircle before her. They showed, she by a characteristic vibration of the palpi, he by the outstretched position of his first legs that each distinguished the other's sex. We have never seen the male of any species make his display before the female at a greater distance than this. The same performance was repeated when they were nine inches apart.

It is evident that the spiders recognize each other by sight and not by any other sense, as they remain perfectly unconscious of each other's presence when back to back no matter how excitable they are when they come within each other's range of vision. The males of *Dendryphantes capitatus* are extremely quarrelsome, especially in the presence of the female, yet sometimes two males while displaying before the females, will each remain unconscious of the close proximity of the other, even backing up and bumping into each other. We once interrupted the courtship of a male of *Dendryphantes elegans* by taking him out and gently blinding his eyes with paraffine. He was then restored to the box where he remained quite indifferent to the presence of the females, which had excited him so much a few moments before.

The same experiment was tried upon a male of *Saitis pulex*. While dancing in the greatest excitement before a female he was taken from the box and his eyes were blinded with paraffine. He was handled gently, and the paraffine was not hot. He was

then replaced in the box but remained perfectly quiet although several females passed near him. After a time the females were removed from the box and the blinded male was left alone. The next morning we found him trying to remove the paraffine by rubbing his face with his palpi. Two females were put in, close to him, but he did not notice them. One of the females seemed interested in him, approaching and finally touching him, but he was entirely unresponsive, and only moved away. By afternoon of the same day he had cleaned his eyes and we found him dancing before a female three and one half inches away.

We repeated these experiments several times upon these two species, and also upon *Phidippus rufus* and *Astia vittata* always with the same results.

We think that our experiments on vision prove conclusively that Attidae see their prey, (which consists of small insects) when it is motionless, up to a distance of five inches; that they see insects in motion at much greater distances; and that they see each other distinctly up to at least twelve inches. The observations on blinded spiders and the numerous instances in which spiders which were close together, and yet out of sight of each other, showed that they were unconscious of each other's presence render any other explanation of their action unsatisfactory. Sight guides them, not smell.

EXPERIMENTS ON THE COLOR SENSE.

Some years ago we made a few attempts to test the color sense of the Attidae by painting the females in the mating season. The results were more or less doubtful. The males unquestionably altered their demeanor at first but some of them became reconciled, after a time, to the new style of coloration. The experiments were as follows:

A female of *Astia vittata* was put into a box with four males, one of which was of the variety *niger*. (This species has two forms of male; one of them is colored somewhat like the female, while the other is black). All the males at once became greatly excited vying with each other in their display before the female. The *niger*, always more active and excitable than the

other variety, would have succeeded in mating with her if they had not been separated. All continued to dance before her until at the end of fifteen minutes she was taken out, and painted with water colors, all over her abdomen, a bright blue, the natural color being pale with reddish bands. After the paint had dried thoroughly she was put back into the box. The three light colored males now treated her with complete indifference, passing close to her without paying her the slightest attention, exactly as though she belonged to another species. The *niger* showed some curiosity, keeping near her and watching her, but did not dance. After twenty minutes he suddenly leaped upon her, but was taken off. He then left her and did not renew his attentions. A second female was now put in. All four of the males at once began to dance excitedly before her and continued their display without pausing, for fifteen minutes when she was removed. All this time they had paid no attention to the blue female, but now they began to notice her a little, not dancing at all but sometimes pausing to look at her when they came near. They were left together for half an hour longer with no further results.

In the next experiment we used entirely different spiders, though of the same species. A female was put in with four males, one of them being a *niger*. All became excited and at once began to dance. At the end of five minutes she was taken out and painted blue, as before. When dry, she was replaced. None of the males paid any attention to her for the first ten minutes, but after that one of the light colored ones gradually became excited, and ended by dancing before her in the most eager manner possible. The other males remained indifferent.

This experiment was repeated with a fresh lot of spiders with the same results at first; but after the painted female had been in with the males for thirleen minutes first one, then a second, and then a third of the light colored males danced before her.

At another time we put a female *vittata* into a box with six males, two of which were of the *niger* variety. Within a minute all but one (a light colored one) were dancing and posturing before her. We took her out, and painted her cephalothorax

and abdomen bright red. When she was put back only two of the males noticed her, one of these being of the *vittata*, and the other of the *niger* variety. These two did not dance nor display at all, as they had done before, but walked about her, eying her attentively, for some minutes. Then one of them, and when he was removed, the other, leaped upon her without any preliminaries. The *vittata* variety returned and danced a little before her, but then retired, and paid her no further attention. The *niger*, however, danced a long time and leaped upon her repeatedly, being as often taken off. The other males in the box seemed perfectly indifferent. After a time she was removed and another (unpainted) female put in. All of the males now became excited and danced before her. She was taken out and her cephalothorax, abdomen and legs were painted bright blue. When she was returned to the box the behavior of the males was entirely different. At first they did not notice her at all, though passing close to her, but after a time three, and then four of them danced before her, though less eager than before. We now put into the box another female which was large and heavy with eggs. This condition always lessens the attractiveness of the female in the eyes of the males, and yet this one now received nearly all the attention. She moved about more than the painted female, which, perhaps, made her more pleasing. In the end one of the *vittata* males mated with the painted female.

The next experiments also indicate a perception of color.

The spiders used were five individuals of *Astia vittata*, two of *Phidippus morsitans*, and one of *Xysticus ferox*.

Astia vittata. 1. June 28. A female that was nearly ready to lay her eggs was put into one of our large boxes. On the following day she constructed a thick silken shelter in one corner and laid her eggs, remaining herself on top of them and under the covering of web, so that she was hidden from view. She was left for twenty-four hours and was then pressed gently out and imprisoned in a bottle, while her nest was entirely surrounded by pieces of bright pink paper, two inches in width, which were pasted on to the sides and bottom of the box. She

was then put into the box close to the paper and at once ran across it and crept into her nest.

July 1. The spider was pushed gently out of her nest and three inches beyond the paper. She ran back at once across the pink paper, and crept into her nest.

July 2. Pushed her out twice, once in the morning and once in the afternoon, and let her go back over the pink paper.

July 3. Thinking that by this time she might have learned to associate the color, pink, with the locality of her nest, we took the spider from the box, while bright blue paper was substituted for the pink around her nest. We then made an imitation of her cocoon of white cotton batting, glued it into another corner of the box and surrounded it with pink paper to make it look as much as possible as the true cocoon had done before. The spider was then dropped into the box half an inch from the edge of the pink paper. She at once walked across the paper to the upper end of the cotton (where she had been in the habit of entering her nest), but as soon as her front legs touched the cotton she stopped, paused a moment, and then slowly retreated a little. Before long she advanced again, touched the cotton and retreated as before. This she repeated four times. She then started to walk across the cotton, but drew back again and took up her stand at the upper end where she remained motionless for half an hour, puzzling, perhaps, over the unaccountable thing that had happened to her nest. At the end of the half hour she touched it once more and then walked away to the other side of the box, passing within an inch of the blue paper without noticing her own nest. Within five minutes she returned to the artificial cocoon and stayed near it, walking about and looking at it for an hour. At the end of this time she was pushed gently toward the blue paper. When on the edge of it she caught sight of her true nest, and running to it crept in.

July 4. When we went to the box in the morning we found the spider on the pink paper near the artificial cocoon. She had never before left the nest of her own accord. When the box was shaken slightly she left the false cocoon, but soon returned to it.

We then took her from the box for a moment, removed the pink paper from around the false cocoon, and replaced her near it. She remained in the same place for fifteen minutes, lifting her head and glancing from side to side. She then began to move about, and coming within four inches of the blue paper ran onto it and remained there for ten minutes. She was then pushed up to the entrance of her nest and quickly ran in. A second artificial cocoon was then placed in an unused corner of the box and was surrounded with pink paper.

July 5. We found *vittata* running about the box. She passed near the plain bunch of cotton and also near the pink paper without paying any attention to them, and finally ran onto the blue paper and crept into her nest.

On July 6, 7, 8 and 9 she was gently pushed to a little distance from the nest and then allowed to find her way back to it across the blue paper. In this way she became accustomed to being away from her nest, more or less, and sometimes stayed out for several hours, eating and drinking as though she had no maternal cares, but always returned to her eggs sooner or later.

July 10. The spider being removed from the box, bright red paper was substituted for the blue around her nest, and the artificial cocoon in another corner was surrounded with blue. She was then put back into the box, but for three hours did not seek for her nest, remaining quiet at one side of the box most of the time and eating four gnats in succession. She was then touched with the end of a lead pencil, whereupon she ran directly across a corner of the red paper, onto the blue, and up to the cotton. At the first touch, however, she left it entirely, and did not return to it. She wandered about the box for half an hour, crossing the red paper three times without noticing her nest. The fourth time that she came onto it she saw the nest, and running to it quickly, crept in.

July 11. Found her in the nest and let her alone.

July 12. She deserted her eggs and could not be persuaded to return to them.

Astia vittata, 2. On July 13 the spider laid her eggs and took her place under the web. She did not come out on the 14 and 15 although gnats were put into the box.

July 16. Pushed her from the nest. She ran to the far side of the box where she caught and ate a gnat. At the end of an hour she returned to her eggs.

July 17. Removed her from the box, surrounded her nest with pink paper, and put her into the box again, five inches away from the nest. She seemed to see it and ran toward it, but stopped at the edge of the paper, and lifted her head as though studying the situation. She then crept under the paper where it was loose, and so into her nest.

July 18. Pushed her from the nest and pressed the paper down so that she could not creep under it again. While doing this we accidentally closed the opening into the nest. The spider soon returned, crossed the pink paper, and tried to get into the nest. She worked for fifteen minutes trying to force an entrance, going all over the nest, poking and working at the web with her first legs as though trying to tear it. She did not seem to use her falcies. Some gnats were then put into the box, and while she was eating one we cleared the opening to the nest. She soon returned and went in.

July 19. Took the spider from the box and removed the pink paper. Then put her back but she would not go back to her eggs although she was pushed close to them. We then replaced the pink paper. She seemed to notice it—ran onto it, and finally settled down under the edge where it was a little loose, but did not go back into her nest.

July 20. Found her wandering about the box and could not make her take any further interest in the eggs.

Astia vittata, 3. A box was prepared by papering the four corners, respectively, with blue, pink, red and light green paper. A clear space was left in the middle of each so that the spider could attach her nest to the sides of the box. On July 25 the spider was put in.

July 27. The spider built her nest and laid her eggs in the middle of the green paper.

July 28, 29 and 30. Pushed her out of the nest and let her find her way back across the green paper.

July 31. Took the spider out and substituted blue paper for green around her nest, putting green around an artificial nest

in another corner. Put her in two inches from the green paper. She ran onto it, and stayed on or near it for half an hour, not, however, touching the cotton. Once she wandered off in the direction of the blue, but soon returned. After an hour and a half she went up to the cotton and made three vain efforts to get under it, lifting it with her front legs and pushing her head under. She then left the green paper. We guided her to the blue, which surrounded the true cocoon, but she would not stay there. After some wandering about she went on to the green again and once more tried to get under the cotton. We then pushed her on to the blue and she ran to her nest and seemed to be trying to get in, for a moment, but then ran away. We tried several times afterward to make her go back to her eggs, but in vain.

Astia vittata. 4. This spider was put into a box which had been papered with the four colors, as in the last experiment, and she also laid her eggs in the green corner.

On July 27, 28 and 29 she was pushed from her nest and allowed to find her way back over the green.

July 30. The spider was taken from the box while red paper was substituted for the green around her nest, the green being transferred to a false nest in another corner. She was then put in at a distance of three inches from the green paper. She moved toward it, and stayed near it or on it for half an hour, looking at the cotton but not touching it. She then made many attempts to get under the cotton, walking over it (with difficulty) and pushing her head and first legs under the sides. She finally settled down under the edge of the green paper. At the end of an hour and a half she was guided gently to within three inches of the red paper. She looked toward it for a few minutes and then turned away. She was then guided to within two inches of it. She again looked at it, but left it, returning to the neighborhood of the green. After some time she crept on to it and tried again to get under the cotton. She was then guided to the edge of the red paper. She looked toward her nest but then turned away. She was then pushed to within half an inch of her nest when she ran to it, and beat it excitedly with her first legs. She then left it and ran to the further side of

the box, in the direction of the green paper. When five inches distant from it she paused, and then crept slowly on to it and remained quiet. She was then taken out of the box while the green paper was restored to the true nest, the red paper being put back into its former position, and the cotton nest removed. She was put back near the green paper, but wandered about the box for two hours. She then re-entered her nest and resumed the care of her eggs.

Astia vittata. 5. This spider laid her eggs in the corner of the box which was surrounded by pink paper. They were laid on August 6. On August 7 and 8 she was pushed out of the nest and found her way back over the paper.

August 9. The spider was taken out and yellow paper substituted for the pink, which was transferred to an artificial nest. The spider was put back close to the yellow paper. She ran at once toward the pink, but before reaching the edge retreated, backing away as though she noticed something wrong. She then approached again, but again retreated.

We left her in the box for two days, but she did not return to her eggs, nor pay any especial attention to the artificial cocoons.

Phidippus morsitans. 1. The spider laid her eggs on June 20, in the corner of one of our small boxes. We at once pasted pink paper around the nest. On July 21, 22 and 23 she was (with difficulty) forced out of her nest and allowed to find her way back over the pink paper.

July 24. We took the spider out of the box and substituted blue paper for the pink around her nest, pasting pink around an artificial nest which we fastened in another corner, and putting a second artificial nest in another corner with no paper around it. We then dropped her in near the cotton which had no paper around it. She did not notice it, but ran violently across the box, across the blue paper, and into her own nest. Being pushed out, and away from the blue paper, she ran onto the pink paper and all over the cotton in the middle of it, although it impeded her very much, trying to get into it or under it. After three minutes of this she went away. She soon found her own nest again and ran into it, but was again pushed

out. She ran about the box for some time, going close to the pink and to the blue paper without seeming to notice them. At last she went onto the pink paper and made two faint attempts to get under the cotton. Then she found her own nest again and worked for a long time trying to get into it from the top and through the front surface, the large opening which she had been in the habit of using being at the bottom. She not only tried to work her legs in, but seemed to be tearing at it with her falcies. Then she hung by the posterior end of her body and tried to work her head in. Failing to make an opening, she finally entered by the door at the lower end, but only stayed a minute. She wandered out and passing the plain bunch of cotton seemed to look at it, but did not touch it. After an hour she went back to her own nest, but passing over the entrance, burrowed and tore at the other parts. She seemed to have lost her wits. She finally entered at the proper place.

July 25. We found *morsitans* wandering about, and guided her toward the pink paper, which had originally surrounded the true nest. She seemed attracted and went to it, and spent fifteen minutes in investigating the cotton by means of her front legs, but did not try to get under it. She then walked slowly away. On coming within three inches of the blue paper she seemed to notice it, walked to it and put her head into the door of her nest, but then withdrew it.

She was left for several days in the box, but manifested no further interest either in the cotton or in her own nest.

Phidippus morsitans. 2. This spider laid her eggs on July 23. We at once pasted pink paper around the nest.

July 24. She was orced out of the nest by pressing a pencil on to it from above. She stayed out for two hours and was then guided back to the entrance.

July 25. When pressed out of the nest she seemed much terrified. She is more nervous than *vittata*, but at the same time is more inclined to fight, instead of running away. When she does turn tail she rushes off blindly. She stayed out so long that we finally guided her back to her nest, and even

then she burrowed and worked over it for a long time before finding the door.

July 26. She was forced out, and in twenty minutes found her own way back.

July 27. Forced her out and to the other side of the box, but she at once returned and entered the nest.

July 28. We took her out and substituted red paper for the pink, putting the pink around an artificial nest in another corner. When she was dropped into the middle of the box she at once ran to the red paper and on to her nest. She was pushed away, and then ran over the pink paper, stopping to touch the cotton with her front legs, but quickly left it and returned to the red. She stood for some time on the paper and then crawled into the nest. We then removed the pink paper and the cotton.

From this time up to August 4, the spider was forced out of her nest every day and found her way back across the red paper.

August 5. The spider was taken from the box and yellow paper substituted for the red, the red paper being put around a false nest in the corner diagonally opposite. When put back she ran to an empty corner and stood there, looking back and forth from the red to the yellow, and from the yellow to the red, for twenty minutes, lifting her head high, and really seeming to study the situation intelligently. At last she started for the red paper; then looked back, turned and went nearly to the edge of the yellow; then turned and walked slowly toward the red—backed away—approached—turned away—came back, and then retreated to the empty corner. After fifteen minutes she walked on to the red paper and approached the cotton nest with her front legs raised in the attitude of defense; then she backed off to the edge of the paper, and then again approached, as if fearing an enemy. She then left the red paper, went to the yellow, and for ten minutes seemed to be trying to get into her nest, after which she went back to the unoccupied corner. After ten minutes she walked to the edge of the yellow paper and then to the edge of the red, and then went back to her cor-

ner. Ten minutes more, and she seemed to have made up her mind, for she walked directly to her nest and entered it.

The spider now had a lesson every day for a week, being forced out of her nest and to the other side of the box, and left to find her way back. She always went back to her eggs, staying out sometimes only a few minutes and sometimes one or two hours. She took water but no food.

August 13. The spider was taken from the box and the papers around the false and the true nests were exchanged, the red being put back around the eggs, while the yellow was put around the cotton. This reversed the position that they had had since the last experiment.

The spider was then put in at the edge of the yellow paper which she was now accustomed to seeing around her nest. She remained motionless, looking at the cotton for three minutes, and then approached it with her first legs raised. She had not taken this attitude before since the last experiment, having constantly passed and repassed the cotton nest surrounded by red paper without noticing it. She walked around the cotton without touching it, then left it and went toward the red paper. On reaching the edge she turned and went back to the yellow and went close to the cotton without raising her legs, and then went back to the edge of the red paper. After standing there a moment she returned to the yellow and walked all around the cotton, feeling of it with her first legs. She then went to an empty corner of the box where she remained for thirteen minutes. At the end of this time she went to the yellow paper and took one more look at the cotton, and then turning to the red went on to it and into her nest.

Xysticus ferox. We had expected that this species would be an especially convenient one for these experiments as instead of fastening its cocoon into some corner it places it upon a flat surface and then holds on to it without any covering for itself. We thought that circular bands of colored paper could be dropped so as to surround her, and could be changed from time to time very easily, but she was timid and easily disturbed, and deserted her eggs before the necessary lessons preliminary to the experiment were over.

The paper used in these experiments was of medium weight, smooth but not glazed. The green paper in which two individuals of *Astia vittata* laid their eggs was of a light shade which did not at all resemble the green of grass or foliage, so that they cannot have chosen it as a familiar color.

Phidippus morsitans seemed to recognize her cocoon by sight more quickly than *Astia vittata*. It must be remembered, however, that she is a much larger spider and makes a very much larger nest. Moreover, the nest is not only conspicuous for its size, but is very difficult to imitate in cotton, as its silky, sticky texture catches and holds many little particles of dust and dirt, and it thus has a very characteristic appearance. One other circumstance that helped her was that she, although larger than *vittata*, was placed in a much smaller box.

The boxes in which the spiders were kept were moved about every day, so that the corner in which the nest was placed bore no constant relation to the points of the compass. This factor, therefore, could not have influenced the action of the spiders.

The idea of surrounding the cocoons with colored paper was suggested by our success with similar experiments on the nests of ground wasps. We found that if we placed a large sheet of colored paper with a hole in the middle over the entrance to the nest, *Vespa germanica* learned within a few hours to associate the color with the nest, and so strong was the association that when the paper was removed to some distance on the ground and a second sheet of a different color substituted for it, the wasps followed the paper to which they had become accustomed and were some time in discovering where their nest actually was.²¹

We have found it difficult to devise tests which will yield positive evidence concerning the sensations of spiders and especially to determine whether they have a perception of color. The experiments which we made with colored glass²² were open to objections of which we were fully conscious, and those which

²¹Some Observations on the Special Senses of Wasps. Proc. Nat. His. Soc. of Wisconsin, April, 1887, p. 91.

²²Mental Powers of Spiders, loc. cit., p. 404.

are here described are far from being conclusive, but it seems to us that since the evidence must, from the nature of the subject be cumulative, they are of value. We, ourselves, are of the opinion that all the experiments taken together strongly indicate that spiders have the power of distinguishing colors.

Milwaukee, Wisconsin, Nov. 20, 1894.