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ON THE

NEPHILA PLUMIPES:

OR

SILK SPIDER OF SOUTH CAROLINA.

BY BURT G. WILDER, S.B., M.D.,
Late Surgeon 55th Mass. Vols.

From the Proceedings of the Boston Society of Natural History,
October 4, 1865.

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Dr. B. G. Wilder exhibited specimens, living and preserved, of both sexes of a large and but little known species of geometrical spider, *Nephila plumipes*? from the coast of South Carolina, together with silk of a brilliant yellow color, which he had reeled directly from the living insect; and gave the following account of the species and of the hitherto unknown method of obtaining its silk.*

*While this was passing through the press I found in the Astor Library, New York, a copy of a rare Italian work by R. M. de Termeyer, entitled "Ricerche e sperimenti sulla seta de Ragni," in which is described his process of obtaining silk directly from spiders. But no allusion is made by others, to either the idea or the book itself, which was published about 1800. I find also that in Jones' "Naturalist in Bermuda," 1859, page 126, is described an experiment of the author for ascertaining the strength of the silk of *Epeira* (*Nephila*) *clavipes*, by drawing the silk out of its body.

By a letter written on the 20th of August, 1863, from the camp of the 55th Mass. Vol. Inf., at the north end of Folly Island, South Carolina, I find that "on that day I caught a large and very handsome spider, from which, as it stood quiet near the top of my tent, I wound off silk upon a quill for an hour and a quarter, at the rate of six feet per minute, making four hundred and fifty feet or one hundred and fifty yards."

This silk is still in my possession, but has been removed from the quill for the purpose of ascertaining its weight, which is one-third of a grain. I had never heard of this method of obtaining silk; neither had I ever seen or read of such a spider; but, though this specimen was not preserved, I was so impressed with its size and the peculiar aspect given by the brushes of stiff hairs upon the legs, that when, during the following summer, another officer* of our regiment described to me a large spider very common upon Long Island, which lies just west from Folly Island, I knew it was the same species and told him what I had done, adding that I was "sure something would come of it sometime." By substituting a cylinder worked with a crank, for mine turned in the fingers, this officer obtained more of the silk, which he wound in grooves cut upon rings of hard rubber, and in other directions upon the sides of such rings; while another officer;† by employing a "gear drill stock" with cog-wheels, accomplished similar results still more rapidly; on the first simple machine I wound off silk into two grooves cut in the periphery of a hard rubber ring, parallel except at one point where they crossed to form a kind of signet, the silk being guided at this crossing by a pin upon a pivot moved by the hand at each revolution of the ring; and on the "gear drill stock" upon a larger ring one inch in diameter and three-eighths of an inch in width, in a groove upon its periphery one-fourth of an inch in width, and across the sides of the ring in two directions, I wound *three thousand four hundred and eighty yards, or nearly two miles of silk*. This length was estimated by accurately determining the different dimensions of the ring where wound upon, and multiplying by this the number of revolutions of the cylinder per minute (170), and this product again by the number of minutes of actual winding (285), having deducted from the gross time of winding (about nine hours), each moment of stoppage for any cause.

This was in the autumn of 1864, and so the matter rested till Feb. 1865, when, preparing to present the subject to the Society, I showed specimens of the spider and silk to Professors Wyman, Agassiz, and Cooke of Harvard University, to all of whom both the species of

* Major Sigourney Wales, 55th Mass. Vols.

† Lieut. Col. Chas. B. Fox.

spider and the kind of silk were entirely new* as was also the idea of reeling silk directly from it or any other insect.

At this time too, a friend † to whom the whole history of the matter was known, expressed his confident belief that this new silken product could be made of some practical utility, especially in view of the anticipated scarcity of the ordinary silk; and it is with his advice and assistance that the experiments and investigations recounted below have been made as far as our limited time and means have allowed.

On the 30th of August, 1865, I obtained from Long Island some living specimens, chiefly females, and have succeeded in bringing a few of them to the North.

I find no mention of this spider in the works of Hentz or any other American entomologist, which may be the result of its being very circumscribed in its locality to a small and unimportant island; but in "Die Arachniden," by C. L. Koch, Vol. 6., is a figure of a mutilated female specimen, the only one ever collected, and said to have been found in Louisiana, which was preserved in the Museum of J. Sturm at Nuremberg.

The description and figure of this specimen are so unsatisfactory that I am really in doubt as to its identity with the spider under consideration, but will provisionally regard the latter as the *Nephila plumipes*, hoping at some time to settle the point by an actual comparison with the unique specimen described by Koch.

I append here a description and figure of the spider drawn from living individuals.

***Nephila plumipes* Koch.**

A large and very elegant species, resembling most of its congeners in the general form of the body, and like *N. clavipes* and *N. fasciculata* possessing peculiar collections of stiff hairs upon the legs, but differing from them in that these hairs are more closely set together, so as to justify the German term "Härbürste" (Hair brushes).

The cephalothorax is black above, but covered, except in spots, with silver-colored hairs. The abdomen is olive-brown variously marked with yellow and white spots and stripes. On the 1st, 2d, and 3d pairs of legs are one or two brushes of stiff black hairs, pointing forward away from the body. The length of the body is from 1 to 1.10 and the spread of the legs 2.75 in a lateral, and 3.75 inches in a longitudinal direction.

The above applies only to the female, which will now be more minutely described; the male is very small and differently marked.

* Prof. Wyman has since found among his alcoholic specimens of insects collected in the South, one female individual of this species, but is not certain of the precise locality in which it was obtained.

† Dr. William Nichols of Boston.

The entire upper and anterior surface of the cephalothorax is jet black, but behind the eye-spots it is thickly covered with little white hairs, except in six spots, three upon each side over the origins of the three anterior pairs of legs; the first pair of spots being the largest and pointing obliquely forward and outward. The edges of the cephalothorax are reddish-brown. The eye-spots are black and eight in number, four in the centre in form of a square, and two upon each side, one above and one below a rounded elevation. The falces are black. The abdomen above is light yellow. On each side of the middle line are six silvery spots, of which the 1st and 3d pairs are the largest, then the 2d, 4th, 5th, and 6th; the three anterior pairs are rounded, the others flattened laterally. On the middle line between the 1st and 2d pairs, and again between the 3d and 4th pairs, the pulsations of the dorsal vessel are visible; besides the larger spots there are many smaller ones irregular in size, shape and position, but more numerous anteriorly. The anterior edge of the abdomen is olive-brown; in front of and below it is a silvery cross stripe semilunar in shape, the horns pointing backward; and just behind it is a similar stripe.

The sides of the abdomen are lighter than the top and the spots are generally silver-colored and oblong, especially in the line of the horns of the above mentioned white stripe. The lower surface is still darker than the sides, but the anterior third is a hard and horny plate with a free posterior edge covering the generative orifice. The surface of this is by its coloring divisible into three sections, one median and two lateral, each of which is again composed of a broad anterior and a narrow posterior portion. The anterior median portion is brown and depressed between the lateral portions, which are black and slightly punctate and bordered internally by a yellow, and externally by a dull reddish stripe; the posterior median section is dark brown, raised and quite convex, while the lateral portions are dull red and flat, with sharp posterior edges.

The middle third of the lower surface of the abdomen is dull red without spots and separated from the sides by yellow stripes or series of spots, and from the posterior third by several yellow spots; this third is also dull red and without spots, but not so distinctly separated from the sides; behind the posterior third, and forming its boundary, is the group of spinnerets, or mammulae, of which there are two principal pairs, anterior and posterior. Between these and concealed by them is a very small pair, the nature and use of which I have not yet ascertained. In color the mammulae are dull red, but the apices are surrounded by short black hairs; behind the spinners and enclosed in the same fold of integument is a median papilla through which the excrement is voided. The posterior surface of the abdomen is flattened, and re-

sembles the sides in color and marking. The lower surface of the cephalothorax is shield or heart shaped, black in the centre but dull red at the sides.

The 1st and 2d segments (shanks) of the limbs are dull red; the 3d segment (thigh) is dirty yellow, but in the first, second and fourth pairs the distal third is dull red, and covered with a brush of stiff black hairs; the depth of the color and the size of the brush decreases from the first to the fourth pair; the thigh of the third pair is perhaps a shade darker where the brushes are upon the others. The 4th segment is dull red in all the legs; the 5th is, in all, dirty yellow as to its proximal portion (a little less than half) while the distal portion is dull red. In the third pair it presents a few scattering black hairs, but on the other three pairs there is a hair brush like that upon the thigh, completely encircling the limb, but the hairs are set a little more nearly at right angles with the surface. There are also a few black hairs on the under side just at the junction of the 5th with the 4th segments, and in the third pair a few in the place of the hair brushes on the others. The proximal portions, (again less than one-half) of the 6th segment (1st of the foot) is dark dirty yellow and the distal portion, with the 7th segment, is dark dull red, or nearly black, and both segments are covered with short black hairs. Upon the proximal yellow portion of the 3d and 5th segments are very fine short hairs, with a few longer ones intermixed.

The outer half of the maxillæ is dirty yellow, the inner half, with the 1st segment of the palpi, dull red; 2d segment dirty yellow and covered by very small black hairs, the 3d segment is dull red, likewise the 4th and 5th, the latter being nearly black and thickly covered by black hairs.

Of the eight eyes, the four intermediate ones form a square, and are set at the four corners of a prominence; the lateral eyes are set upon the extremities of two more oblique tubercles, those of each pair being separated from each other by more than their own diameter, and looking, the one downward and forward and the other upward and backward.

The body of the male is one-fourth of an inch in length, and his legs spread less than one inch in a longitudinal and three-fourths of an inch in a lateral direction. The general color of both body and legs is dark-brown, the former presenting a median dorsal stripe of a darker color, and the latter a few scattering black hairs, but no such brushes as those of the female. His palpi are strongly clavate at the middle of their length and end in a sharp point turning outward.

I have never, during a two years' stay on the coast and in the interior of South Carolina and Florida, met with any traces of this spider elsewhere than near Long Island; nor, with the exception of

the first specimen found upon Folly Island, and a cocoon found in a tree on James Island, have I seen it upon the adjoining islands, though there seems no reason why it should not also occur all along the sea-coast.

Long Island is a low, narrow, uninhabited strip of land about five miles southwest from Charleston, surrounded on all sides by creeks and in the midst of a great salt marsh. The spiders are found in the forest, building their webs between trees and shrubs, sometimes within reach, but more often ten or fifteen or even more feet from the ground so as to be reached by the sun. The web is very large, from three to four feet in diameter, quite strong and very viscid; its yellow color is seen in the sunlight, or when the web is gathered into a mass. It is composed of two kinds of silk, of which one is white or silver-gray, inelastic and perfectly dry; the other is of a bright yellow or golden hue, very elastic and studded with little globules of gum which render it exceedingly adhesive; the *frame-work* of the web, namely, the guy-lines or stays and the diverging lines or spokes of the wheel-shaped structure, is all composed of the former or silver colored, dry and inelastic silk, while the concentric circles which serve for entangling the prey are composed of the latter, or golden, elastic and sticky silk; these circles are very numerous, being generally less than one-third of an inch apart, but for the further strengthening of so large a web, between every eight or ten* such circles occurs one of the silver colored silk; these latter are made before the viscid lines, but neither of them are in the web of this species spiral, as in the web described by Blackwall and others, † on the contrary they seldom if ever, form complete circles, but are looped and return in the opposite direction into a corresponding point at the other side of the web, leaving above the centre a space occupied only by radii through which the spider can pass to either surface of her web, the greater part of which, therefore, is below the point where the radii converge, the dry lines are not destroyed on the completion of the web, but remain and seem necessary for its stability.

As might be inferred from these facts this spider not only has the power of regulating the *size* of its thread, according as one or two, or three, or four of its mammulæ are pressed upon the surface from which the line is to extend, or as a greater or less number of the spinnerules in any mammula are employed; but can also use in the construction of its web, either the white or the yellow silk at will; for of its two principal pairs of mammulæ, one, the anterior, yields the *yellow*, while the other or posterior pair yields the *white* silk. Of this I satisfied myself

*The number varies according to the individual and even in different parts of the same web.

† Zoological Journal, Vol. V., p. 181.

by carrying the thread from the anterior pair of mammulæ upon one part of a spindle and that from the posterior pair upon another, guiding them with pins while the spindle was in motion; the result being the formation of two circles of silk, one of a golden, the other of a silver color, as in one of the specimens exhibited; moreover, if while both threads are being drawn out, they are slackened, the lower silver thread will wrinkle and fly up, being inelastic, while the other will contract and, within certain limits, preserve its direction. At that time the existence of a smaller pair of mammulæ intermediate between the other two, was unknown to me, and it is possible that the yellow line proceeded from them, and that both the larger pair yield the white silk. Most of these experiments were made in the field under unfavorable circumstances and will be more accurately repeated.

The careful dissection of an alcoholic specimen will readily discover the organs from which this silk proceeds, and which have been described in other species by several authors; the preparation exhibited to the Society shows one set of silk-glands consisting of six elongated yellow bodies, more or less convoluted and measuring about one-third of an inch in length, lying under the integument of the lower surface of the abdomen, three upon each side of the middle line; the excreting ducts, one for each gland, are also plainly visible. But beside these, there are to be found at least four more glands, of which one pair shorter but thicker and larger, and also of a yellow color, are located in the upper and anterior angles of the abdomen; while the other two glands are white, or transparent, and lie nearly in the center of the abdomen; the ducts of all these glands are easily traced to the region of the spinnerets, but I have not yet observed the precise mode of their termination. It will be noticed that the yellow silk is secreted in greater abundance, as also that it is more extensively employed in the construction of the web.

All these glands contain a semi-fluid and very viscid gum which may be drawn out into threads of variable diameter; these however, being single and not, like those spun by the spider, minutely compound, break up on being sharply bent.

A familiar, but thus far unexplained, fact is, that while the yellow thread as spun by the spider in its web is so exceedingly viscid on account of the numerous globules of gum with which it is studded, as to follow the point of a pin, this same yellow silk when reeled from the insect, whether slowly or rapidly, and also when employed by the spider to form the cocoon about her eggs, is perfectly dry and much less elastic and yielding, though still more so than the white variety. I have put several specimens under the influence of chloroform which apparently has no effect upon the evolution of silk.

I have never been able to reel above three hundred yards of silk from

a spider at one time; but this evidently does not exhaust the supply, for on opening the abdomen the glands are still partially filled and the following day a quantity equal to the first may be obtained; this I did upon three successive days, so that, if, as now seems probable, the emission of the silk is mainly mechanical, then a certain degree of preparation is necessary after it is secreted before it is ready for use.

The diameter of the silk as spun by the insect or as reeled from it, varies from $\frac{1}{1000}$ to $\frac{1}{10000}$ of an inch; * it is exceedingly strong, but I have not yet been able to accurately determine its strength as compared with fine ordinary silk. The largest threads are those composing the outer layer of the cocoons, but these are evidently compound, and the two, three or four strands are apparently such as proceed from the single spinners, the minute fibrils of which have united at once on leaving the spinnerules so as to form the ordinary silken fibre which generally appears simple under the microscope.

Having completed her web, the female stations herself at its centre head downward, waiting for prey; the diminutive male (they are not constantly present) preserves a respectful distance from her, and, as far as I have seen, never attempts to do anything for himself, except of course the impregnation of the eggs; he builds no web and catches no prey; and while she is moving from place to place, or even while making her web, he gets upon the upper or lower side of her abdomen holding on with his legs and darting about to keep out of the way of hers; for she seems to pay no attention to him and might easily do him an injury even by accident.

On one occasion I saw a male stray away from his proper home to an adjoining web, from which, however, he was speedily driven by the indignant female possessor, with the loss of two of his legs; of which injury he shortly afterwards died.

In the webs of these spiders are found insects of all kinds, even the largest and most vigorous, such as the great cicada of the South. When anything strikes the web, the spider instantly starts, and, if the vibrations indicate that it is suitable for food she rushes to it and seizing it in her powerful jaws holds on till it is dead; after which she throws a net around it and carries it to a place where she can devour it at her leisure; in this respect unlike some other geometrical spiders, of which one species, common on James Island, S. C., never attempts to seize the prey with the jaws till it has first dexterously spread a net over it by turning it over and over with the first and third pairs of legs and, with the fourth pair, used alternately, drawing out the silk as a broad white band.

But if the violent struggles of the prey show it to be of large size, then our spider advances with caution, feeling with her anterior legs,

*The micrometer measurements were made by Mr. E. C. Greenleaf.

and if satisfied that she can do so with safety, will suddenly close with the victim; but if not, or if some foreign body is placed in the web, then she will snip off with her jaws every line which supports it till it drops to the earth; this I saw done by several spiders, which had made their webs in my room in South Carolina, with a dead snake six inches in length.

It is remarkable, that although these spiders possess eight eyes and can evidently distinguish light from darkness, yet, so far as my observation goes, they cannot see anything at all whether near or remote; they pay no attention to an object put close to them nor to the quiet movements of any one about them, and will often rush by an insect entangled in their web if it chance to cease its struggles before the spider has accurately determined upon its position; it will then slowly return to the center of the web and wait till another vibration indicates the whereabouts of the insect; a fly offered to it upon the point of a needle will not be noticed till it begins to buzz, when it will be seized at once; the hearing and touch are evidently very acute; the organ of the former sense is not known; the latter is exercised by the palpi and by the extremities of all the legs, especially those of the first pair, which are continually used as feelers. How acute the sense of smell is I do not know.

This spider is remarkably quiet in its habits, never leaving its web unless disturbed in some way, and it bears handling better than any species with which I am acquainted. That it can bite is evident from the size of the jaws and the firmness of their hold, and that the venom is active is shown by the speedy death of its victims;* but they never attempt to bite unless provoked, and may be allowed to run over one's flesh with impunity, care being taken not to remove them from it suddenly or roughly for they are apt to hold on with the jaws when the grasp of the legs is not sufficient. The length and comparative weakness of the legs renders it easy to put this spider in the only position in which any spider can be safely handled, namely with all the legs held behind the back. In their webs they are active and sure-footed, but slow and awkward on the ground or any plane surface. They always prefer the light, and construct their webs where the sun can reach them; the young manifest the same instinct and always seek the sunny side of a glass vessel containing them; they also keep the

*Blackwall, (Linn. Transactions, Vol. xxi. page 81-87) recounts experiments to support his opinion that the bite of the larger British species causes no more injury to man, to other spiders, or to insects than an ordinary puncture or laceration of equal extent and severity; and the same author in his Spiders of Great Britain and Ireland, Part 1, p. 2, does not even mention the word *poison* in speaking of the colorless fluid emitted through the falces, but although we seldom hear of well authenticated cases of injury from the bite of a spider, it would hardly be safe to suppose all of them harmless.

head downward and will instantly turn over if the vessel containing them be inverted.

The eggs are laid in a rounded, or flattened mass about one half an inch in diameter; they are .04 to .05 of an inch in diameter, white and at first slightly agglutinated together, but become yellowish and easily separable as the time for hatching arrives, which, in the case of some eggs laid this fall was in about thirty days; the young spiders are yellow with whitish legs, which however soon become darker in color while the abdomen presents some faint markings on its surface; some have cast one skin within a few days and can spin a thread within a week after leaving the egg; but of their own accord they do not leave the cavity of the cocoon for some time, during which, as far as I know, they take no food, excepting perhaps that they devour one another, but seem to undergo an increase of the legs and cephalothorax at the expense of the abdomen; but for some reason, whether on account of the elements, or birds, or other insects, or the attacks upon one another, I cannot say, only five or six out of the five or six hundred hatched in any one cocoon ever come to maturity in the natural state.

The mass of eggs is enclosed in a loose silken cocoon, the threads of which are very large and strong, especially the outer ones, which are $\frac{1}{1000}$ of an inch in diameter while the interior ones are $\frac{1}{2000}$ of an inch in diameter; this cocoon weighs from .320 to .655 of a grain.

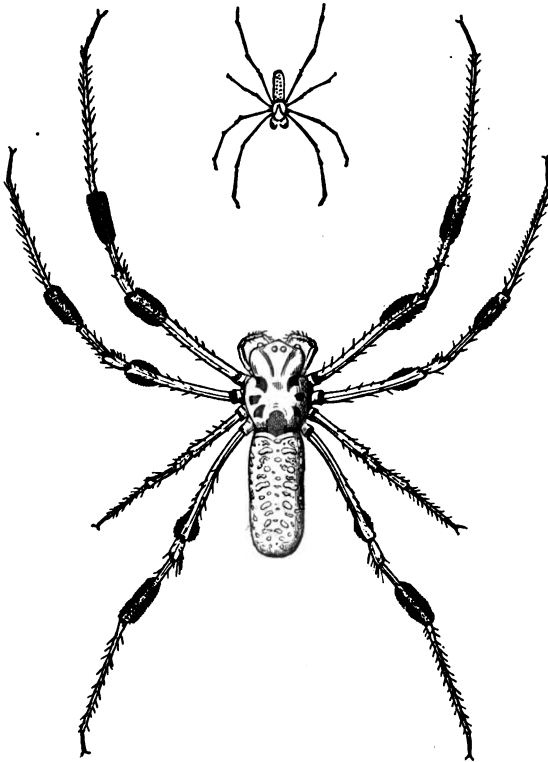
The grown females, which I have kept alive for one month or more, in boxes or in webs constructed in my room in South Carolina, have all readily taken, from the point of a needle, live flies or bits of fresh chicken's liver, from which they suck the juices; they likewise take water from the point of a stick or hair pencil, holding the drop between the palpi and the jaws while it is slowly swallowed; one spider has thus taken six drops of water in succession.

Much more might be related concerning the habits of the insect, of the manner of keeping and feeding the young, of the means of securing the spider while its silk is obtained, and of the various apparatus employed; but I am so impressed with the peculiarities thus far observed in themselves, and with the beauty and strength of the silk that if time and means permit, I shall continue the inquiry as far as possible, and will defer to a future occasion a more complete account of the spider, its habits, anatomy and embryology, and of the various qualities of its silk, with whatever conclusion can be reached concerning the practicability of rearing the young, and also how far it is possible to apply the same method of extraction to the silk worm, and other silk producing larvæ.

NOTE. April 2d, 1866. Some of these spiders, hatched in October, 1865, are now more than an inch in length.

It is but recently that I have had the benefit of an acquaintance with the investigations of others upon the economy of the geometrical spiders; and in the entire absence of any American works on this subject, I will refer to the memoirs of Blackwall and other British naturalists published in the Linnæan Transactions, Vols. xvi., xviii., and xxi., in the Zoölogical Journal, Vols. iv. and v., in the Transactions of the Entomological Society, Vols. i., ii., and iii.; Entomological Magazine, Vols. ii. and iii., and Reports of the British Association for 1844 and 1868. The earlier papers are quoted in Kirby and Spence's Entomology, while a brief synopsis of nearly all is contained in the introduction to Part 1. of Blackwall's Spiders of Great Britain and Ireland, published by the Ray Society in 1861 and 1864.

Many of these opinions have been confirmed by my observations upon the *Nephila plumipes*, and where it is otherwise stated, the differences may sometimes (as with the construction of the webs, mentioned above) be in consequence of specific peculiarities.



Nephila plumipes Koch.

The smaller figure, the male; the larger, the female.



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