Spiders / by Cecil Warburton.

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C. WARBURTON

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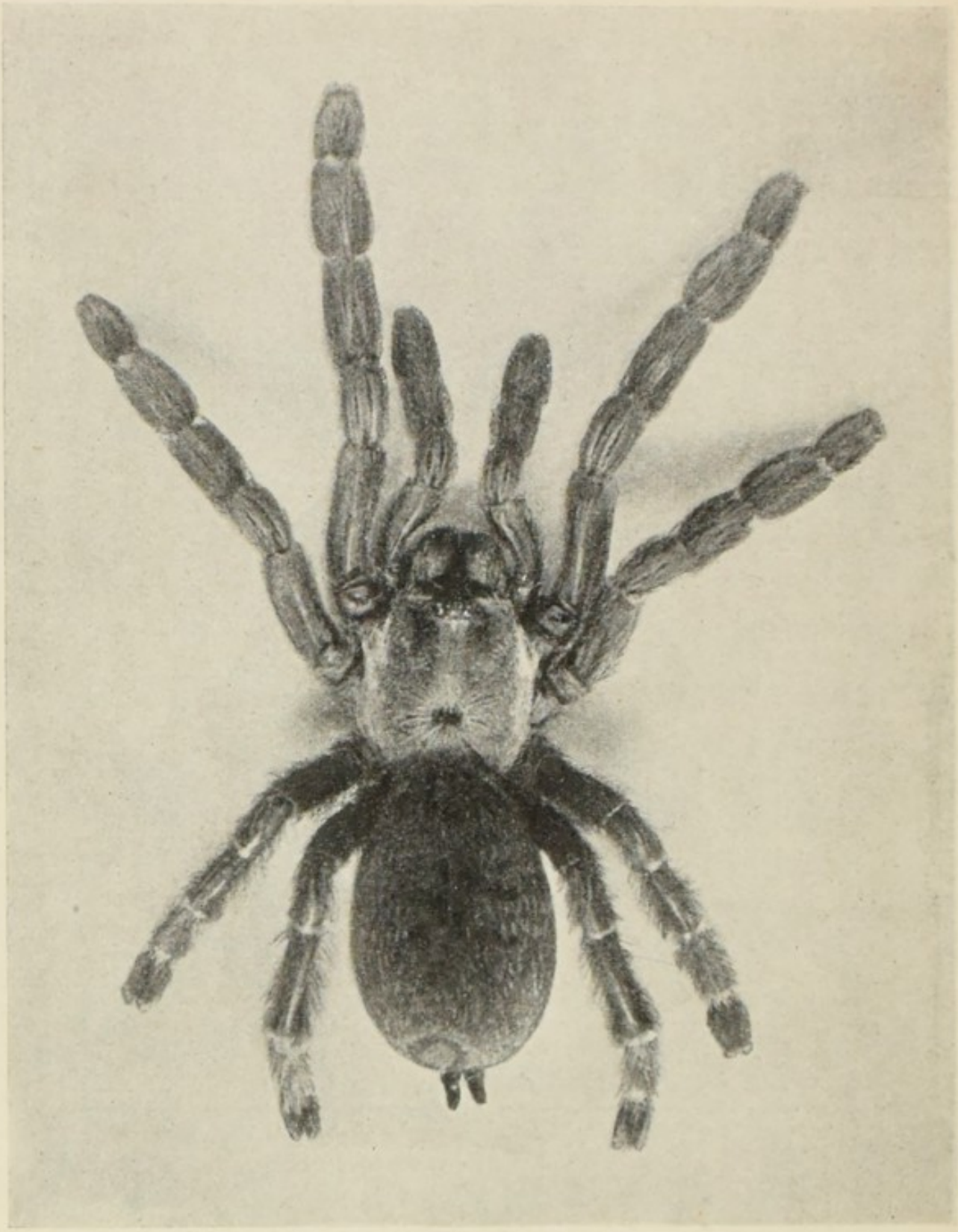
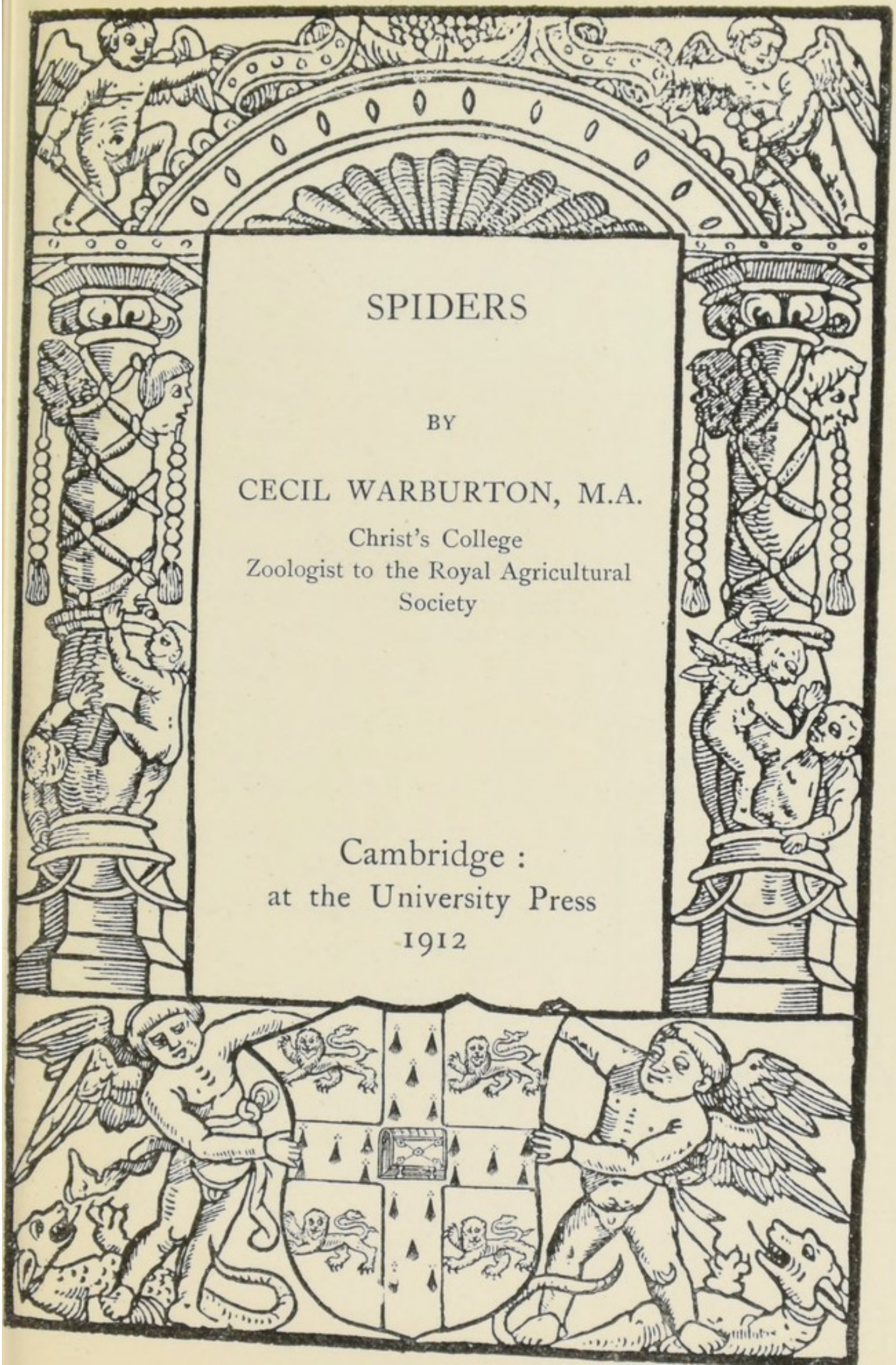


The Banana Spider, natural size, from a photograph by Mr James Adams.



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PREFACE

THE modest dimensions of this book are perhaps sufficient indication that it is not intended as an aid to the collector. There are about five hundred and fifty known species of spiders in the United Kingdom alone, and at least an equal number of pages would be needed to describe them.

Our concern is with the habits and modes of life of spiders—especially of such as are most frequently met with and most easily recognised, and the reader, especially if he is fortunate enough to spend an occasional holiday in southern Europe, will find little in the following pages which he cannot verify—or disprove—by his own observations. Indeed the hope that some of his readers may be induced to investigate on their own account has actuated the writer throughout, and has led him to lay considerable stress upon the methods of research and the ingeniously devised experiments by means of which whatever knowledge we possess has been obtained.

CECIL WARBURTON

CAMBRIDGE
March, 1912

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CHAPTER I

A SURVEY OF THE FIELD

THERE are certain days of the year when the immense wealth of spider industry going on all around us is revealed in a way calculated to strike even the least observant. We all know—and derive no peculiarly pleasant thrill from the knowledge—that we can, if so minded, find abundance of cobwebs and their occupants by visiting the cellar or the tool-house; and probably we have all at times noticed, with a languid interest, large circular webs on our favourite rose-bushes, with a spider motionless in the centre.

But some spring or autumn morning, when the night has been foggy and the sun has only just succeeded in dispersing the mists, every bush and hedge is seen to be draped, every square foot of lawn and meadow to be carpeted with spiders' silk. There has been no special activity in the domain of these creatures, but every silken line is beaded with drops perhaps fifty times its diameter, and what yesterday

required careful observation to detect is now visible yards away, and we realise for once something of the prodigious activity constantly going on though ordinarily unnoted.

And it never entirely ceases. True hibernation, if it ever occurs, is not the rule among spiders, and there is no time of the year when some species may not be found at work. Beat trees or bushes over an old umbrella, or sweep grass and herbage with a sweeping net in summer, and you will never draw a blank—some spiders are sure to be found. In winter such measures are profitless, but if you take the trouble to grub among ground vegetation, or shake fallen leaves over a newspaper, or search under stones or logs of wood you will have no difficulty in finding spiders enough, and by no means dormant. I have even seen an enthusiastic collector remove inches of snow and disinter rare species from among the roots of the grass beneath!

Spiders, then, are plentiful enough, and it is not only individuals that are numerous but there are vastly more kinds or species than most people dream of. The Rev. O. Pickard-Cambridge, in a book under the modest title of *The Spiders of Dorset* indispensable to all British collectors, quaintly observes that most of his friends claim acquaintance with three kinds of spiders—the garden spider, the harvest spider and the little red spider—two of which, as it

happens, are not spiders at all. Yet the British List contains about five hundred and fifty species, and the spiders of the world, though only very partially investigated, already include many thousands of known and described forms.

In this little work we shall not at all consider the spider tribe from the collector's point of view. We shall concern ourselves rather with habits and modes of life and such structural modifications as are correlated therewith. Certain well-defined groups of spiders we shall recognise, but specific names will interest us little. And we might do worse than step out on such a spring morning as we have imagined and rapidly survey the field which lies open for our investigation.

First, then, examine a little more closely one of the garden bushes in which the spiders have been so busy, and the chances are that three different types of snare will be readily distinguishable. There are sure to be some of the familiar wheel-like snares of *Epeira*, but note also the fine-spun hammocks of *Linyphia* with stay-lines above and below, and the irregular labyrinths of *Theridion*, its lines crossing and recrossing without apparent method. These are sedentary spiders, and always to be found at home. All spiders spin for some purpose or other, but these—or at all events *Epeira*—have brought the art to its highest perfection. Leave them for the present

and examine a sunny wall or fence. You may chance to see a little zebra-striped, flat-bodied spider exploring the surface and directing its opera-glass-like eyes in all directions in search of prey. This is one of the Attidae or jumping spiders—few and sober-coloured in this country, but extraordinarily abundant and often extremely beautiful in tropical regions. Pause at the iron railing before leaving the garden and observe how the topmost bar and the knobs which crown the uprights are alive with spiders, mostly very small, and obviously of many different kinds, extremely busy about something that it may be worth while to investigate later; then go on into the lane, and note, in the banks of the hedgerows the great sheet-webs and tubes of *Agelena*, a near relative of the house-spider, but with a cobweb, thanks to its situation, comparatively free from accumulations of dust and filth.

The creatures skipping, dry-shod, on the surface of the river or pond, though often called water-spiders, are true insects. The real water-spider, *Argyroneta*, which, though air-breathing, spends most of its time below the surface of the water, is not to be found everywhere, but there are many riparian species which are semi-amphibious in their habits and have no objection to a wetting.

Finally, turn into the wood and look carefully on the ground, especially where last year's leaves are

still lying. You are certain to see a few—and may very likely see countless myriads—of sober coloured, rapidly moving "wolf-spiders" (Lycosidae), roaming in quest of food. No stay-at-homes, these, but rovers, trusting to speed and agility, and not to guile, for their food supply.

All the spiders we have observed so far are in active pursuit of their daily business, but if we turn over stones, or logs, or look under sheets of loose bark, we shall find others, quiescent for the moment, but waiting for nightfall to begin their operations.

But we have probably seen enough to show that a pretty wide field for investigation lies immediately at hand, and that a detailed study of what we have cursorily glanced at will occupy us so long that we shall have little time for considering the spiders of other lands. In the first place, however, we had better make quite sure of what is meant by a spider.

CHAPTER II

WHAT IS A SPIDER?

Not many years ago the group Insecta was held even by Zoologists to include numberless small creatures—centipedes, spiders, mites, etc.—which further study has shown to present essential differences of structure, and in popular language

any fairly minute animal is still an insect, just as any insect is popularly a "fly"—or, in the United States, a "bug." Scientifically the use of the term Insect is now much restricted, though still extensive enough in all conscience, since it includes many more than a quarter of a million known species. Zoologists recognise a large group of animals characterised by having no internal skeleton but a more or less firm external coating of a peculiar substance called *chitin*, often strengthened by calcareous deposits, which necessitates the presence of joints in their bodies, and especially in their limbs if they are to move freely, just as medieval suits of armour required to be jointed. These are the Arthropoda. One subdivision of this group consists of aquatic animals, breathing by gills, and known as Crustacea. Crabs, lobsters, shrimps and "water-fleas" are familiar examples, and with the exception of the so-called land-crabs the only Crustaceans habitually found on land are wood-lice.

The other Arthropoda are air-breathing, and since their characteristic breathing organs are branching tubes known as *tracheae*, the term Tracheata is sometimes used to include them all. They fall naturally into three divisions, the Myriapoda, the Insecta and the Arachnida, and it is in this last-named division that we shall find the spiders.

The Myriapoda are the centipedes and millipedes,

and having said this we may dismiss them, for insects and arachnids are strictly limited as to legs; and no myriapod can ever be mistaken for a spider.

The Arachnida are so varied in structure that it is not easy to give characteristics common to them all, and to any general statement there are bound to be exceptions, but for practical purposes it may be said that while an insect, when mature, has only six legs, and a pair of feelers or antennae of quite different structure, Arachnids have normally eight legs, and their feeling organs are not antennae but leg-like "pedipalps."

Most insects are distinguishable at once by the possession of wings, which are never found among the Arachnida, and they generally undergo a marked transformation or metamorphosis in their progress from the egg to maturity, taking on at first the form of a caterpillar or grub and then that of a chrysalis; but as there are many wingless insects and many in which the metamorphosis is very slight, the test supplied by these characteristics is only of partial application, and we shall do better to rely on the number of legs, and the nature of the feeling organs. If, therefore, we find a small wingless animal with eight legs and a pair of feelers which are not thread-like but much of the same character as the legs, though not used for locomotion, we may be sure that we are concerned with an Arachnid.

But is it a spider?

Now some groups of the Arachnida may be put out of court at once as having an appearance so characteristic that no confusion is possible. Such are the Scorpions, and the minute Chernetidea or "False Scorpions," but this cannot be said of the Phalangidea or "harvestmen" or of the Acarina or "Mites," members of which groups not only may be, but frequently are popularly taken for spiders. In fact the Phalangidea are very commonly spoken of as "harvest spiders" and the "red spider" is a mite. A very brief inspection, however, with a pocket lens will settle the matter without the least difficulty.

A spider's body consists of two parts, a cephalothorax (head + thorax) and an abdomen. There is a waist, but no neck. The eight legs are attached to the cephalothorax, and the abdomen is not segmented or ringed like that of an insect, but entire, and bears at its extremity or on its under surface a little group of spinnerets or finger-like projections from which the spider's silk proceeds. For the moment these three characteristics will suffice—the "waist" behind the leg-bearing portion of the body, the unsegmented, legless, abdomen, and the spinnerets (fig. 1 *B*). A harvestman, for instance, lacks the waist, and its abdomen is segmented. Mites are of very varied form and in some the body is more or less divided into two portions, but at least two pairs of legs will be found

to be attached to the hinder portion; and neither harvestmen nor mites possess the spinnerets which

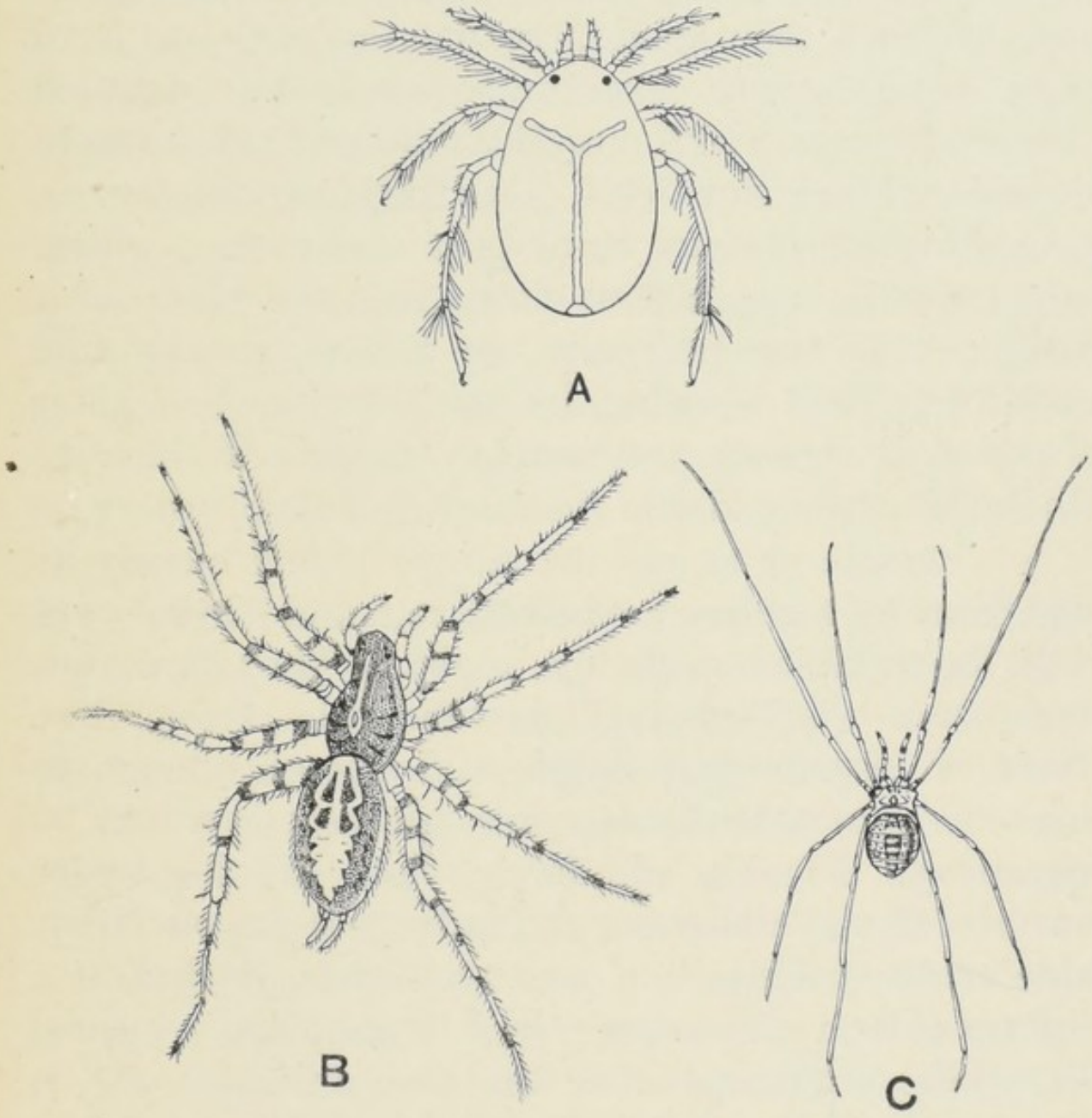

Fig. 1. *A*, a Mite; *B*, a Spider; *C*, a Phalangid.

are the most striking characteristic of the spider; some mites—like the "red spider"—can spin, but

the mechanism by which that operation is performed is of quite a different nature.

Having, then, very readily determined our specimen to be a true spider, we may as well use it to note some further structural points the detailed examination of which may be deferred till we have considered their functions. Note the jaws or *chelicerae*, consisting of a stout basal part and a fang which, when not in use, is shut down like the blade of a knife; note the pedipalps or feelers, exactly like small legs, but showing by their action that their function is sensory and not locomotor. If they are knobbed at the end, the specimen is a male, otherwise it is a female or as yet immature. Look closely at the front part of the cephalothorax, and several eyes will be visible—probably eight. They are not compound—divided into innumerable facets, like those of insects—but simple and smooth, though to make sure of this the use of a microscope would be necessary. Finally, obtain a view of the under surface of the abdomen, and note in front, on either side of the middle line, two semilunar patches of a lighter colour. These are the "lung-books,"—special breathing organs peculiar to these animals; two is the usual number, though certain spiders possess a second pair behind the first.

But the spinning mammillae or spinnerets are still more characteristic and more easily seen, though,

curiously enough, it is not among the cleverest spinners that they are most conspicuous. In the family to which most of the cellar spiders belong (Agelenidae) and in the elongate brown or mouse-coloured spiders found lurking under stones (Drassidae) they are visible as little finger-like projections at the posterior end of the abdomen, but if we have taken our specimen from a circular web (Epeiridae) we shall have to look for them more closely. In these spiders they are beneath the abdomen near its termination, and are not visible from above. Moreover when at rest their tips are applied together so that they form a small rosette in surface-view, or, in profile, a slight cone.

The best way to capture a spider for examination is to induce it to run up into a small glass specimen tube—for spiders readily part with their legs if handled roughly—and if we have adopted this method we shall see the spinnerets in use as the animal crawls about the tube. It will not move without first attaching a silken cable to the glass, and this cable lengthens as the spider progresses, so that before long the interior of the tube will be a network of silken threads, and its sides will be flecked with little white specks where the threads have been re-attached for a new departure; and by observing closely we shall be able to note the extreme mobility of the spinnerets in action.

All spiders spin, but it is by no means all spiders that make snares for the purpose of catching prey. The fundamental purpose of the spinning organs seems to be to connect the spider with its point of departure. The jumping spiders (Attidae) make no snare, but this "drag-line" as it has been called comes in very useful when stalking prey on the vertical surface of a wall, when a miscalculation at the moment of pouncing upon it would entail a considerable fall were it not for such an anchorage. It can hardly be doubted—though of course it is incapable of proof—that all the more complicated spinning operations originated in this universal spider habit, but all known spiders have learnt to apply their power of making silk to other purposes. If they do not make snares they at least spin "cocoons" for the protection of their eggs, and if they have a definite home from which they emerge to seek food, such a retreat is always more or less lined with silk. It is clear that a spider cocoon is quite different from that of an insect; it encloses the eggs and is manufactured by the mother, whereas among the insects the larva makes the cocoon for the protection of the pupa or chrysalis into which it is about to turn. However far from exhaustive the foregoing study of spider structure may be it will suffice for our purposes, at least for the present, and we may proceed at once to an investigation of one of the

most remarkable achievements in the way of spinning —the familiar circular snare or wheel-web of the garden spider.

CHAPTER III

THE CIRCULAR SNARE

SELECT the most perfect circular snare at hand, and examine it attentively. In the autumn, when the large garden-spider, *Epeira diadematа* (fig. 2 *A*), is mature, it will probably be easy to find such a snare a foot or more in diameter. It is stretched within an irregular frame of *foundation lines* of extra thickness and strength, and consists of a large number of radii or spokes connected by what appear to be a series of concentric circles, in reality a continuous spiral, like the hair-spring of a watch. The central portion is different from the rest of the wheel. Probably in the very centre there is a vacant space and round this a hub, consisting of a spiral line different in appearance from that of the main spiral. It does not leave a radius exactly at the point where it trikes it, and the rather zig-zag effect has caused it to be known as the "notched zone." Touch the web and it adheres to the finger, but all its lines are not adhesive. Test this with some fine-pointed

implement, and the foundation lines, the radii and the notched zone will give negative results; the spiral line alone is viscid, and its viscidity is due to the presence of thousands of little beads of gummy matter strung on a thin elastic thread. The vast number and uniformity of these beads—estimated at 120,000 on a large web—excited the wonder and admiration of naturalists until it was proved that they were not deposited by the spider as beads at all, but as a uniform coating of viscid matter which subsequently arranged itself into equidistant globules easily explicable by the physicist. Indeed precisely the same phenomenon is seen on a dew-laden web, where similar but very much larger beads of water decorate all the lines.

From the hub of the wheel we shall very likely notice a rather stout cable diverging from the plane of the snare and leading to a nest of leaves spun together. Here the spider is to be found when not on duty in the centre of the wheel, and here it constructs its egg-cocoons.

This, then, is the complete circular snare, but we shall understand it much better if we watch the spider at work in its construction.

The first business of the spider is to lay down the foundation lines. Any sort of trapezium—or even a triangle if large enough—in a more or less vertical plane will suffice, and under some circumstances the

Fig. 2. *A*, the Garden Spider. *B*, diagram of a sector of the snare. *f*, foundation line; *r*, radius; *v.s*, viscid spiral; *n.z*, notched zone; *h*, hub.

operation is simple enough. The spider attaches a line at the point of departure and crawls along, spinning as it goes and holding up the newly-spun thread by the claws of one of its hind feet, till it reaches a suitable spot for its farthest limit. It then hauls in the slack and makes it fast. It will probably return along the line thus laid down—still spinning—to the starting point, thus doubling the strength of the cable, and indeed a large spider will often repeat this operation several times. Now the upper boundary of the future web is secured. It is next necessary to find points of attachment for the lower boundary, and the spider either drops or climbs down—always carrying a line—from one of the ends of the upper line till it reaches a spot suitable for its purpose, and the previous performance is repeated. If there is any difficulty about a fourth attachment it is always open to the spider to climb back along the two lines already laid down, and by carrying a loose line with it, to secure at all events a triangular frame-work. This frame-work, whether trapezoid or triangular, will be re-inforced several times and made thoroughly trustworthy before the work of making the actual snare is proceeded with.

Now the foregoing operation is obviously perfectly simple in certain cases, as, for instance when a spider has chosen lattice work, or the mouth of an empty barrel as its "pitch," but snares may easily be found

in situations where such a mode of procedure seems impossible. In a pine forest, for example, one may see huge webs stretched at a great height from the ground between boles ten feet apart; or one may find such a snare spread across a stream at a spot where the trees on either side do not intermingle their boughs. How in such cases does the spider accomplish its purpose?

There is little doubt that, wherever practicable, the spider walks round, sometimes crawling quite an astounding distance, but that it can at need, resort to another method, is easily proved by a very simple experiment in the house. Fill any vessel—a basin or a bath—with water and arrange an upright post in the middle, placing a spider upon it. If the air in the room is absolutely still the captive is powerless to escape, but if draughts are present it will sooner or later disappear; and it accomplishes this feat by emitting a thread which, caught by the air-current, is drawn out from its spinnerets till it by and by becomes entangled in the surrounding furniture. This power of emitting silk to some little distance and allowing the wind to draw it out is, as we shall see, frequently exercised in the early life of many spiders.

The foundation lines which may thus have given the spider great trouble to secure, are of extreme importance to it, and may serve for several snares in

succession. There is little hesitation or delay about the subsequent operations. The spokes of the wheel are readily formed by carrying lines across to opposite points of the frame-work and uniting them where they intersect. They are laid down in no special order, but more or less alternation is generally noticeable—apparently for the purpose of keeping the tension equally balanced—and the spider will occasionally desist in order to go and brace up the frame-work with additional stays, which generally have the effect of converting it to a polygon.

Before long the requisite number of fairly equidistant "spokes" or radii are visible, and then the spider, starting from the centre, rapidly spins a spiral thread consisting of a few coils only, to the circumference, stepping from spoke to spoke. This is only a temporary scaffolding and will not be suffered to remain in the completed snare. If the structure is touched at this stage of the operations it does not adhere to the finger; the viscid spiral remains to be laid down. Though it does not hesitate for a moment, the spider now works with a peculiar deliberation, but the operation will be much better understood by actual observation than by any amount of description, and we shall only recommend the reader to note that the new spiral is exceedingly elastic and that at the moment of its attachment to a spoke it is stretched and let go like the string of a

bow. The spider seems carefully to avoid treading on it as it proceeds, utilising the non-viscid spiral scaffolding already described.

A little attention to the centre of the wheel, and the snare is complete. Some species of *Epeira*

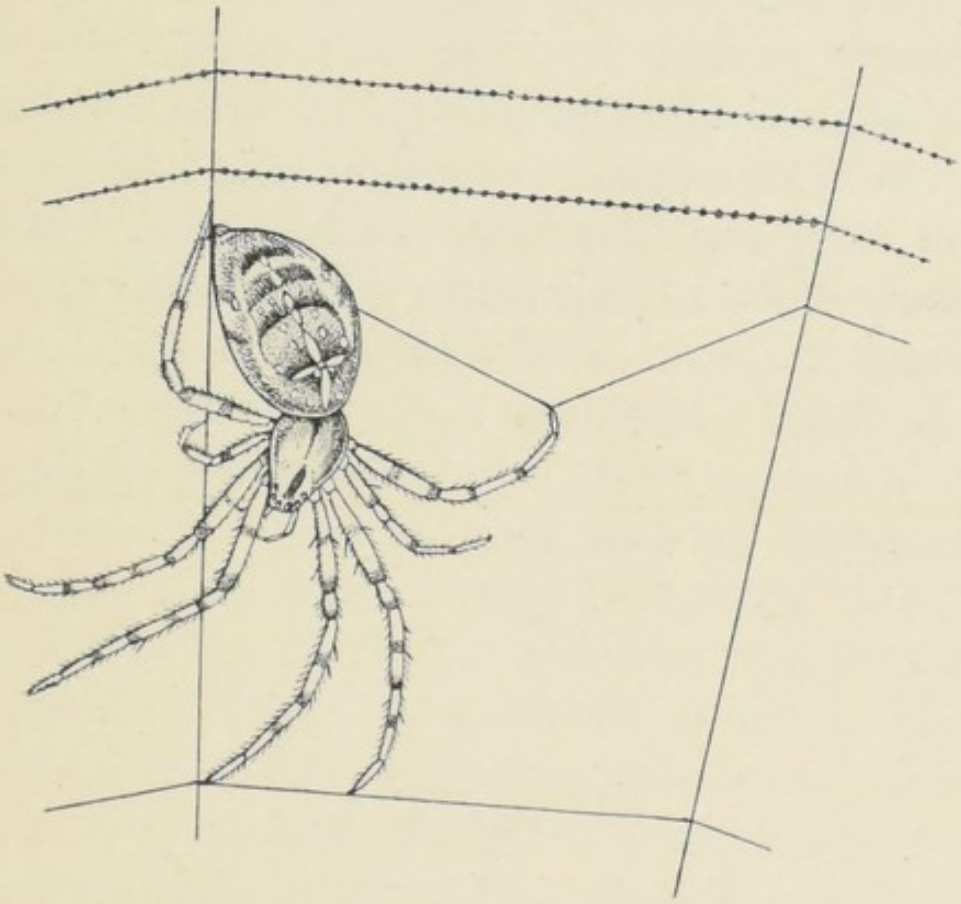

Fig. 3. Stretching the viscid spiral.

entirely remove the centre, leaving a circular empty space, while others fill it with an irregular network of threads.

How does the garden spider avoid getting caught in its own web? We have shown that there are many lines which are not viscid, and no doubt these

are utilised as far as possible, but it can hardly happen that the spider never touches adhesive portions of the web with legs or body.

Possibly some explanation is furnished by an ingenious experiment which Fabre performed. He found that a glass rod, lightly smeared with oil, did not adhere to the viscid spiral; neither did a leg freshly taken from a garden-spider unless allowed to remain in contact for a considerable time. When, however, this leg had been washed with bisulphide of carbon, which dissolves any kind of oily substance, it adhered at once. It would seem likely, therefore, that the legs and body of the spider itself are protected by some oily exudation from any danger of adherence to its own lines.

CHAPTER IV

MENTAL POWERS OF SPIDERS

BEFORE leaving the garden-spider let us undertake some little investigation of its mental powers—if it possesses any. The commonest mistake with regard to all animals is to interpret their actions from the human standpoint, and to credit them with emotions and with deliberate forethought of which there is in

reality no proof whatever. The power to spin such a complicated snare as we have just described predisposes us to attribute a high order of intelligence to a creature capable of such an achievement, and when it "shams death" on being disturbed we immediately pronounce it "cunning." The wildest conclusions are sometimes arrived at. One author, for instance, states that he has seen an Attid spider "instructing its young ones how to hunt" and adds that "whenever an old one missed its leap, it would run from the place and hide itself in some crevice as if ashamed of its mismanagement." Such inferences, of course, were entirely unwarranted from the facts observed. Now the fact that a newly-hatched garden-spider can make a complete snare without ever having seen the operation performed immediately relegates that action to the realm of instinct,—not less wonderful than intelligence perhaps, but certainly quite distinct from it. With the much discussed origin of instinct we are not here concerned, but a pure instinct differs from intelligence in this: that it is due to inherited nervous mechanism and results in actions the object of which may be quite unknown to the actors. There is no conscious adaptation of means to an end. When a young spider spins a web there is not only no evidence that it does so with the deliberate purpose of catching flies, but many known facts go to prove that it performs the feat, "because it feels as

if it must," and is quite ignorant of the purpose to be subserved.

It is no doubt quite beyond our power to ascertain accurately the mental condition of a spider, but it is perfectly easy to make a few illuminating experiments on two points which have a very decided bearing on intelligence :—the development of the senses, and the degree of what has been called *educability*, or the power of learning from experience. To what extent can the spider see, hear, smell, feel, taste? How far is it capable of varying its action as the result of experience? The senses, as far as we know, are the principal—if not the only—avenues by which external impressions can reach the seat of intelligence, and there is no surer indication of the intelligence of an animal than the degree to which it is susceptible of education. Probably most readers know the immortal story of the pike cited by Darwin in the *Descent of Man*. The pike was in an aquarium, separated by a sheet of glass from a tank in which were numerous small fish. Not till three months had expired did the pike cease to dash itself against the glass partition in its attempts to seize the fish in the neighbouring tank. It then desisted and had evidently learnt something—but what? After three months, the glass partition was removed, but the pike refused to attack those particular fish, though it immediately seized any new specimens introduced to the tank. All

that it had apparently learnt was that an attack on a particular fish resulted in a violent blow on the nose. Some degree of intelligence must be conceded to the pike, but it can hardly be considered of a high order.

Now the garden-spider possesses eight eyes, and might be expected to see fairly well, but the experimenter will very soon come to the conclusion that the habitual use it makes of them—at all events in day-light—is very slight. Touch a web with a vibrating tuning-fork and the spider will rush to the spot and investigate the instrument with its fore-legs before distinguishing it from a fly. Remember, however, that this is only true of what are sometimes called sedentary spiders; species which hunt their prey have much better vision. Yet even among sedentary spiders the power of sight is not negligible, for a most trustworthy observer states that he has several times seen *Meta segmentata*, a very common small Epeirid, drop from its web to secure an insect on the ground beneath, and return with it by way of the drop line, and the same action has been observed in the case of *Theridion*, which spins an irregular snare.

There are peculiar difficulties attending experiments on the subject of hearing. An absolutely deaf person may be aware of the sounding of a deep organ note through the sense of feeling, and a well-known

experimenter was on the point of drawing interesting conclusions from the behaviour of a spider in response to the notes of a flute, when he found that precisely the same results were obtained by a soundless puff of air. It seems hardly possible to make sure, in the case of a spider in a snare, that the sound vibrations are not *felt*, apart from any sense of hearing, and it is a remarkable fact that it is only the snare-spinning spiders that make any response to sounds:—free-roving spiders are apparently quite deaf.

In experimenting with sound we must take two precautions: the instrument used must not necessitate any marked action which may be visible to the spider, nor must it give rise to palpable air-currents. These requirements are best met by a tuning-fork of not too low a pitch. We cannot *feel* the air vibrations emanating from it, but can only perceive them by the ear, but we have no proof that the spider's sense of touch ceases precisely at the same point as our own. However, no better instrument for experiment seems to be available, so we take a tuning-fork, and approach it cautiously—in the quiescent state—towards the spider, stationed, we will suppose, in the centre of its snare. No notice is taken, and we carefully withdraw it, set it vibrating, and approach it again in the same manner. There is now generally a response, the spider raising its front legs and extending them in the direction of the fork, or, if the

sound is loud, dropping suddenly by a thread and remaining suspended some inches below the snare. The experiment should be repeated several times with the fork sometimes still, sometimes vibrating, and the conclusion arrived at will be that the spider is aware of the vibrating fork—but by which sense? It is noteworthy that a fork giving a low note is always most effective.

Now here is a very remarkable fact. In two widely different groups of spiders—the Theraphosidae or so called "bird-eating spiders" and the Theridiidae—there are species with a stridulating or sound-making apparatus, and we should hardly expect a deaf creature to evolve an elaborate mechanism for the production of sound. This is a matter, however, that we shall discuss later.

No amount of research has succeeded in localising the sense of hearing in spiders, supposing it to exist. The creature may lose any of its five pairs of limbs (four pairs of legs and one pair of pedipalps) without alteration in its response to sound. If the front legs are missing the second pair are raised when the vibrating fork is approached.

It is fairly easy to test the sense of smell in these creatures, the only necessary precaution being that no acid or pungent substances capable of having an irritating effect on the skin, such as vinegar or ammonia, must be employed. Such perfumes as

lavender or heliotrope are free from this defect. Take a clean glass rod and present it to the spider as before, and no notice is taken. Now dip it in oil of lavender, allow it to dry, and present it again. Most spiders respond to such a test, Epeirids generally raising the abdomen, and rubbing one or other of the legs against the jaws, while jumping spiders generally raise the head and back away from the rod. Different essences produce different effects, but there is seldom any doubt that the creature is aware of their presence; it is not deficient in the sense of smell, but its localisation has hitherto baffled research.

The sense of taste does not seem to have been made the subject of any definite experiments among spiders, though such experiments might well lead to interesting conclusions, and the reader might do worse than undertake some on his own account. It would be easy, for instance, to supply a garden-spider with various insects which are generally rejected by other insectivorous animals, and to note its behaviour. It might refuse to have anything to do with them, or it might sample them and turn away in disgust. In the first case the explanation might be that it was warned of their probably evil taste by their coloration or smell, but in any case here is an interesting little field for research. It is the general belief among arachnologists that the sense of taste is well developed among spiders, and it is highly improbable

that a sense so necessary for the discrimination of suitable food should be lacking in animals with so respectable a sensory equipment.

There is no doubt at all that the sense of touch is extremely well developed in spiders, especially perhaps, in the sedentary groups, and it is probable that, under ordinary cirumstances, the garden-spider works almost entirely by its guidance. Whether in the centre of the web or in its retreat under a neighbouring leaf it is in direct communication with every part of its snare by silken lines, and the least disturbance usually suffices to bring it to the spot; and then, as we have said, it will generally touch the disturbing object, however unpromising in appearance, before deciding on its line of action. There is little doubt that many of the numerous hairs and bristles with which its limbs are furnished are distinctly sensory in function.

So much, then, as to the senses of spiders; but what about their "educability"—their power of learning from experience? Here is evidently a wide subject, and a difficult one full of pit-falls for the unwary, but we may nevertheless draw some inferences from the quite elementary experiments on the senses which have been outlined above. A spider drops on account of the sounding of the tuning-fork in its neighbourhood; can it be educated to take no notice of the sound after repeatedly finding that no evil

consequences follow? It will perhaps be most instructive to give in a condensed form the results of an actual experiment selected from many performed by two American arachnologists, George and Elizabeth Peckham, whose researches have thrown more light than any others upon the mental equipment of spiders. They had an individual of the small Epeirid species *Cyclosa conica* under observation for a month, and tested it almost daily with the tuning-fork. At the sound of the fork the spider would drop ; when it had recovered itself and returned to the snare the fork would be sounded again, and so on. Now on July 20 the spider fell nine times successively—the last three times only an inch or two—and then took no further notice of the vibrating fork. On subsequent days, until August 5, she fell either five, six or seven times, except on two occasions when a day's test had been omitted, and then eleven successive falls occurred before the spider ceased to respond. On August 5 she seemed startled at the sound but did not fall, though the fork was sounded nine times. During the remainder of the experiment she generally remained perfectly indifferent to the fork, though on one or two occasions she partially forgot her lesson and dropped a very short distance, immediately recovering herself.

Observe that the basis of educability is memory. For a fortnight, in the case of this particular spider,

the lesson learnt on one day seemed to be entirely forgotten the next morning, but thereafter a definite change of habit seemed to result. This does not appear a very great intellectual achievement, but it is by no means despicable, for it must be borne in mind that the habit of dropping when alarmed is almost the only means of defence such a spider possesses, and the instinct which prompts it must be very strongly ingrained. In the words of the experimenters—"Taking this into consideration, it seems remarkable that one of them should so soon have learned the sound of the vibrating fork, and should have modified her action accordingly."

This single experiment has been here described in some detail largely for the purpose of impressing the reader with the importance of reducing the problem to its simplest terms before any inferences are drawn, and it may well act as a model for any which he may be inclined to undertake on his own account. The more complicated the action, the more likely is the experimenter to read into it motives and mental operations which exist only in his own imagination, and with this warning we must take leave of a subject which might tempt us to encroach too much on an allotted space.

CHAPTER V

TRAP-SNARES AND BALLOONS

THERE are some interesting variants of the circular snare spun by some exotic Epeirids. One North American species spins it in a horizontal position and then raises the centre, and, by an elaborate system of stay lines from above, converts it into a very accurately shaped dome. A whole group of orb-weavers habitually decorate a sector of the snare with bands of flocculent silk, the object of which for a long time puzzled arachnologists, till it was observed that the spider drew upon this reserve supply of material to wrap up particularly obstreperous insects. It is not unusual for a spider of one of the common species to remove a whole sector of the snare, and by stretching a line from the centre to a place of retreat along the gap thus formed, to provide an unencumbered avenue between its home and its post when on duty. For it must not be forgotten that a spider has to walk warily on its own web, and must avoid, as far as possible, treading on the adhesive lines, or delay and damage to the structure are sure to ensue.

As a rule the circular snares of the different British species are of a very uniform pattern,

differing chiefly in the degree of neatness with which they are constructed, and in certain minor details of the "hub," but we have one spider, *Hyptiotes paradoxus*—an exceedingly rare species, scarcely ever seen beyond the limits of the New Forest—which makes such a strange snare that it seems a pity to omit all mention of it. It consists of a sector—about one sixth of the full circle—comprising about four radii with cross lines. From the point where the radii meet, a "trap-line" connects the sector to another point of attachment; on, or rather under, this trap-line, the spider takes up its position, hauling it in so as to tighten the web and to leave a slack portion of the line between the points where it holds on by its front and hind legs. When an insect impinges on the web and causes it to tremble, the spider immediately lets go with its fore legs, and the consequent vibration of the web helps to entangle its prey.

The circular snare is the highest form of spinning work attained by spiders, and there is little temptation to expend much time in studying the cruder structures that meet the eye everywhere, but two other types are worth a brief notice. Examine any garden bush—particularly a holly bush, of which the rather rigid leaves provide excellent points of support—and you will find numberless small webs made without any discoverable method, the lines crossing

one another at random in all directions. These are the snares of some species of *Theridion*, and if the webs lack interest the spiders themselves are worth looking at, for they are nearly always quite prettily ornamented.

The other common type of snare is that of *Linyphia*. It is larger and of more definite design, consisting of a finely-spun hammock stretched horizontally, and surmounted by a labyrinth of irregular lines. Flies entangled in the labyrinth fall upon the hammock in their struggles to escape, and the spider is at hand—always on the under surface of the hammock—to ensure their capture.

Having noted these three common types of snare, let us leave the garden and choose a new field for our observations.

If it is an absolutely calm sunny October morning it will be a suitable occasion for visiting an iron railing, the "knobbier" the better. Early summer will do, but late autumn is generally more fruitful. Almost any railing will serve, but the most satisfactory kind is one with the uprights surmounted by round knobs, and not by spikes. We see at once that the knobs, and the upper rail are glistening with silken lines; many spiders have obviously been at work there. Lines streak the top-rail in all directions, stretch from knob to rail, or from knob to knob if not too distant, while here and there loose ends or streamers

flutter gently in the slight currents of air. And closer inspection reveals various small objects moving among this labyrinth of threads. Most of them are spiders, though insects, and particularly weevils, are not wanting. No doubt the weevils know their own business, though the writer has not been taken into their confidence, but the spiders are the particular object of our investigation. And first of all note that it is a veritable race-congress of spiders; the most varied groups are represented. Wolf-spiders (Lycosidae) which under ordinary circumstances rarely leave the ground are found in company with crab-spiders (Thomisidae), jumping spiders (Attidae), as well as Epeiridae and Theridiidae of which we already know something. They have only one thing in common—they are either small species or small and immature specimens of larger species. They seem to be scrambling about in a meaningless sort of way, paying little or no attention to each other—which is odd, for spiders are terrible cannibals, and as a general thing it would be exceedingly unsafe for a small spider to rub shoulders with a larger one of a different species.

The majority of them are very small, more or less black, Theridiid spiders, the "micros" of the tribe, and their proper home is among the roots of grass and herbage. Many of these are interesting objects for the microscope—especially if males—because of

the remarkable protuberances or turrets which rise from their heads and bear their eyes as on a watch tower.

These spiders are clearly not "out" for food; they have left their ordinary beat for quite another purpose, and we shall probably not have to wait long before discovering it. Some one of the group ceases its apparently purposeless wandering, and, turning its head in the direction of what slight wind there is, raises its fore-body to the full extent of its straightened legs, and elevates its abdomen to the utmost. Now watch closely—using a handglass if you have one—and you will see streamers of silk proceeding from its spinnerets. They are shot out for a short distance and then the air current draws them out further till they often extend for several feet, though their extreme fineness makes it almost impossible to form an accurate judgment of their length. Meanwhile the spider has not merely been standing on its "toes,"—it has been firmly gripping the silken lines on the railings with its claws. Soon it feels the pull of the streaming threads, and when the tension is sufficient it lets go with all its claws simultaneously, vaults into the air and sails away. Sometimes a start is made prematurely and the insufficient buoyancy of the streamers causes the spider to descend almost at once, and a new start is made.

This, then, is the habitual method by which new

broods of spiders distribute themselves, especially the sedentary kinds which would otherwise soon become over crowded in the neighbourhood of the parent nest. And we really need not have sought out a railing at all except for its very great convenience of observation. The same thing is going on every-

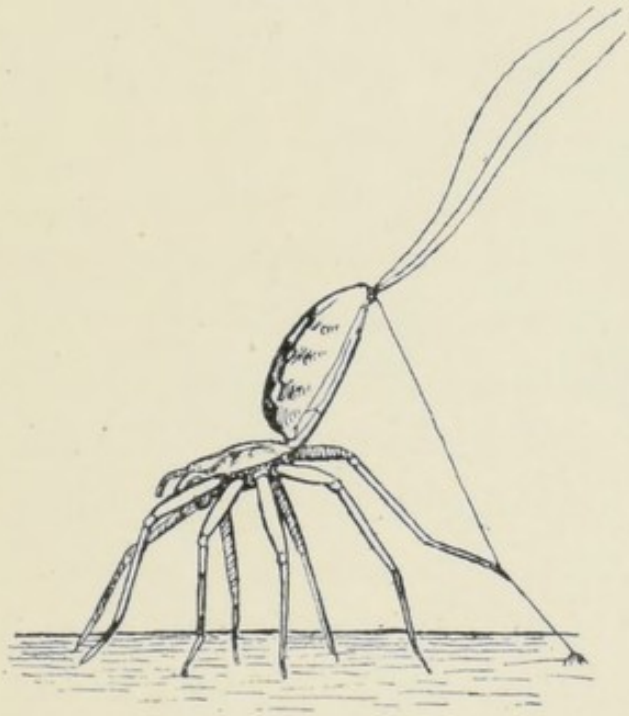

Fig. 4. Young spider preparing for an aerial voyage.

where. It largely accounts for the astonishing carpet of silk that the dew reveals to us on lawns and meadows at such times of the year. Young spiders have been busy from early dawn crawling over the grass, climbing the higher blades, and setting sail, and the whole field is covered with their lines. Railings come in handy as furnishing an elevated

starting point, but any shrub or bush will do, and young spiders have been seen setting sail from the parent web itself.

McCook has given some interesting notes of his own observations on aeronautic spiders. He followed an Attid spider fifty feet till it was carried upward out of sight in a current of air. A Lycosid disappeared in the same way after being followed—at a run—for a hundred feet. The largest Epeirid he ever saw taking flight was "the size of a marrowfat pea, say one-fourth of an inch long. After having floated over a field and above a hedgerow, it crossed a road and anchored upon the top of a young tree." But perhaps his most interesting observation was on the ability of spiders to control in some measure the duration of their flight by reefing their sails if they wish to descend, for he saw a ballooning spider collecting some of the streamers into a ball of silk which accumulated near its mouth as it gradually sank to earth.

The phenomenon known as "gossamer" has puzzled people for centuries, and English poetical literature is full of allusions to it. Chaucer classes it with "ebbe and floud" as an unsolved riddle, and Spenser, Quarles and Thomson all make mention of it, generally embodying the popular belief that it somehow had its origin in dew. "Scorchèd deaw" Spenser calls it, while Thomson's expression is "dew

evaporate." The phenomenon in question is the occasional appearance of vast numbers of silken flakes which fill the air, and which in some recorded instances extend over many square miles and to a height of several hundred feet. Our observations will have given a clue to its origin which is entirely attributable to spiders, and in large measure to their ballooning habit, though no doubt reinforced by a large quantity of silk spun for other purposes and caught up into the air by the breeze. For a vivid account of such a shower the reader is referred to Letter LXV of White's *Natural History of Selborne*, and Darwin in his *Naturalist's Voyage* (Chap. VIII) records a case of the "gossamer spider" descending in multitudes on the "Beagle" when sixty miles from land.

In the ballooning habit we have the probable explanation of the wide distribution of certain species of spiders which seem at first exceedingly ill adapted for covering large distances. The Huntsman Spider, *Heteropoda venatorius*, is practically cosmopolitan in tropical and sub-tropical regions and the usual view has been that ships have conveyed it from port to port. McCook, however, gives several reasons for believing that the trade winds have much more to do with the matter, and this may well be the case, though both agencies have doubtless been at work.

Very likely it was not obvious to the reader why he was recommended to select a particularly calm, sunny autumn day for his study of spider aeronautics; a strong steady breeze might well appear more suitable for the purpose. Yet he would find these operations at a standstill on a windy day, and the best possible conditions are a still warm morning after a spell of cooler weather. The lightest air-currents serve to float the delicate silken threads, and, what is more important, the increase of temperature causes an upward draught which rapidly carries the spider to a useful height where it sails gently away instead of being swept roughly over the surface of the ground.

CHAPTER VI

AGELENA

BEFORE going farther afield, let us investigate one of the spinners of the sheet-webs that are so unpleasantly familiar in the house. We object to them on very obvious grounds, first as evidence of neglect and bad housewifery, and secondly as repulsive objects when covered by accumulations of dust which their firm texture and their durability make inevitable.

The common house-spiders belong to the family Agelenidae. It is quite likely that their original home was in a warmer climate where they lived out of doors, but that was long ago, and now they uniformly select buildings of some sort for their operations. They have, however, even in this country, several open-air cousins, and most people know the great sheet-web spider of the hedge-rows, though its name—*Agelena labyrinthica*—may be new to them. Its web consists of a closely woven wide-spreading sheet connected with a tube of even denser material, in the mouth of which the spider may generally be seen lurking, a rather sinister object. If a better view of the animal is desired it is only necessary to agitate the web slightly and the spider runs forward to investigate. It is a large species as British spiders go—about three quarters of an inch in length—with the abdomen rather prettily marked with oblique white streaks.

It is very unlike our garden spider in certain points of structure; its body is more elongate and rather rigid, with little play of action between the cephalothorax and the abdomen; its legs are notably long, and so are two of its spinnerets, which can be seen protruding beyond the abdomen as we look down upon it.

But we shall gain little information by looking at the completed web, and our best plan is to take

the animal home and observe it in captivity. We have prepared for its reception a box about a foot square, with a gauze top and a movable glass front.

It is not such an easy matter to secure the spider, which can run like a lamp-lighter, and which has a way of escape at the lower end of its tube. The safest way is suddenly to shut off this means of retreat with the finger and thumb of the left hand and simultaneously to present a glass phial at the mouth of the tube ; the spider runs up into it and is taken without the risk of injury. It is never advisable to handle spiders, not because any British species is formidable, but because they so readily part with their limbs in order to escape, and the chances are that only a mutilated specimen will be obtained.

Now *Agelena* does not seem to be a particularly engaging pet, but it has its points. In the first place, it very quickly makes itself at home ; a short time is spent in exploring its new quarters, but it adapts itself almost at once to its changed situation. Moreover it is of a peaceable and domestic disposition and the male and female live amicably together, which is far from being the case among the Epeiridae, whose peculiar marital relations are often—quite wrongly—attributed to the whole tribe of spiders. A male garden-spider courts the female at the risk of his life, and it is not surprising that he should evince

great hesitation and caution in his advances. If his attentions are unwelcome, or even if they have been accepted, he will be promptly trussed up and eaten unless he beats a hasty retreat. But with *Agelena* the conjugal relations are exemplary, and harmony reigns in the home. The question of food is certainly a difficulty, but if insects are let loose in the cage the spider will attend to the catching of them. In some cases raw meat has been found a satisfactory substitute.

After a brief exploration of the box the captive soon becomes busy, going to and fro across its cage and attaching lines to the sides at some height up from the floor. So fine is the work that for a long time hardly anything is visible, and the movements of the animal are the only clue to what is taking place. By and by it becomes evident that a sort of skeleton platform has been spun across the box, upon which the spider is able to walk. It is continually strengthened by new threads, and braced by stay-lines above and below. It has been hardly possible to follow the operations by which this has come about, and even now we are chiefly aware of the existence of the platform because we see the spider walking upon it; its movements seemed very scrambling and unmethodical, but they have resulted in the foundation of the sheet-web and its terminal tube. But now it begins to behave quite differently,

and another phase of the work has clearly begun ; it crawls about over the almost invisible foundation lines with a most curious gait, using its long legs to sway its body from side to side, raising and depressing its abdomen at intervals, and as this motion continues a beautiful gauzy sheet of incredibly fine texture gradually grows into view. What is happening is that the spider is strewing over the foundation lines multitudinous threads from its long posterior spinnerets, which are beset on their under surface with numbers of hair-like spinning tubes from each of which the silk is issuing. All day long the process goes on, and by slow degrees the web increases in density. Indeed for days after the structure is complete the spider spends odd moments in going over the ground again till the sheet, and especially the tube proceeding from it to a corner of the box, are so closely woven as to have become almost opaque, and its occupant at length appears to be satisfied with his handiwork, and retires into the tube to wait patiently for casual visitors.

July is a good month in which to experiment with *Agelena*, for if the captives include female specimens some further spinning operations of a very complicated description may be observed. The time of egg-laying is at hand and elaborate preparations have to be made, but if the experimenter wishes to see the whole process he must be prepared to sacrifice his

night's rest, for the most critical part of the performance takes place in the small hours of the morning. We will describe what occurred in the case of one *Agelena*.

The approaching oviposition was heralded several hours beforehand by the animal commencing to weave a hammock-like compartment from the roof of the box and above the sheet-web. This chamber was about four inches long and was constructed precisely in the same manner as the sheet, to which it was braced by lines from various points of its under surface. Its construction occupied the whole day previous to the laying of the eggs, and not until half an hour before midnight was it completed. Within this compartment, close to the roof, the spider next wove a small sheet one inch long, working diligently in an inverted position, ventral surface upwards. After a quarter of an hour it rested for an equal space, apparently exhausted by its prolonged efforts. An hour and three quarters intermittent work served to complete the sheet, the spider varying the monotony of its sinuous walk round this small area by occasionally walking over it and strengthening the lines which attached its angles to the roof.

A marked change now became observable in the manner of working. The animal abandoned its incessant to and fro motion but began to jerk its body up towards the sheet, throwing silk strongly against

it. At the same time the posterior spinnerets were actively rubbed together and the long posterior spinnerets separated and brought together again with a scissor-like action. The result of this performance was to invest the under surface of the small sheet

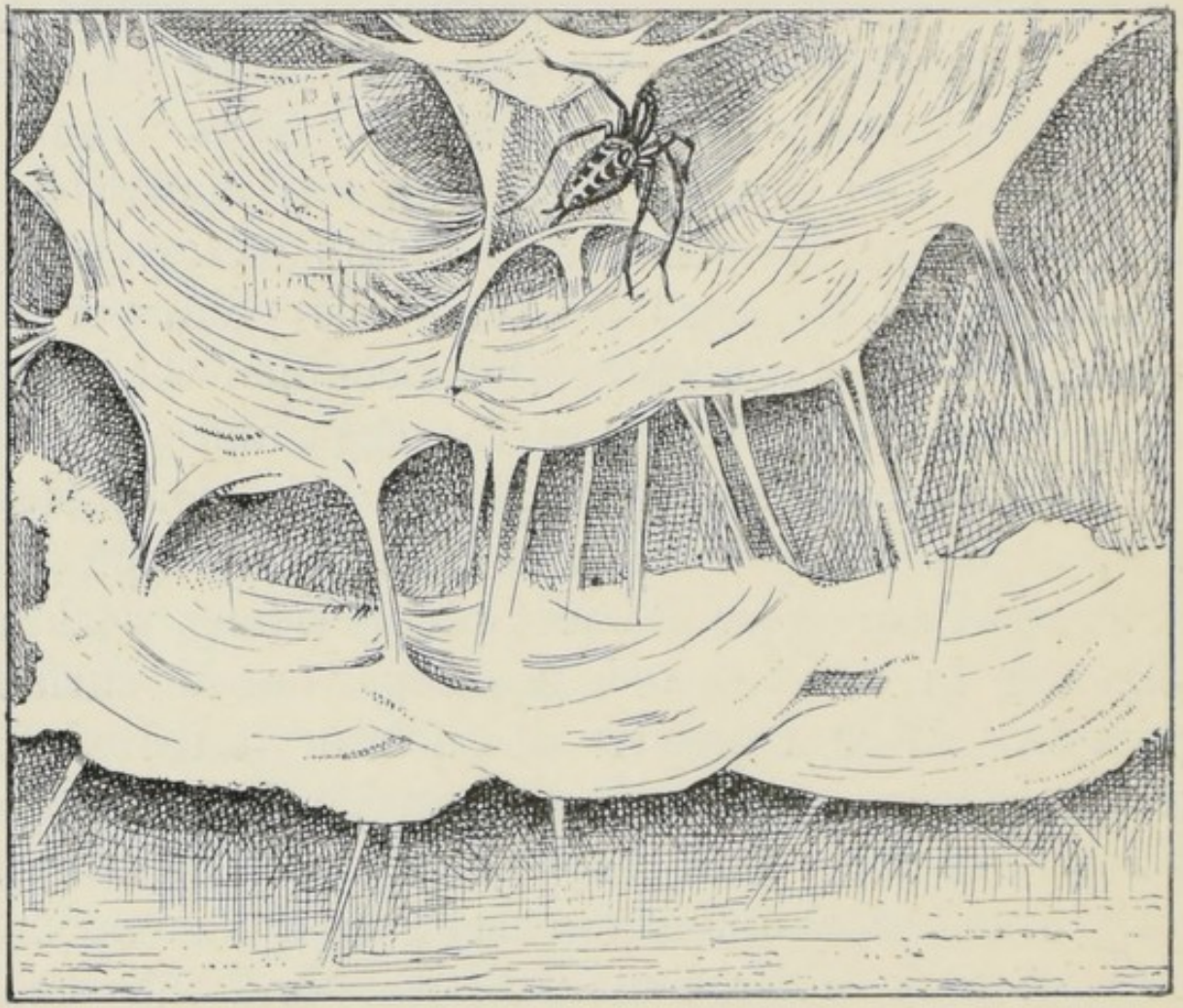

Fig. 5. *Agelena* weaving her egg-cocoon.

with a coating of flossy silk quite unlike the ordinary web in texture, the purpose of which soon became evident, for at about a quarter past two the spider began to deposit its eggs *upwards*, against this loose-textured silk, aiding the egg-mass to adhere by

occasional upward jerks of the body. This occupied between five and ten minutes, and as soon as it was accomplished the under surface of the egg-mass was covered by a layer of flossy silk similar to that against which it was laid, the eggs being thus entirely enveloped in a coating of soft loose-textured material. This was next covered in by a sheet of firm texture like that of the original web.

It might be supposed that the work was at length finished and that a well-earned rest might be enjoyed, but this was far from being the case. The spider remained as active as ever though an hour or two passed before the object of its industry was evident. All this time it was incessantly climbing backwards and forwards between the egg-sheet and the hammock and generally scrimmaging round in the most unaccountable way, but it gradually became evident that the eggs were being enclosed in a wonderful transparent box of filmy silk with the egg-bearing sheet for its roof. By nine o'clock it was of moderate strength and opacity, and the spider, having worked "the clock round," no longer laboured continuously. Days elapsed, however, before it was entirely finished to the satisfaction of the spider, which remained all the time in close proximity to the box and could with difficulty be frightened away, but clung tenaciously to it when interfered with.

Now this remarkable performance, which any

reader endowed with sufficient patience may observe for himself, gives food for thought. The spider has never seen a cocoon constructed and has no model to work by, and yet it performs with absolute precision all the stages, in their proper succession, of a work which involves quite a number of different spinning operations, nor does the absence of light by which to work trouble it in the slightest. It seems hard to believe that this is not a sign of high intelligence and that the spider is probably quite unconscious of the object for which it has laboured so long and so aptly. But how otherwise explain this curious fact? If the eggs are removed the moment they are laid the work is continued precisely as if they were still there. The box is laboriously built round the place where they ought to be, and the spider refuses to budge from the empty casket, though there is no longer any treasure to guard.

Clearly as the egg-laying time approaches the spider feels an irresistible blind impulse to perform in a definite order certain complicated actions. It is like a machine actuated by an internal spring, and in the spider's case the internal spring is the inherited nervous mechanism we call instinct, which urges it to actions which it is not in the least necessary that it should understand.

CHAPTER VII

WATER-SPIDERS

HERE is the place to insert a short account of some near relations of *Agelena* which we shall certainly not meet in our walk, but of which the mode of life is too interesting to be altogether passed over in silence.

We have seen that the class Crustacea (crabs, shrimps etc.) is the great division of the Arthropoda entirely adapted to an aquatic life, breathing, by means of gills, the air which is dissolved in the water. Insects and spiders are air-breathing, and properly belong to the land; yet there are many insects which pass their early stages—often the greater portion of their life—in the water, and some which are very fairly at home there when adult. Such insects often have gills when young, and are therefore at that period true water animals, like the Crustacea.

The Arachnida—that division of the Arthropoda to which the spiders belong—include a few groups which permanently inhabit the sea, and could not live on land. There are even some weird creatures called Sea-spiders (Pycnogonids), but these do not concern us, for they are very far removed from the true spiders which are the subject of our investigations.

Now the true spiders are always air-breathing, and if they venture into the water at all they must frequently come up to the surface to breathe, or else they must store up a reservoir of air beneath the surface of the water if they are to avoid death by drowning. Nevertheless some of them have been hardy enough to encroach on the domain of the Crustacea. Not a few are able to run freely on the surface of the water and even to dive occasionally for the purpose of seizing one of its denizens, but the number of those which have succeeded in really adapting themselves to aquatic life is very limited, and is, as far as we know, restricted to two small groups, both of them members of the Agelenidae.

Among the coral reefs of the Indian and Pacific oceans, and also off the southern coast of Africa there are found spiders of the genus *Desis* which spend almost all their time under the surface of the sea, from which they only emerge at low tide. They construct very closely woven tents, impermeable to sea-water, which imprison air at low tide, generally choosing for the purpose some cavity which has been excavated by one of the burrowing molluscs. Beyond this we really know very little about them, and there is much difference of opinion as to the mode in which they obtain their food. Some writers state that they only leave their shelters at low tide to chase small crustaceans, and that when placed in vessels containing

sea water they are quite helpless and soon drown. On the other hand one observer found that a species of *Desis* was quite at home in a sea-water tank, in which it swam freely and even attacked and fed upon a small fish. Possibly different species of the genus behave in different ways, some being more truly aquatic than others, though it is certain that the troubled waters of a coral sea are not a very promising field for sub-aqueous operations. We know a great deal more of the mode of life of those Agelenids which have taken to living in fresh water. Indeed the subject of the water-spider, *Argyroneta aquatica*, is so hackneyed that in dealing with it we shall probably be telling the reader much of what he knows already, but that possibility must be risked.

There is, then, in many of our lakes, ponds and slow-flowing rivers with a weedy bed, a spider which has entirely taken to a water life, and for which it is useless to search on land. It is a docile captive, and consequently a favourite subject for transference to an aquarium, where its habits can be observed at leisure. Its first care is to construct beneath the water a small dome-shaped web, open below, and it generally selects the under surface of the leaf of a water weed for the purpose of anchorage, though a ready-made shelter is often furnished by the empty shell of some fresh-water mollusc. Its next proceeding is to fill this retreat with air in a very ingenious manner.

While swimming about in the water the spider has a most striking appearance, its abdomen almost resembling a globe of quicksilver. This is because the body is enveloped in a bubble of air, retained largely by the long hairs with which it is clothed. Thus it carries its atmosphere about with it, and as often as not it swims with its back downwards, which has the effect of bringing the bulk of the air-bubble towards its ventral surface, where the breathing pores are situated. Now when the dome-shaped web is ready to be filled with air the spider rises to the surface, lifts its abdomen above it, and brings it down with a flop, thus imprisoning an extra large air-bubble which it embraces with its hind-legs by way of holding it more securely, and then, swimming rapidly down by means of its other legs to the web it discharges its load of air beneath the downwardly directed mouth of the dome.

By a frequent repetition of this process the dome is at length filled and converted into a veritable diving-bell, in which the spider can exist quite comfortably until the supply of oxygen in the imprisoned air is exhausted and has to be renewed. From this base it issues forth to feed upon fresh-water insects and crustaceans, sometimes even attacking small fishes.

The proceedings of the male *Argyroneta* in the mating season are very curious. He seeks out the

tent of a female and sets up his own establishment—generally somewhat smaller—close at hand, filling it with air in the approved manner. He then builds a sort of corridor uniting the two domes, and when this is complete he bites through the female dome, thus uniting the two air reservoirs by means of a connecting tube. Not seldom it happens that the female is in no mood for dalliance, and a battle royal ensues, with disastrous results to both domiciles and the tube that connects them. The male, however, is in this case well able to hold his own, for he is larger than the female, a phenomenon elsewhere unknown in the spider realm. *Argyroneta* lives for some years, and makes two diving-bells each year—one near the surface in summer and one at a greater depth in winter. It was thought at first that one was constructed especially for receiving the eggs and the other as a habitation, but the egg-cocoon may be found in either, for there are two broods in the course of the year. The winter dome is of very dense silk, glossy in appearance, and giving the effect of a uniform sheet of silky material rather than a fabric. Moreover its mouth is closed, and the spider remains inactive within. It is this winter domicile that is most frequently found in the shells of molluscs. The egg-cocoon is also dome-shaped, having a convex upper and a flat under surface. The newly hatched young inhabit their mother's tent for a time and then

set forth in the water to seek their living and set up establishments on their own account.

There is only one known species of *Argyroneta*, widely distributed in the temperate regions of Europe and Asia. The female is about half-an-inch long, of no particular beauty out of the water, its colour being reddish-brown, and its body and legs very hairy. There are, however, a few New Zealand spiders rather closely allied to it and of very similar habits.

CHAPTER VIII

CRAB-SPIDERS. MIMICRY

ALL spiders can spin, but by no means all use that power to entrap their prey. Many have no settled abode or resting place except perhaps for a short time when they are rearing their young. Among these roving tribes, there are three groups which may engage our attention for a time—the Crab-spiders (Thomisidae), the Wolf-spiders (Lycosidae) and the Jumping spiders (Attidae).

Crab-spiders are seldom seen by the ordinary observer, for their habits do not bring them prominently into notice, and many of them are of small size. They are well named, for their is something exceedingly crab-like in their appearance and

in their actions. Their body is generally broad and flattened, and their legs, instead of being arranged fore and aft, like those of most spiders, extend more or less laterally, and though they can move pretty actively in any direction their normal method of progression is sideways. Then again, when frightened they cramp their legs up under their bodies in a most crab-like fashion and "sham dead."

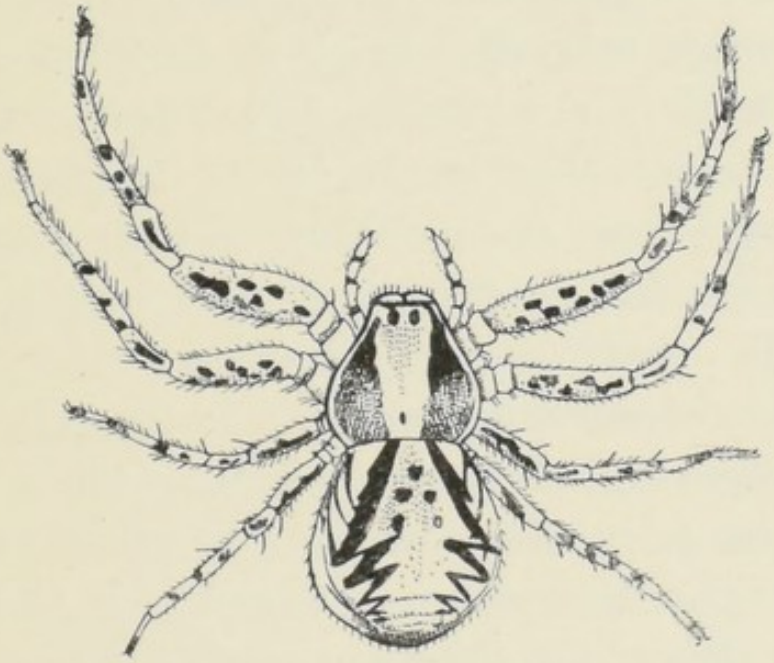

Fig. 6. A Crab-spider (*Thomisidae*), × 3.

We saw some of these spiders on the iron railing, but their real haunts are among grass and herbage or upon the trunks of trees. Some are true rovers, hunting their prey by day and camping out wherever they happen to find themselves at night. Their methods are without guile—except that they approach their victims warily; their trust is in rapidity of

action and superior strength. But other crab-spiders lead a less strenuous life; their habit is to lurk in moss, lichen, or flowers till an insect draws near enough to be seized without any great expenditure of energy.

Now in the case of some of these spiders the chance of obtaining a meal is very greatly increased by a remarkable similarity of coloration between the spider and its usual hunting ground. The spider's object is to remain invisible, and concealment is obviously more easy if its colour matches that of its environment. To a greater or less extent this protective coloration as it is called prevails universally:—spiders are seldom conspicuous objects among their usual surroundings, but it is only occasionally that we meet with cases of very remarkable colour adaptation. Two such, however, occur among English crab-spiders. One is a species not uncommon in the south of England, and fairly plentiful in the New Forest, where it is to be sought among the lichen on the tree trunks, where its blue-grey body, marked with black and white blotches makes it practically invisible except when in motion. It rejoices in the name of *Philodromus margaritatus*. The other case is that of the spider known as *Misumena vatia*, which is variable in colour, some specimens being yellow and others pink, while a variety of the species has a blood-red streak decorating the front part of its abdomen. If it were

to choose lichen as a hunting ground there would be little chance of concealment, but it does nothing so foolish:—it hides among the petals of flowers, generally, but not always, among flowers more or less of its own colour.

Now this phenomenon of resemblance is sometimes carried very much farther than a tolerable correspondence between the colour of an animal and its surroundings; it occasionally amounts to an apparent imitation, in form and in behaviour as well as in colour, of some other object, either animal or vegetable and in such cases we have examples of what is known as Mimicry. Most people have seen remarkable instances of this phenomenon in the "stick" and "leaf" insects of entomological collections. There are several different ways in which such a resemblance may be profitable to the imitator. Clearly it may be advantageous for a weak animal to be mistaken for one much more formidable and less likely to be attacked, or for an insect which is really extremely good eating to resemble closely one which birds well know to be unpalatable. Or again, if your line is to lie *perdu* and wait for some unwary insect to come within reach, it must be a distinct asset to be indistinguishable from such an innocent object as a twig or a leaf; and the same disguise may serve you if you are the possible victim and you can make the would-be devourer believe that you are a mere vegetable.

It is seldom difficult to see some such possibility of gain in the numerous well-known cases of insect mimicry. The wasp tribe—formidable with their stings—are often "mimicked"; the unpalatable Heliconid butterflies are "imitated" by members of edible families, and some insects are such exact imitations of leaves that the all-devouring army ants have been seen to run over them without discovering the imposition.

"Mimicry" is an unfortunate term inasmuch as it seems to imply intentional imitation; "protective resemblance" is better. It is generally accounted for by the action of "natural selection" upon random variations. No two members of a brood are exactly alike; slight variations in form, size, colour etc., are constantly occurring, and when the variation is a useful one the animal possessing it has a slightly better chance of surviving and rearing progeny, some of whom will probably possess the same peculiarity, perhaps even in a more marked degree, and will be better equipped than their neighbours in the struggle for life. The happy possessors of such favourable variations are thus in a sense "selected" by nature, and this selection, acting through countless generations, is thought to be the chief agent in bringing about the remarkable phenomenon of protective resemblance.

The theory has, no doubt, been pushed too far;

fanciful resemblances have been detected and advantages of which there is no proof are sometimes asserted, and moreover other possible ways of accounting for the facts have been too much overlooked.

But however it has come about, there is a case of "mimicry" among crab-spiders which deserves more than a passing mention. The name of the spider in question is *Phrynarachne decipiens*, and it was accidently discovered by Forbes when butterfly-hunting in Java. It spins a white patch of silk on the upper side of a leaf on which it places itself back-downwards, clinging to the web by means of spines on its legs. It then folds its legs closely and lies absolutely still. In this position the spider and web look precisely like the dropping of some bird upon the leaf; such droppings are frequently seen, and seem to be particularly attractive to butterflies. It was not until Forbes tried to catch a butterfly settled on a leaf that he found that what looked like excrement was really a spider which held the butterfly in its grasp. Even after this experience he was again deceived by the same species in Sumatra.

There are several extremely ant-like spiders, and it is remarkable that some of the imitators belong to widely different spider families:—that is to say the resemblance has arisen independently from quite different starting points.

It is very noteworthy that resemblance in structure is always accompanied by similarity of behaviour—as indeed it is bound to be if any benefit is to accrue to the mimic. Your resemblance to a leaf will deceive no one if you run wildly about, and your imitation of an ant will lack verisimilitude if you adopt a slow and stately method of progression. Ant-like spiders adopt the hurried and apparently undecided gait of their models, and insects which look like sticks, leaves, or inanimate objects all possess the power—and the habit—of remaining for a long time perfectly motionless.

CHAPTER IX

WOLF-SPIDERS

Of the groups of wandering spiders, which spin no snare but trust to speed and agility for their food, the Lycosidae or wolf-spiders supply the best subjects for study. To begin with, they are very numerous at certain times of the year, some species absolutely swarming in woods during May and June among the leaves which fell in the previous autumn. During the summer months they are still in evidence, but as winter approaches they rapidly disappear. The swift motion and predaceous habits have earned them the

name of wolf-spiders, but though they sometimes occur in incredible numbers so that it seems impossible to avoid treading upon them, they do not hunt in packs; each one is entirely concerned with his own individual quarry. They are moderate-sized or large spiders—commonly about half an inch long in this country though there are exotic species which attain an inch and a quarter—and in build they are very unlike the garden-spider, being elongate, and with the abdomen nothing like so globular.

Their habits vary considerably. One genus, appropriately named *Pirata*, is semi-aquatic, living at the margins of rivers and ponds, and able to run on the surface of the water, but most of the Lycosidae prefer dry land—the dryer the better. Heaths, sandhills, bare and stony stretches of soil, even deserts, are fertile in examples of this group. Most of the smaller species love the sunlight, and it is often noticeable on a bright day, when the ground seems to be alive with wolf-spiders, that a chance cloud obscuring the sun will cause them to disappear as if by magic.

Some of the small Lycosids seem to be absolute wanderers, having no home at all, but spending the night under a stone or any casual shelter, while others dig a more or less temporary hole in the ground into which they carry their captured prey, and in which they take refuge on the appearance of

an enemy. The large wolf-spiders have permanent burrows from which they do not wander far and in the mouths of which they spend most of their time, on the look out for passing insects.

Let us first catch one of the small wolf-spiders and examine it. This is not a very simple operation with creatures which can run so swiftly, but after a few attempts we induce a specimen to run up into a glass tube held in the line of its course. We see it to be a long-bodied spider thickly beset with hairs which entirely hide the integument of the abdomen. Its general hue will probably be a dark grey, and its abdomen will be decorated by a more or less distinct pattern due, not as in the garden spider to pigments in the skin, but to the coloration of the hairs. But look particularly at its eyes. A pocket-lens will suffice to reveal that two of them are much larger and much more business-like in appearance than anything *Epeira* had to show. These are directed forwards, being placed at the upper angles of the perpendicular front face, so to speak, of the animal. Below them, just above the jaws, are four small eyes in a transverse row, and behind them at some distance, on the upper surface of the cephalothorax, are yet another pair of moderate size. In some groups of spiders the eyes are not only small but have an indefinite, dull, ineffectual appearance; here they are clear-cut, glossy and convex; sight

apparently counts for something in the case of the Lycosidae. And this is what we should expect. A sedentary spider is informed of the whereabouts of its prey by the sense of touch, through the trembling of the web, but a wolf-spider spins no web and is dependent on the keenness of its vision.

There is a very prettily marked English Lycosid which is often found on sandhills, in situations particularly convenient for observation. Its name is *Lycosa picta*, and it is incidentally interesting as affording a good example of protective coloration, for the sandhill variety is light-coloured and very inconspicuous when stationary on the sand, while an inland variety not uncommon on the dark soil of heaths is of a much darker hue. Carefully scrutinising the firmer sand of the dunes on a sunny June day, I detect a number of small holes—the burrows of a colony of these spiders—and approaching cautiously I establish myself at full length at a distance of a yard or so on the side away from the sun, in such an attitude that I can observe closely for a considerable time without too much discomfort. The minutes pass and nothing happens, but I know that the cardinal virtue of the naturalist is patience, and I wait. Presently the dark circle of one of the burrows is obliterated—it is filled by the sand-coloured head of the spider, coming up to prospect. Other heads appear, and soon one spider, bolder than the rest,

emerges bodily, and remains for a minute motionless, on the *qui vive*. Finding no cause for alarm, it presently begins moving about stealthily, and before long several members of the colony are busily exploring the neighbourhood. A cloud passes over the sun and all quickly disappear into their holes, but this time without alarm, for they come forth unhesitatingly when the sun shines again.

It is a fascinating sight to observe these little creatures pursuing their operations in absolute silence under my very eyes. A few stealthy steps are taken, the body being so moved that the battery of eyes is brought to bear upon different points of the compass; a short quick run ensues, followed by more cautious movements. I am not fortunate enough to see the actual running down of a quarry, but in time I note one of the colony bringing home an insect in its jaws. So absorbed am I that I fairly jump when a horrified human voice close at hand observes "He's in a fit"! I have excited the solicitude of a girls' school which has approached noiselessly over the sand on their afternoon promenade, and stands gazing at me with as much fascination as I at the spiders. I hasten to reassure them, but the spell is broken, and the séance is at an end. Not a spider is visible.

But I can still do one thing. Here is a good opportunity of finding out something about the burrows of these spiders. In turf the investigation

would be difficult, but it is easy to operate in the tolerably firm sand where the colony has established itself.

I insert a straw into one of the burrows as a guide to the exploration, and with a knife carefully begin to remove the sand immediately round it. It is lined, I find, by a very delicate and slight coating of silk, no more than sufficient to keep the sand particles of its walls from falling down into the tube. I go down for an inch and a half or so and find that the tube ends blindly in a sort of silk-lined pocket, but no spider is there! This is mysterious, for I am pretty sure that my spiders are at home.

I go to work upon another burrow, but this time in a different way, digging it out bodily with its surrounding sand, and placing it on a sheet of paper, with which I am luckily provided, for a detailed examination. I can now approach it from the side, and by carefully removing the sand, lay bare the whole silken tube. As before there is a straight perpendicular burrow, ending blindly, and uninhabited, but at a point at about half-way down the tube I find a branch bending upward, so that the whole tunnel is Y shaped, and at the blind end of this branch I find the spider.

This observation suggests that the tunnels of some of our English wolf-spiders may be more complex than was imagined. At present nothing is known of their nature in the case of other species.

A little later in the summer the appearance of a troop of wolf-spiders has undergone a marked change; almost every individual will be found burdened with a circular bag of eggs attached firmly to its spinnerets, and carried about with it in all its wanderings.

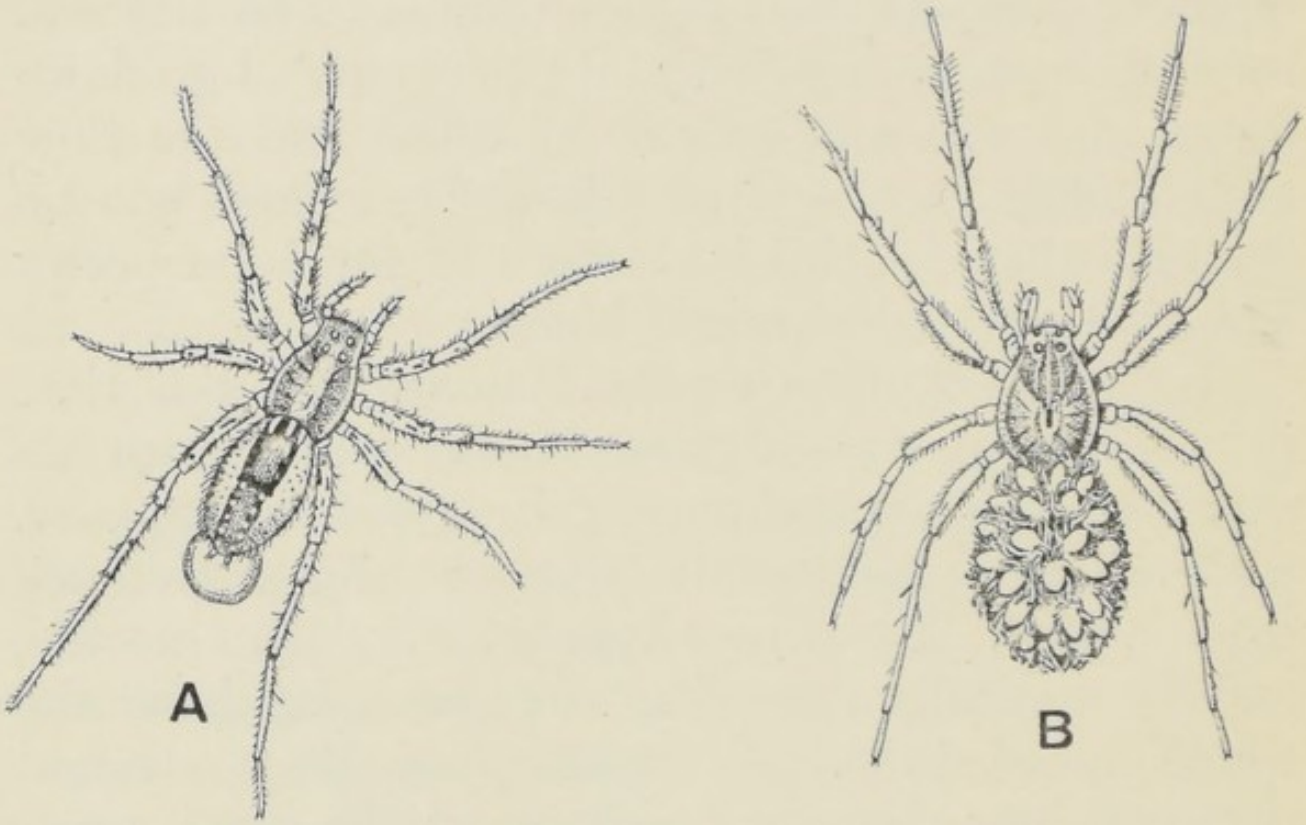

Fig. 7. Wolf-spiders; *A*, with egg-cocoons; *B*, with young on its back.

The "cocoon" is worth examination. It is a rather flattened sphere, with an equatorial line round it, giving the effect of two valves—an upper and a lower. The operation of making it has very seldom been observed, because it takes place in a closed retreat constructed for the purpose. McCook was fortunate enough to see something of it in the case

of a captive *Lycosa* which he kept in a glass jar partly filled with soil. Luckily the spider dug its tunnel for cocooning purposes up against the side of the jar, so that its interior was visible. It was about an inch deep and fairly wide, and its aperture was closed with silk.

Against the perpendicular wall of soil a circular silken cushion about three quarters of an inch in diameter was spun, and the eggs deposited in the centre. The edges of the cushion were then gathered up and pulled over the eggs, and the bag thus formed was finished off with an external layer of spinning work on the two halves of the sphere, the seam or "equator" being left thin for the exit of the young spiders. The *Lycosa* then attached the cocoon to its spinnerets and proceeded to bite away the silken sheet which sealed the burrow. The whole operation lasted about four and a half hours.

Thenceforward, till the young are hatched, the wolf-spider never quits her egg-bag, which she carries about on all her expeditions attached by threads to the spinnerets. Garden-spiders die soon after laying their eggs and never see their progeny, but here we have a case of maternal solicitude persisting for many days, and the Peckhams seized upon it as a good subject for investigating the subject of the memory of spiders. If the cocoon were removed from the spinnerets, after how long an interval would it be recognised by the mother?

A *Pirata* was selected for experiment. It offered great resistance to the removal of the cocoon, seizing it with its jaws and trying to escape with it. When it had been taken away the mother displayed great uneasiness, searching for it in all directions. It was returned to her after an hour and a half, when she received it eagerly and immediately attached it in the usual position.

From three others of the same species the cocoons were removed and restored after thirteen, fourteen and a half, and sixteen hours respectively. All remembered them and took them back immediately. But twenty-four hours seemed to be the extreme limit of their memory; after that interval two of the mothers refused to have anything to do with their cocoons, while the third only resumed hers, slowly and without any enthusiasm, after it had been placed before her seven times in succession. Some other species seemed to possess a rather longer memory, but the experimenters found no Lycosid constant in her affection for so long a period as forty-eight hours.

We have said that Lycosid spiders see comparatively well; yet, if they are placed within an inch or two of their cocoons they may be quite a long time finding them. This is very puzzling until it is considered that its habitual position is such that the spider never sees it. She never has seen it since

its construction, and does not in the least recognise it by sight. Spiders of other groups, where the female remains near but detached from the cocoon, are not at the same disadvantage, and if the cocoon is removed to a short distance the mother will go straight to it and bring it back. The wolf-spider only knows the *feel* of the cocoon; she may pass close by it without recognition, but as soon as she touches it the cocoon is immediately resumed—if the interval of separation has not been too great.

But is it necessary to restore to the spider her own cocoon? Will not that of another spider serve as well? Certainly it will; a wolf-spider will eagerly adopt the cocoon of a spider even belonging to a different genus, if not greatly unlike her own in size. Nay, even a ball of pith of the same size will be attached with alacrity to the spinnerets, though if offered a choice between a cocoon and a pith ball the spider, after some hesitation, selects the real article. One spider even accepted a cocoon into which a leaden shot had been inserted, making it many times its original weight. She could hardly crawl with her new burden, but stuck to it gallantly, and when several efforts to secure it to her spinnerets had proved ineffectual she carried it about between her jaws and the third pair of legs. Again we find the intelligence of the spider distinctly limited, but its powerful instincts are equal to all ordinary

requirements. Nature does not, as a rule, play extravagant pranks, such as interchanging cocoons or substituting for them pith balls and leaden pellets.

The famous Tarantula is a wolf-spider, though in America, unfortunately, the name has been quite wrongly applied to the members of an entirely different group. Everyone has heard of its deadly repute, and of the myth that its bite can only be cured by the wild tarantula dance or tarantella. It is one of the large Lycosids of southern Europe. These, as we have said, are much less nomadic than the smaller species, but have a permanent home, from which they do not wander far afield. They prefer waste, arid places, and their burrows are simple cylindrical tubes with the upper portion lined by silk, the mouth being often surmounted by a sort of rampart of particles of soil mingled with small pieces of wood collected in the neighbourhood. The spider lurks in the mouth of the tube where its glistening eyes can be distinctly seen. If an insect ventures near it rushes out and secures it ; if alarmed, it retreats instantly to the bottom of the burrow.

That most fascinating of all entomological writers, J. H. Fabre, made some observations on a tarantula of southern France which well deserve attention. Colonies of the spider were numerous in his neighbourhood, and he set himself to procure some specimens. Old writers assert that if a straw be

inserted into the burrow the spider will seize it and hold it so firmly that it may be drawn forth. Fabre found this method exciting, but uncertain in its results. Another plan which had been advocated was to approach warily and cut off the retreat of a spider by plunging the blade of a knife into the soil below it and so cutting off its retreat, but this required very rapid action, and was, moreover, apt to be prevented by the presence of stones in the soil. He devised a new scheme. He provided himself with a number of "bumble" bees in narrow glass tubes—about the width of the spider burrows. Repairing to a tarantula colony he would present the open end of the tube to the mouth of a burrow. The liberated bee, seeing a hole in the ground exactly suitable for its own purposes, would enter it with very little hesitation. There would be a loud buzz and then instant silence. Inserting a pair of forceps into the hole, Fabre would then withdraw the bee with the spider clinging tenaciously to it. In all cases the death of the bee was instantaneous, though the closest examination of its dead body revealed no wound.

Now Fabre was fresh from his wonderful studies of the habits of the solitary wasps, which provide their young with insects stung in such a way as to cause paralysis but not death. In their case the problem was to secure food for their larvae which should

remain fresh for many days, an instinct taught them to solve it in the most remarkable manner. The problem of the spider was different. It was a case of killing instantly, or being killed; a merely wounded bee is as formidable as one unharmed. What Fabre desired to know was this: did the spider trust to one invariable deadly stroke in dealing with the bee, as the solitary wasp, according to its species, had been found to act always precisely in the same way in paralysing its victim?

To settle this point the spider must be seen at work, and the obvious plan seemed to be to enclose a bee and a tarantula in a glass vessel and see what would happen. But nothing happened at all. The spider, away from its burrow, refused to attack. The equally matched antagonists treated each other with the greatest respect and only evinced a desire to keep as far apart as possible. Even when placed in the same tube both acted on the defensive, and no light was thrown on the problem.

But Fabre's ingenuity was equal to the occasion. It occurred to him that to use as a bait an insect of burrowing habits had been a tactical error; if instead of a bumble bee some other insect, equally formidable, but not attracted by holes in the ground, were selected for the purpose, the spider might be induced to rush forth and reveal its method of attack.

A large carpenter bee—*Xylocopa*—was chosen

and the mouth of the tube containing it was presented as before to the mouth of the tarantula tunnel. The insect showed no disposition to enter the tunnel, but buzzed in the tube outside. Many burrows were tested before any luck attended the investigator, but at length a spider responded. There was a fierce rush, a clinch, and the bee was dead; the operation was too rapid to follow, but the spider's fangs remained where they had struck—embedded just behind the insect's neck. The experiment was repeated until sufficient cases had been witnessed to establish the fact that the tarantula dealt no random stroke but with unerring precision and lightning rapidity plunged its fangs into the vital spot. Fabre quaintly exclaims "J'étais ravi de ce savoir assassin; j'étais dédommagé de mon épiderme rôti au soleil!"

Examples of the same species of tarantula kept in captivity threw further light of the habits of the group. These large Lycosids live for years, and though stay-at-homes when *rangé* so-to-speak, they are at first wanderers on the face of the earth. They do not settle down and burrow till the autumn just after they have attained maturity. These young adults are only about half the size they will eventually attain, but the burrows are enlarged at need, so that it is customary to find tubes of two sizes—those of the newly established small females, and those of the fully-grown females of two or more years old.

Curiously enough, if disturbed, they entirely decline to burrow unless it be the proper season for that operation, but remain inert and helpless on the surface till they die. If, however, a tunnel is provided for them, they enter it at once and adapt it to their needs.

The legs take no part in the burrowing process, which is entirely carried out by the jaws. With infinite labour small particles of earth are dislodged and carried by the mandibles to be dropped at a considerable distance from the nest.

The parapet round the mouth of the tube is in nature usually quite a small erection, but this seems to be due to the fact that only a small amount of suitable material is available in the immediate neighbourhood, and the spiders will not go far afield. In captivity, when abundance of material was supplied, they attained a height of two inches. Small stones, sticks, and strands of wool cut into lengths of one inch and of various colours were placed within reach, and all were used in building the parapet. Comparatively huge pebbles were rolled up for a foundation, and fragments of earth and pieces of wool entirely irrespective of colour were bound together by irregular spinning work.

On sunny days the spiders would crouch behind the parapet with their eyes above its level. To distant insects they paid no attention, but if one

approached within leaping distance, it was pounced upon with unfailing accuracy.

In due season the captives laid their eggs and enclosed them in the regulation cocoon which they attached to their spinnerets, never parting from them thenceforward, though considerably hampered by them in their movements up and down the tube. But a very remarkable change now took place in their behaviour at the mouth of the tunnel. In sunny weather, instead of remaining, as Fabre puts it, "*accoudé*" on the parapet, they reversed their position, raised their egg-cocoons with their hind legs, and slowly and deliberately turned them about, so that every part in succession should be exposed to the sun's rays.

We now come to a remarkable habit possessed by all the Lycosidae. When the young are ready to leave the cocoon they find an exit at the thinner equatorial seam, and proceed immediately to climb on to the back of the mother, clinging firmly to her covering of hairs. If a wanderer, she carries them thus on all her expeditions; if a stay-at-home, they accompany her up and down her tube. They are often dislodged—indeed, when alarmed, they scatter for the moment, but when the peril has passed they immediately swarm up the maternal legs to their former position.

Now in the case of the tarantula, it is seven

months before they are able to fend for themselves. Meanwhile they eat nothing, and look on with indifference while their mother feeds. She not only carries them willingly, but exhibits solicitude when deprived of them, but she shows no discrimination as to her own offspring, and is quite content with those of another spider. The young, when brushed off, climb the legs of the nearest female, and a spider may thus be laden with thrice her proper load without any protest. They form a layer two or three deep, and can then only find room by covering the whole of her back. They nevertheless take care not to obscure her vision by covering her eyes.

Two mother tarantulas, each with her young on her back, came into contact, and a battle *à outrance* took place. One was slain, but the double brood, scattered by the conflict, on its cessation climbed on to the back of the victor, and remained calmly in position while she proceeded to dine in leisurely fashion on the vanquished!

In March, seven months after hatching, the young were ready to start life for themselves. Their first action was to climb to the highest points attainable, whence they set sail in the manner already described, and were borne gently away in the air.

We can hardly leave the tarantula without saying something on the vexed question of spider venom. All over the world there are certain particular spiders

whose bite is especially feared. Among them are the "Tarantula" and the "Malmignate" of southern Europe, the "Vancoho" of Madagascar, the "Katipo" of New Zealand, and the "Queue rouge" of the West Indies. Quite an extensive literature has arisen around the subject but its perusal leaves one not much wiser than one was before. Circumstantial accounts of deaths from the bite of a spider are countered by the assertions of experimenters that they have allowed themselves to be bitten repeatedly by the same species without suffering any inconvenience. There is at all events some basis for the popular view in the fact that all spiders possess a poison gland which is analogous to that of the snake inasmuch as it opens near the tip of the fang which is plunged into the animal attacked. In the case of the large, powerful spiders of the family Mygalidae, and perhaps in the tarantulas the effects of the bite on higher animals are not negligible, and clearly exceed the results of a mere puncture. A young sparrow and a mole bitten by Fabre's tarantula in spots by no means vital died within a few hours. But it is a very remarkable fact that many of the most dreaded spiders are neither large nor powerful. The "Malmignate," the "Vancoho," the "Katipo," and the "Queue rouge" are all members of the comparatively weak-jawed Theridiidae, and their only striking characteristic is vivid coloration,

all being marked with red spots. It is probable that their deadly powers are almost entirely fabulous; and that they have been singled out as particularly dangerous merely because of their conspicious appearance.

The smaller species are certainly harmless as far as man is concerned, and it is even disputed whether their poison plays much part in the ordinary slaying of insects. The very inconsistent results of experiments may be due to some control exercised by the spider over the output of poison. There is no proof that its ejection is automatic, and it is quite possible that the spider is economical in its use. Or again, in some of the cases of innocuous biting, the supply of venom may have run short.

CHAPTER X

JUMPING SPIDERS

We are not in the land of the jumping spiders or Attidae, and our few and sober-coloured examples of the group give but a feeble idea of the Attid fauna of tropical countries where these creatures abound and often rival the "ruby-tail" flies in the brilliancy of their hues.

It is one of the largest groups, numbering several

thousand species, but the British list includes barely thirty, and most of these are of rare occurrence, or at all events exceedingly unlikely to be met with by any but the most energetic collector. Indeed it may be said that there is only one British species which we may look forward with tolerable confidence to finding upon some sunny wall or fence in the summer, in whatever part of the country we may be. This is

Fig. 8. *Salticus scenicus*, female, × 4.

Salticus scenicus, sometimes called the Zebra Spider. Though absolutely dowdy in comparison with most of its tropical cousins, it is a not unattractive little creature, and illustrates sufficiently well the characteristics of its tribe. Armed with a pocket-lens, a glass tube or two, and—more necessary still—the very largest amount of patience we can summon, we go in quest of the zebra spider. A tarred fence is a good hunting ground, because the spider, if present,

is readily seen, but if this is drawn blank we must have recourse to a wall, where sharper eyesight will be required.

Our quarry is of small size, not more than a quarter of an inch long in the body, which resembles that of the wolf-spiders in build, the abdomen not rising above the level of the fore-body or cephalothorax. It is thickly clothed with short hairs—black, white, and grey—so arranged as to show oblique zebra-

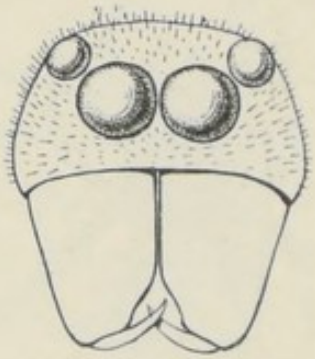

Fig. 9. "Face" of an Attid spider, shewing the anterior eyes and the chelicerae.

like stripes on either side of the abdomen. The legs are short and robust, very different from the long thin limbs of the garden-spider; especially strong are the fore-legs. The head is broad and square, with a high perpendicular forehead, but the most remarkable features are the eyes.

On the vertical front are four splendid eyes. The wolf-spider's eyes were large, but these, in comparison are immense, especially the median pair. Their axes are directed straight in front. Four other eyes are

placed on the top of the head, far apart from each other, the more forward pair very small, the hind pair of moderate size. In some Attid spiders these great anterior eyes are wonderful objects under the microscope, deep sea-green in hue and fringed with coloured hairs. They form a veritable battery which the spider brings to bear upon the object of its chase. Human eyes, to match them in comparative size, would literally have to be as large as saucers!

If we are in luck, we soon descry a *Salticus* showing up boldly against the black surface of the fence, and to set ourselves to watch its antics attentively. One thing strikes us at once; it is quite at home on a perpendicular surface—nay, on the under side of a horizontal beam, for that matter. Now a garden-spider would have great difficulty in maintaining itself in such a position unless well supplied with silken lines to which to cling; evidently there is some difference in the structure of the feet of these spiders which may be worth investigating later on.

Also we notice some odd tricks of movement in the jumping spider; a curious way of exploring the surface on which it is working by a succession of short runs alternately with periods of absolute stillness as though on the *qui vive*; a noticeable freedom of movement between the fore- and the hind-bodies so that its battery of eyes may be directed to this side or that; sometimes an elevation of fore part

as though for the purpose of obtaining a wider view.

We may have to wait long before we see it successful in the chase. It will often patiently explore a large area, testing the surface with its palps as it goes, without any obvious reward. It conscientiously searches all depressions and crannies, and, sometimes remains in them for a considerable time—perhaps to devour some minute creature which did not call into play its special methods of attack. At last it sights a small insect which has alighted on the fence a few inches away; we see it turn its head in that direction and remain motionless. Soon it begins to edge nearer in a stealthy manner, striving to approach its prey from behind, till, with a sudden spring, it pounces on its back. Not always is the spring successful; often the insect sees its peril at the last moment and takes to wing. But in this case, how does the spider avoid a fall? We see, what we had not noticed before, that it is anchored to the fence by a silken line; indeed all the time it has been hunting it has been trailing behind it an exceedingly fine thread of silk which it has attached at frequent intervals to the fence, so that it can check its fall at will in the case of accident. At the right angle, we may see the delicate filaments glistening in the sun over the surface of its explorations. The garden-spider entangles its prey in a web,

the wolf-spider runs it down by sheer strength and speed, but the jumping spider stalks it like a Red Indian.

The actions of the spider make it quite evident that its power of sight is well developed. Mr and Mrs Peckham, whose remarkable observations on the mating habits of jumping spiders must presently be considered, established friendly relations with some of their captives which became so tame as to jump on their hands and take food from their fingers. They frequently induced them to jump from a finger of one hand to one of the other, gradually increasing the distance up to eight inches. They also twice observed a male chasing a female upon a table covered with jars, books and boxes. "The female would leap rapidly from one object to another, or would dart over the edge of a book or a box so as to be out of sight. In this position she would remain quiet for a few moments and then, creeping to the edge, would peer over to see if the male were still pursuing her. If he happened not to be hidden, she would seem to see him, even when ten or twelve inches away, and would quickly draw back."

Moreover that they have the ability to discriminate colours has been shown by their behaviour when imprisoned in cages consisting of a series of communicating chambers each with a glass top of a different hue. They show a marked preference for

the red chamber under these circumstances while the least attractive colour seems to be blue.

It has been known for a long time that the males of many kinds of birds—and especially of the more ornamental species—are accustomed to perform the most extraordinary antics in the presence of the female at the time of mating. The Peckhams made the unexpected discovery that precisely similar "love dances" took place in the case of the jumping spiders. Even the comparatively sober-coloured "zebra spider" performs a weird *pas seul* in courting its mate, but its display is feeble compared with that of some of the more ornate of the Attidae.

Certain isolated observations on captive jumping spiders led these observers to suspect that the mating habits were unusual and worthy of accurate investigation, and they laid their plans accordingly, taking their summer holiday a month earlier than usual, so as to miss nothing of the pairing season, and including in their party an artist whose drawings should furnish an indubitable record of the attitudes assumed by the male spiders in their evolutions.

On arriving at their destination they found a small species, *Saitis pulex*, with no great claims to remarkable beauty, mature, and ready to pair. A female was placed in one of the experimental boxes which had been provided in advance, and a male was admitted on the following day. He sighted her at

a distance of twelve inches, and showing signs of excitement, advanced to within about four inches and then performed a most ludicrous dance—something in the nature of a "highland fling," in a semicircle before her, she, in the meantime, moving in such a manner as to keep him always in view. His exact behaviour was this: he extended all the legs—and the palp—on the left side, folding the first two legs and the palp of the right side under him, and leaning over sideways so far as nearly to lose his balance, and in this attitude he sidled along towards the lowered (right) side till he had described an arc of about two inches; then the position was instantly reversed, the right legs being extended and the left folded under, and the arc retraced. A male was seen to repeat this performance 111 times! He then approached nearer and when almost within reach "whirled madly around and around her, she joining and whirling with him," after which she accepted him as a mate.

The next species to engage attention was an *Icius*. It was noteworthy that although the neighbourhood was well known to the experimenters they had never met with this spider before, but for a few days it swarmed on the fences just as birds are known to assemble from all quarters for the so-called "love dances." After the mating season the spiders wandered off into the woods again and were seen no more.

The performance was much as before, but the spiders assumed different attitudes. The female lay flat on the ground with her front legs raised; the male danced on the six hind legs, with the front legs lowered and meeting at the tips. The males of this species were exceedingly quarrelsome, sparring frantically whenever they met, but their battles were

Fig. 10. A male Attid spider (*Astia vittata*) dancing before the female. (After Peckham.)

entirely bloodless. "Indeed," say the observers, "having watched hundreds of seemingly terrible battles between the males of this and other species, the conclusion has been forced upon us that they are all sham affairs, gotten up for the purpose of displaying before the females, who commonly stand by, interested spectators." In the case of one species,

after two weeks of hard fighting between the males, the Peckhams were unable to discover one wounded warrior. The females, on the other hand, were often really formidable. *Phidippus morsitans* is an example. The male has handsome front legs, thickly fringed with white hairs, and he displays these to the best advantage in his love antics. Two males supplied in succession to one female "had offered her only the merest civilities when she leaped upon them and killed them."

In the case of most of the spiders whose love-dances were investigated, the chief ornamentation of the male consisted of fringes of white or coloured hairs on the face, the palps, and the front legs, and they kept these parts always before the females, displaying their glories to the utmost advantage. The male of *Habrocestum splendens*, however, possesses an extremely brilliant abdomen, and, lest anything of its beauty should be lost upon the object of his admiration, he varies the ordinary performance in a remarkable manner. He often pauses in the dance, and, raising his abdomen, "strikes an attitude" in which he remains motionless for half a minute. Moreover he frequently turns his back on the female —a most unusual occurrence in the course of these antics.

The males of one species, *Philaeus militaris*, were observed to capture and keep guard over young

females, which they imprisoned in webs spun for the purpose until they had undergone their last moult and were mature, chasing away all intruders in the interval.

The jumping spiders furnish a much stronger case for those who believe that ornamentation plays an important part in sexual selection than do either birds or butterflies. With regard to the birds it has been objected, first, that there is little evidence that the females pay much attention to the antics of the males, and secondly, that practically all the male birds pair, whatever their claims to pre-eminent beauty. Now in the case of the jumping spiders the females follow the performances of the males with the utmost attention, and seeing that the males are present in large numbers when the females begin to appear, the latter are certainly in the position to reject such mates as do not please them.

The mere relation of the results of this most interesting investigation conveys no hint of the unwearied patience and close observation necessary to those who would surprise the secrets of nature. One is apt to infer that it is only needful to place some spiders in a box, establish oneself in an arm chair, and ring on the performance, so to speak. The Peckhams modestly remark: "The courtship of spiders is a very tedious affair. We shall condense our descriptions as much as possible, but it must be

noted that we often worked four or five hours a day for a week in getting a fair idea of the habits of a single species."

CHAPTER XI

THERAPHOSID SPIDERS

It is quite impossible in a work like the present to deal with the classification of spiders. About forty families have been established, some of them of vast extent, the Attidae, for example, including some four thousand species. The great French arachnologist, M. E. Simon, has occupied 2,000 quarto pages in defining the families, sub-families and genera, without concerning himself with the species at all! It is, however, desirable, that the attention of the reader should be called to the primary division of the group, according to which all spiders are either *Araneae verae* (true spiders) or *Araneae theraphosae* (theraphosid spiders.)

Now these two kinds of spider may readily be distinguished by a single easily observable characteristic, the nature of the mandibles or *chelicerae*; but it is necessary to describe the spider's mandibles before the difference can be appreciated.

Their nature is perhaps best explained by saying that each mandible is not unlike a penknife with

a single small blade, rather more than half open when in use, closed when at rest. The handle of the penknife is certainly in most cases very short and thick, and the blade not really a blade at all, for it has no cutting edge, but is a "fang" or piercing instrument generally somewhat curved, and with a sharp point. The "blade" is, moreover, perforated by a tube which comes from the poison-gland, situated in the thickened "handle," or in the spider's head, so that poison can be forced into the wound which it inflicts.

Now take two penknives with the blades half open and hold them so that they hang with the hinge downward and with the blades directed towards each other; it is clear that the blades may be made to pierce an object situated between them by moving the handles laterally, the object being attacked simultaneously on either side. This is the arrangement in the true spiders, whose jaws move sideways, though they do not always hang perpendicularly, but are more often somewhat slanted forwards.

To represent the jaws of a theraphosid spider the penknives must be arranged differently. Place the handles horizontally and parallel to each other, with the blades directed downwards and also parallel. They will now work not sideways, but up and down, and both fangs will pierce the victim from above. In a word, the true spiders have jaws which can be

separated or brought together, and which tend to meet in the object into which they are plunged, while the jaws of theraphosid spiders work in parallel vertical planes, and strike downwards.

All the spiders which have so far concerned us are *Araneae verae*, and we have incidentally had occasion to note some of the principal families of that division—Epeiridae (or Argiopidae as some prefer to call them), Theridiidae, Agelenidae, Thomisidae, Lycosidae and Attidae.

Indeed there is only one theraphosid spider that there is the least likelihood of our coming across in this country. Their true home is in hotter climes, and though stragglers from their army are not rare in the warmer portions of temperate regions, they abound only in tropical countries. They include the "Trap-door" spiders, common in the Mediterranean region and in many other widely distant parts of the world, and the great "Bird-eating" spiders of the tropics—the spiders which are quite wrongly but universally alluded to in America as Tarantulas.

The single British example is well worth the study of any reader who is fortunate enough to come across it. But he must first catch his hare, for *Atypus affinis* (or *piceus* as it used to be called) does not grow in every hedge-row, nor is it easy to find it where it does occur. Most of the localities recorded are in the south of England. It is a thick-set

dark-coloured spider about half an inch in length, and with very thick, powerful mandibles, which, as we have seen, work vertically.

Its nest is a loosely-woven tubular structure, which partly lines a more or less vertical hole in the ground and partly lies exposed on the surface, but which does not present any obvious opening for entrance and exit.

The situation chosen is generally a sloping sandy bank covered with vegetation. The burrow is about eight inches in depth and about three quarters of an inch in diameter. Near the bottom it narrows and then expands into a somewhat wider chamber where the spider lives and constructs its egg-cocoon. The portion of the tube above the ground is sometimes longer but more often shorter than the buried portion, and it tapers to a closed end.

Mr Joshua Brown, who first found this spider near Hastings in 1856, took home several of the tubes with the spiders inside. He could find no opening, and though the spiders moved up and down the tubes they did not emerge. On tearing a tube open he found no remains of insects inside, but in one case he came across a worm, partly within, and partly outside the lower part of the tube, and apparently partially devoured by the spider.

The same species is not rare in France and M. Simon's observations on it closely agreed with those

of Mr Brown. He believed that the spider chiefly depended for its food on earthworms which, in the course of their burrowings, came casually into its neighbourhood. Since these observations, however, considerable light has been thrown on the habits of the spider by Enock, who found colonies on Hampstead Heath and near Woking. His investigations extended over several years, and wonderful patience was needed before the secrets of this curious animal were divulged.

It appears that the female, when once established, never leaves the nest at all! The aerial portion of the web was always a puzzle, but now we know, thanks to Enock, that it constitutes the whole hunting ground of the spider. Like promises and pie-crust it is apparently made to be broken. If it is accidentally brushed against by a passing insect the spider is instantly aware of the fact, rushes to the spot, and transfixes the intruder with its powerful mandibles. It turns on its back to do this, and strikes the insect from behind, afterwards pulling its prey through the weft and into the tube by main force. It drags it to the bottom of the tunnel, makes sure of its death, and immediately returns and repairs the rent.

Insects were held against the tube, and the spider, if hungry, accepted them at once; if replete however, it always gave a tug at the tube, which retracted a portion of it into the burrow—a curious action

which Enock quite learnt to interpret as the "I don't want any more" movement.

The males made nests exactly like the females, but shallower, and they left them to search for their mates, leaving the ends open. On finding a female nest, they "serenaded" by tapping with their palps, and after some delay, tore open the web and entered. By and by the female came up and repaired the rent, first pulling the edges together with her jaws and then uniting them with silk from her spinnerets. In one case nothing more was seen of the male for nine months, when his empty skin was observed at the end of the tube. After nine months of connubial bliss his consort had devoured him!

In the autumn and spring, eggs and newly-hatched young were often found in the nests. Late in March a small hole, $\frac{1}{16}$ inch in diameter, was noticed at the end of some of the webs, and presently the young began to emerge—never to return to the nest. They immediately climbed the highest objects at hand, and some were seen to be carried off by the breeze.

Enock found, by an ingenious experiment, that the sand which is incorporated in the aerial part of the tube—no doubt to render it inconspicuous—is obtained from within, and not from outside the nest. Carefully covering the exposed web, he powdered the ground all round it with red brick-dust, but the particles which the spider embedded in the web were

of brown sand, evidently obtained from the bottom of the burrow and not from the surrounding surface. But in the case of some newly-dispersed young spiders he was able to see this operation performed. The first part of the nest to be made was the aërial portion, at the foot of which the digging was commenced. Particles of sand were brought up in the jaws of the young spider and pushed into the weft of the tube. Occasionally the jaws were thrust through the delicate web and particles from without were seized and *pulled* into the silken fabric.

It is sad to have to relate that such young spiders as did not emerge from the web within a reasonable time were devoured by their unnatural parent. It sometimes happened that a change of weather rendered it unsuitable for the departure of the young, and in this case the mother closed up the exit-hole, and retired to feed upon her offspring! Thus, though there were as many as a hundred and forty in a brood, a good many perished at the outset, and the ants in the surrounding soil accounted for some of the rest.

The Atypidae form a small outlying group of the Theraphosid spiders and are able to live in colder regions than most of their relatives. The great bulk of the division belong to the family Avicularíidae.

Some of the Avicularíidae are not unlike Agelena in their mode of life, spinning a dense sheet-web

terminating in a tube, and entrapping their prey. Far the greater number, however, as far as their habits are known at all, are earth dwellers, either inhabiting more or less complex burrows of their own, or sheltering under stones or in chance cavities by day and emerging at night to seek food in the immediate neighbourhood of their hiding-places. Some of them are quite small, but the majority are large robust spiders, of formidable appearance. The largest known spider, *Theraphosa leblondi*, is found in South America, and its body measures more than three and a half inches in length. Few spiders have attracted more attention than the fabricators of the curious "trap-door" nests, which are common in the Riviera, and indeed in all the countries bordering the Mediterranean. But abundant though they are, they are extremely difficult to find, and it is generally only by chance that their existence is detected.

The Tarantula occasionally closes the mouth of her tunnel with a sheet of silk in which are encrusted the *débris* of insects or particles of soil. She does this at the time when she is spinning her cocoon and any intrusion is particularly inopportune, but she does it also on other occasions which are not so easily accounted for. A reason which would naturally occur to us would be the exclusion of excessive rain or excessive sunshine, but the facts, unfortunately, do not accord with this explanation.

Now, however desirable occasional closure may be, a permanent door would hamper the tarantula in her hunting operations, but the habits of the trap-door spider are different, and she closes her retreat with a wonderful hinged lid or "trap-door." And the commonest form of trap-door is also the most perfect, being thick and tapering, and fitting accurately into the bevelled mouth of the tube like a stopper in the mouth of a bottle. It is made of alternate layers of spider silk and earth, and is free for more than half its circumference, the remaining portion of the surface disc being attached to the side of the tube by a flexible hinge of silk. Moggridge dissected the door of a full-sized tunnel into fourteen graduated discs. The smallest—and of course the lowest—represented the first door ever made by the spider, and the successively larger discs indicated the stages at which its increasing size rendered an enlargement of the tube—and therefore of the door—necessary.

The spider always interweaves vegetable matter from the neighbourhood into each new disc, so that, as a rule, it is entirely indistinguishable from its surroundings when closed; and not only *dead* vegetable matter, for if the tube is situated amongst moss, moss grows upon the lid. From our previous experience, however, we shall not be surprised to find that blind instinct and not forethought is

responsible for this action. Moggridge removed the lid of a tunnel and also cleared the ground immediately round it of all vegetation; nevertheless, when the spider made a new door, it covered it with moss taken from the undisturbed vegetation beyond, so that the trap-door was now conspicuous as a green oasis in a sandy desert! And on another occasion a spider interwove fragments of scarlet fabric left purposely at hand into the lid of its tunnel. It is clear, therefore, that the decoration of the door is due to an instinct which impels the spider to utilise any material of the neighbourhood without any regard to the effect produced.

The tube is densely lined with silk, which affords its architect a secure foot-hold, and if any enemy attempts to open the lid from without, the spider resists with all its strength—which is not inconsiderable—clinging on to its under surface with its front legs and jaws, while the claws of its other feet grasp the silken walls of the tube.

The other type of trap-door is less interesting and much more elementary, consisting simply of a wafer-like sheet of silk mixed with earth and vegetable matter, but it is a curious fact that while all known trap-door nests of the cork type are simple tubes, the burrows with wafer doors are often much more complex. In some cases there is a branch tube, like that constructed by *Lycosa picta*, leaving the main

tunnel at a depth of some three inches, and reaching the surface perhaps two inches away from the trap-door, so that the whole excavation is Y-shaped. This branch tube is permanently closed by a thin sheet of silk and earth, which, however, it would not be difficult to break through if it were urgent for the spider to escape while the enemy was exploring the main tunnel.

But a more interesting case is the occurrence of another trap-door some way down the tube. If the tube is unbranched, this forms merely a second line of defence if the outer door is forced, but in the case of a branched tube the additional door hangs at the fork of the Y, and is so shaped as to form a perfect valve, so that the spider, by holding it against one or the other side of the tunnel, can connect the bottom limb of the Y with either fork at will, leaving to the intruder a beautifully smooth-lined tube to explore, with no hint of the possibility of escape in other directions.

There are sometimes other complications in the ramification of the tube, but these need not detain us. Each species of spider adheres to its own particular type of architecture, and may safely—in a given neighbourhood—be identified by its nest.

As with the Lycosidae, the burrowing is all done by the mandibles, but here the first joint—the handle of the penknife—is of more importance than the

blade or fang. Indeed the burrowing species of the Avicularíidae may be distinguished from the rest by their mandibles, which are provided in front with a *rastellum*, or row of teeth for digging. A trap-door spider, then, does not go to work like a rabbit, or a terrier, scratching and kicking away the earth as it digs; it laboriously dislodges particles of soil with its powerful mandibles, and carries away the loosened fragments to deposit them at a distance.

The trap-door spiders of the Mediterranean region are nocturnal creatures, and little is known of their habits. Erber relates that a species found in the island of Tinos comes out at night, fixes open the trap-door with a few threads, and spins a web near its nest to entrap passing insects, clearing away any trace of it before the dawn. In the case of some Chinese and also some Australian species observers allege that they frequently wander from their nests in the day-time.

A Californian species was able to leave its nest when the trap-door was weighted with three ounces of lead. On re-entering, it seized the edge of the door with its mandibles, and, raising it slightly, inserted its front legs. It then turned round and slipped backwards into the tube. It always resisted the forcible opening of its door to the last moment, when it let go and slid into the tube "as though going down a well."

The larger Avicularíidae have acquired a reputation for feeding on birds, and this has given rise both to their scientific and their popular name—bird-eating spiders. Several travellers have stated that they have observed them with birds in their grasp, and there is no doubt of their ability to kill any small bird or mammal, though it is probable that they seldom have the opportunity, for they spin no snare in which birds may be caught. Even without the aid of their poison, their jaws are so large and powerful that they may easily attain the vital organs of small animals. Probably their staple food consists of the larger insects.

They live in holes in the ground or in trees, or sometimes in the fork of a tree-branch. In such hiding places they spend the hours of day-light, emerging at night in search of food. Their large size and uncanny appearance have attracted the attention of the collector, and a great many species are known, but the fact that they chiefly inhabit tropical countries has militated against any very extended study of their habits, and the few items of information we possess are best related with regard to the particular spider observed, and not taken as necessarily characteristic of the whole tribe. There is little doubt that they live for several years. McCook kept a specimen of *Dugesiella hentzi* in captivity for five and a half years, and he considered that

when it reached him it was at least a year and a half old, and probably more. The same species has recently been made the subject of some very interesting observations by Petrunkewitch, who obtained numerous living specimens from Texas and kept them in captivity; unless carefully packed, they bore the railway journey badly, and it was above all things necessary to supply them with water.

The captives were fed on grass-hoppers, crickets, cockroaches and wolf-spiders, but they ate sparingly, one grass-hopper sufficing for three days in the summer, while in the winter hardly any food at all was taken.

The sense of touch is extremely well developed in these spiders, but in sight, hearing and smell they are strangely deficient. No response whatever, was obtained to either high or low notes. A cricket sang for hours quite close to a spider which had been kept hungry for several days, without attracting any attention. It is very remarkable, by the way, that insects show no instinctive dread of these formidable creatures, not attempting to keep at a distance, and indeed frequently running over them in trying to find a way out of the cage. Nor do the spiders seem to be at all guided by smell; they evince no knowledge of the presence of insects which emit a strong odour, nor do they react to such tests as those to which the garden-spider was subjected unless strong

irritants such as chlorine are employed, in the perception of which it is perhaps unnecessary that smell in the strict sense should take any part.

They have eight eyes—two of them round and rather business-like in appearance, and the others oval or pear-shaped—and they are very sensitive to light, retreating at once from the direct rays of the sun or from a light flashed on them, but they do not appear to *see* anything at all, recognising neither friends nor enemies by sight, however close at hand. It was far otherwise with a wolf-spider in the same cage. Running towards the Dugesiella it was clearly aware of it at a distance of several inches, and could not be persuaded to approach nearer. But the supremacy of the sense of touch is most striking when the spiders are courting. When the male is seeking the female he seems quite unaware of her proximity unless he accidentally brushes up against her. If he loses contact for a moment he is quite at sea and wanders blindly about, turning, perhaps, to the left when the least motion to the right would bring them together again. This frequently happens when he has accidentally touched the female with one of the hind legs. He immediately turns about, and if she is still there, all is well, but if she has chanced to move out of reach, he is quite at a loss. Neither sight nor sound nor smell guide him, but touch only. The delicacy of this sense, however, is quite

remarkable. He seems to be aware at once of the nature of the object which touches him, assuming a threatening attitude if the touch is hostile, or pouncing instantly if hungry and the touch is that of a passing insect. If, however, the insect is lucky enough to escape, it is in no danger of pursuit.

As in the case of many spiders—though by no means of all—his courting is not unattended with peril. The tragic fate which sometimes overtakes the male spider has so hit the popular imagination that there is a general impression that the female spider is a confirmed misanthrope and desires the life of any suiter bold enough to approach her. Not at all! We have simply to remember that spiders are carnivorous and prone to cannibalism. If the female happens to be hungry she makes no nice discrimination between an amorous male and a succulent grasshopper; if replete, she may find time for the play of softer emotions. The male of *D. hentzi* appears to be more or less prepared for a hostile reception on the part of the female, for the thighs of his front legs are furnished with spurs at their extremity and with these he holds back and renders powerless her threatening fangs.

There is no doubt that the spider's delicate sense of touch resides in the hairs with which both body and limbs are thickly clothed. They are of various kinds—fine hairs, bristles, and stout spines—and

many of them are supplied with nerve-fibres at the base. The finer hairs are probably not sensory, and they are, in the case of some Aviculariid spiders very easily shed, and have a strongly irritant action on the hand that touches them, not unlike the sting of a nettle.

It is not at all unusual for one large Aviculariid spider, *Psalmopoeus cambridgii*, to be brought over to England in cases of bananas from the W. Indies. Mr James Adams of Dunfermline has kept two specimens alive for a considerable time. The first specimen lived in captivity for two years and nine months, during which it moulted five times but grew very little in size. Arriving in September, it was at first fed on flies, and in a few weeks, when these began to fail, it accepted beetles, consuming about three a day. In November, even these insects were difficult to obtain, and recourse was had to cockroaches. At first about three cockroaches a week were eaten but the number decreased until, in the middle of March it ceased feeding altogether, and on April 13 it cast its skin. It moulted again in October, and twice a year for the rest of its life—in spring and autumn. During six months it took no food at all, and very little for four months previously. At the last moult but one it lost a limb, which however, reappeared when the spider again changed its skin, though it never attained the proper size.

With spiders, as with insects, moulting is a very serious matter, involving much more than the mere casting off of an external coat. If all does not go well limbs may easily be lost in the operation, nor is it rare to meet with instances in which the animal has perished in its unsuccessful attempt to discard the old integument.

Mr Adams' second specimen was kept alive for three years and ten months. It moulted only once each year—in June or July—and it died in the act of casting its skin. In the case of these spiders, also, it was noted that insects supplied to them as food displayed no fear whatever. There were always a few cockroaches in the same box, and they were often observed actually with the spider in its nest, but no notice was taken of them unless their host chanced to be hungry. A photograph of this spider is given in the Frontispiece.

It is an interesting fact that many of the Avicylariidae of Southern Asia and Australia possess a sound-producing apparatus which is entirely lacking in African and American forms, but this is a subject which deserves a chapter to itself.

CHAPTER XII

STRIDULATION

MANY of the Arthropoda—the large group which includes insects and crustaceans as well as Arachnida —are able to produce sounds, a fact familiar enough in such insects as crickets and grass-hoppers. As, however, the breathing apparatus of these animals is entirely different from that of mammals and has no connection whatever with the mouth and alimentary canal, the mode of sound production is not at all the same. Instead of setting vocal chords in vibration by the expulsion of air through the larynx, insects "sing" or "chirp" by rapidly rubbing together certain specially roughened surfaces, which constitute what is called a "stridulating organ." In crickets, for instance, each tegmen or wing-cover is provided with a kind of file, and when the wing-covers are rapidly vibrated, the edge of each rubs against the opposite file, and a loud shrill sound is produced.

The stridulating apparatus is by no means always in the same place; the thorax may rub against the abdomen, the leg against the wing-cover, or one of the mouth appendages against another. Nor are the sounds produced always audible to human ears;

at all events there are many creatures with what appear to be very well developed stridulating organs whose note has never yet been heard by any naturalist, but there are doubtless numberless sounds beyond the range of our hearing, which is limited, like the key-board of a piano.

Now such a stridulating apparatus has been detected in many spiders, and always in one of three situations—either between the two parts of the body (cephalothorax and abdomen) or between the palps and the mandibles, or between the palps and the front legs. In some of the Theridiidae the hind end of the cephalothorax is roughened and fits into a sort of socket in the abdomen which is provided with parallel ridges, so that when the abdomen is vibrated the two surfaces are rubbed together, but no one has yet heard a sound produced by these spiders. The stridulating Aivculariidae, however, are easily heard, the sound in some cases being described as a kind of whistle,—in others it has been said to have the effect of shot dropping upon a plate.

There are two quite distinct purposes for which sounds may be produced; they may either serve as a call from one sex to the other, or as a warning to intruders. Obviously the first purpose requires a sense of hearing in the sex appealed to, and it is interesting to note that in the Theridiidae, which are among the spiders which show some appreciation of

sound, the organ is well developed in the male only, being rudimentary or altogether absent in the female, while in the Avicularíidae, which appear to be quite deaf, both sexes possess it equally. In them its function is probably to warn off its enemies—a purpose for which it is not at all necessary that the spider itself should hear it.

Sometimes sounds have been quite wrongly attributed to spiders; there is, for example, an Australian species widely known among natives as the "barking" or "booming" spider, for no better reason than that the spider has been found in the day-time at a spot where the booming was heard at night. This case was investigated by Professor Baldwin Spencer, who found that quails were really responsible for the sounds with which the spider was credited. The creature could, however, achieve a kind of whistle by rubbing its palps against its mandibles. Its stridulating apparatus was of the type common among the Avicularíidae. Its principle is that of the musical box, where nail-like projections on a barrel strike against the teeth of a metal comb, except that the barrel is stationary and the comb is moved up and down against it. The barrel is here represented by the first joint of the mandible which is beset on its outer side with spines. The inner edge of the first joint of the palp is furnished with "keys" which are rubbed against the mandible spines when the palps

are vibrated. These keys are very curious structures. They are of various lengths, and their shape will perhaps be understood when it is said that a tolerable model of one would be obtained by taking a flat iron bar, sharpening it at the end, and then so twisting it in the middle that the flat surface of one half is at right-angles to the flat surface of the other half. Its

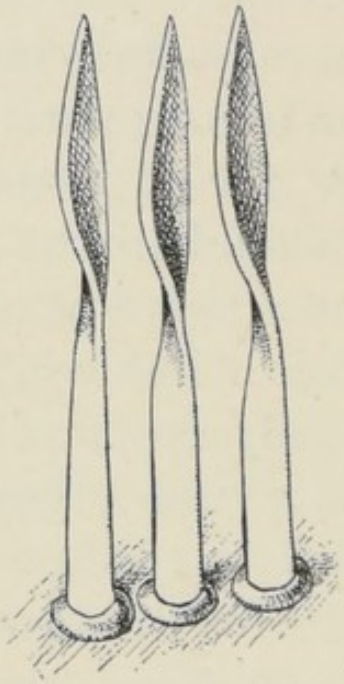

Fig. 11. Three "keys" of a stridulating organ, after Spencer.

appearance therefore varies according to the point of view, the narrow edge of one half and the broad edge of the other being visible at the same time. A moment's consideration will show that this torsion is calculated to give great rigidity to the keys, for when the outer half is struck on the flat surface the inner half opposes its greatest diameter to the shock. A similar structure is found in all the Theraphosid spiders which are able

to produce a sound, though sometimes the "keys" are on the mandibles and the spines on the palp.

In Staten Island there is a wolf-spider—*Lycosa kochi*—which is known as the "purring" or "drumming" spider because of a curious habit which the male has, at mating time, of rapidly drumming on the dead leaves in a wood with its palps. It runs hither and thither over the ground as if in search of something, pausing at short intervals to "purr," and the sound had frequently been heard and correctly attributed to the spider before the way in which it is produced was discovered. In this case it is probable that the production of sound is not the object of the spider at all, for we have no evidence that wolf-spiders hear. On the other hand rapid tapping with the palps is a very characteristic action with male spiders at mating time, and it is easy to believe that contiguous dry leaves would conduct vibrations to a female at some distance away and inform her of the presence of the male. Just so, as we have seen, our English Theraphosid announces his arrival by tapping on the exposed part of the nest of the female.

CHAPTER XIII

THE SPINNING APPARATUS, AND THE FEET

SEEING that the possession of spinnerets is a characteristic of all spiders, and that a great deal of the interest attaching to their life-history arises from their spinning operations, any account of the group, however brief, would be incomplete without some attempt to describe these remarkable organs.

Among the spiders to which the attention of the reader has been directed, some have been highly accomplished spinners, constructing complicated snares, retreats and egg-cocoons, while in the case of others the spinning work is very meagre and employed chiefly for the protection of the eggs. As might be expected, the organs attain a very much higher development in some spiders than in others, and the most complex of all are those of the Epeiridae, the constructors of the circular snare.

Now in the first place it is rather striking that the spiders with the most conspicuous spinnerets are by no means the most able spinners. The "bird-eating" spiders are a case in point, for they spin very little, yet two of their spinnerets are much more obvious than anything Epeira has to show, for they protrude behind the body and strike the eye at the first

glance. Indeed excessive length has nothing to do with complexity but is found wherever a wide sweep is necessary in laying down the threads—as we saw in the case of Agelena, when constructing its sheet-web.

Roughly speaking, the spinnerets are very mobile finger-like projections, generally situated under the hind end of the abdomen and, bearing more or less numerous tubes from which the silken threads proceed. The usual number of spinnerets is six, but there is a pretty wide range, one group of spiders having only two, while a few possess eight.

The spinnerets, then, are only the bearers of the actual tubes which emit the silk. The distribution of the tubes themselves is different in the different kinds of spiders, but it is usually possible to distinguish two kinds. There are generally present a large number of very fine cylindrical tubes or "spools" and a few conical tubes of much larger base, which are called spigots. Each of these orifices, whether on spool or spigot, is connected by a fine tube with a separate silk gland, or organ for manufacturing silk, situated within the spider's abdomen. Epeira has about 600 of such glands, each with its own terminal spool or spigot, and the large number of these tubes has given rise to a misconception that is very widely spread—namely that the spider's line, fine as it is, is "woven" of hundreds of threads of very much finer silk. This is not so, as we shall presently see.

Though Epeira has some 600 silk-glands, it has only five different *kinds* of gland, manufacturing silk of different properties. No other family of spiders has so many, though two other kinds of gland have been found in less elaborate spinners. Within the spider the silk is fluid but it solidifies on meeting the air, each thread hardening as it emerges though still continuous with the fluid contents of the gland, so that the drawing out of a silken thread is just like the operation so familiar with the glue-pot, or with spun glass, except that the hardening is not due to cooling but to exposure to the air. This general description will, it is hoped, make an account of the organs in Epeira more comprehensible.

The spinnerets of Epeira are so small and inconspicuous that their disposition is not very easy to make out. When not in use they form a tiny cone under the tip of the abdomen, and only four are visible, their free ends being so brought together as entirely to conceal a small central pair. There are really, then, three pairs of spinnerets which we may call at once the anterior, median and posterior pairs, though when at rest only the anteriors and posteriors can be seen. If the spider is observed with a pocket-lens as it crawls about in a glass tube it will be noticed that the spinnerets are capable of great mobility. Their ends can be separated or brought together, or they may be made to rub against each

other or against the sides of the tube. The anteriors and posteriors, moreover, are two-jointed though the medians consist only of a single joint.

So much can be seen without any great magnification, but the microscope will be necessary if a complete understanding of their mechanism is to be arrived at. What it reveals will now be briefly described, and will, it is hoped, be made tolerably clear by the accompanying figures which are simplified by the omission of a large number of bristles which tend to hide the essential structure, and by a great reduction in the number of "spools," though the spigots are all indicated.

The anterior spinneret (that nearest the head end of the animal) is a sort of cone, divided into a large basal joint and a small terminal joint. The latter bears on its inner side a single spigot (fig. 12 *a*) and is crowned with a battery of spools, about a hundred in number.

The median spinneret has three spigots, two at the tip and one on the inner side (fig. 12 *b*), and about a hundred spools, mostly on its inner surface.

The posterior spinneret is divided very obliquely into two joints, so that the terminal joint extends much lower down on the inner than on the outer side. It has five spigots in groups of three and two, and again there are about a hundred spools.

Now the point that I wish to make clear is that

there is no interweaving of the out-put of these various spools and spigots. At the moment of emission the threads are adhesive, and can be made to stick to the glass or to one another, but they are not in any sense either fused or interwoven. For ordinary operations the brunt of the work is borne by the spigots marked *a* in the figure, sometimes reinforced by silk from the spigots on the median

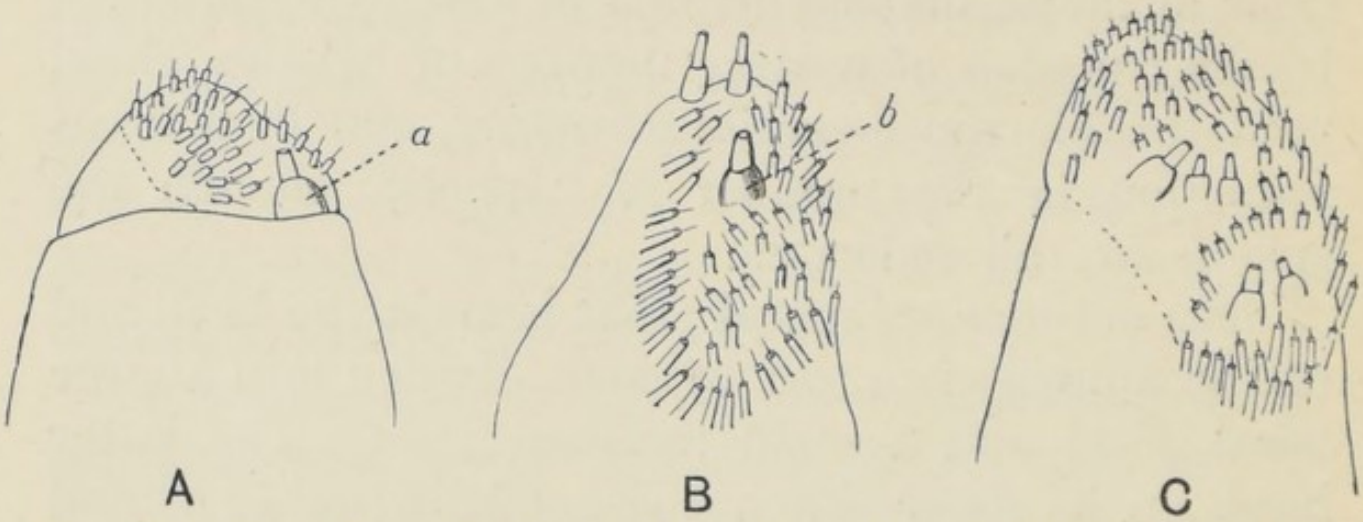

Fig. 12. View, from the inner side, of one of each of the three spinnerets of *Epeira*. *A*, anterior; *B*, median; *C*, posterior spinneret.

spinnerets marked *b*, the functions of all the other spools and spigots being special and occasional. For instance, when Epeira is laying down a foundation line, this is what happens. The spider sits down, so to speak, on a twig, separating its spinnerets and rubbing them on the surface. As it raises its abdomen a multitude of little threads are seen merging into what appears to be a single line.

In reality the line is double, emerging from the

spigots (*a*) on the anterior spinnerets, and it can easily be separated into two—and two only—anywhere along its length. The multitudinous spools have emitted short lengths of silk to anchor the foundation line at its commencement, but they are then closed and have no share in the ever-lengthening line as the spider lets itself drop or crawls away to attach it to a new spot. One of their uses, then, is to anchor the main lines from the spigots to external objects, but they have another function not less important. Everybody has seen a garden-spider trussing up a captured fly. It is held in the jaws and front legs and slowly revolved while with its hind legs the spider draws out bands of silk from the spinnerets and swathes it like a mummy. No silken rope, this, of fused or interwoven threads, but a broad band, every strand of which is separate and distinct and proceeds from a different spool. Two or three hundred fine threads wound simultaneously round the insect form a much more effectual winding sheet than would a single cord composed of them all.

So far we have accounted for the spools, and for one pair of spigots—those on the anterior spinnerets. The lower spigot (*b*) on the middle spinneret often assists in laying down a foundation line when extra strength is required. In that case the line is four-fold, and can easily be split into four along its whole length, the threads from the middle spinnerets being

rather finer than those from the anterior, but composed of the same kind of silk.

There remain seven pairs of spigots whose function has still to be explained, two on the middle and five on the posterior spinnerets. The three which are clustered together on the posterior spinneret do not form *silk* at all, that is, the material they emit does not harden on exposure to the air but remains fluid and adhesive. When the spider is spinning the "viscid spiral" of its web it is from these spigots that the sticky matter oozes, enveloping the true silken lines and presently resolving itself into little globules in the manner already described.

The remaining spigots—two on the middle and two on the posterior spinnerets are employed only in spinning the egg-cocoon, and the silk they produce is unlike that used in making the snare, being much stronger and less elastic, and—in the case of the garden-spider—of a yellow colour. In the occasional attempts which have been made to substitute spiders for silkworms as commercial silk producers, it is only this cocoon silk that has given any considerable results, the produce of the other glands being far too frail for profitable use. Such attempts, however, have always failed, principally for a reason quite unconnected with the particular nature of the silk, namely, the difficulty of keeping the spiders in captivity. It is a simple matter to supply dozens of

silkworms in the same box with mulberry leaves, but spiders require separate compartments or they will fight and devour each other, and the provision of suitable food for them is such a troublesome matter that it has proved quite impracticable on a commercial scale.

We have incidentally seen that there are quite a number of different operations in which the spinning apparatus takes part. There is the line which most spiders lay down as they wander, and which secures them from the danger of a fall if they lose their footing; there is the snare for catching prey, the nest or retreat, and the egg-cocoon, and in addition, silk from the spinnerets may be used to enwrap and paralyse captured insects, or to assist the young spider to migrate. Since the Epeiridae perform all these operations, and are, moreover, the most finished of snare-makers, it does not surprise us to find in them the highest development of the silk glands and the most complete battery of spools and spigots on the spinnerets. Many spiders, as we know, make no snare at all, and in the case of some, very little spinning is attempted beyond the manufacture of a rather rudimentary covering for the eggs. Naturally a less complex spinning apparatus is required, and we accordingly find that jumping spiders, for instance, have only about fifty silk-glands comprising three different kinds of gland, while the glands found in

such of the large Aviculariidae as have been examined have been all alike.

There is in some spiders a spinning organ, not to be found in Epeira, which deserves a passing notice. It does not take the place of spinnerets, of which the usual three pairs are present, but it is situated in front of them, and only occurs in the female of the species. Its peculiarity is that the silk does not emerge from projecting spools; but through fine holes in a sieve-like plate, called a *cribellum*, which is flush with the surface of the abdomen. It has no mobility, therefore, and the threads from it have to be combed out and distributed by the spider's hind leg. For the better accomplishment of this purpose there is a special comb of stiff hairs or bristles, called a *calamistrum*, on each of the fourth pair of legs.

The web of these spiders is not unlike that of Agelena, but of a rather finer texture, and it can be seen, on magnification, to consist of an irregular ground-work over which have been spread wavy bands of excessively fine silk, combed out from the orifices of the cribellum glands. Some of these cribellate-spiders, of the genus *Amaurobius*, are not uncommon in our cellars and out-houses; their bodies are of stouter build and their legs much shorter than those of the common house-spider.

We have no space for anything approaching a full description of the anatomy of spiders, but there is one

other point of structure of which the reader has been promised some account. Attention was directed to the fact that while some spiders are helpless on smooth perpendicular surfaces unless they have lines to cling to, others can run with ease upon the walls or even the ceiling, of a room.

The last joint or *tarsus* of the spider's leg is very different in the two cases. It always terminates in claws—either two or three—so that any species can

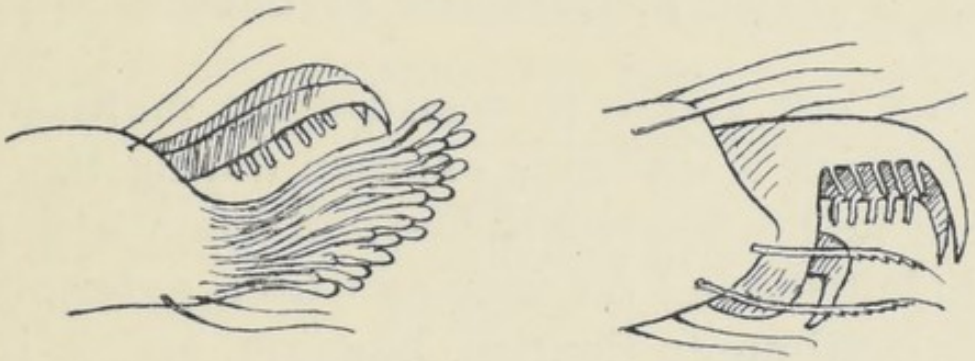

Fig. 13. Foot of Jumping Spider (on left), foot of Garden Spider (on right).

make some show of climbing where the surface is rough and there is anything to cling to, but to obtain a hold on a polished surface it needs a special contrivance. This takes the form of a pad of curiously modified hairs, called a *scopula*. The hairs are club-shaped, narrow at their stalk and swelling towards the tip, and their clinging power seems to be due to a viscid secretion. The foot of any jumping spider will show this structure well. Epeira has no scopula, and its climbing is always laborious unless it has a thread

to cling to, but it is supreme as a rope walker, treading daintily on the most delicate threads, mounting a line "hand over hand" with great agility, and manipulating the silk in its various spinning operations with unerring skill and facility.

CHAPTER XIV

THE ENEMIES OF SPIDERS

WHEN one comes to consider the multitudinous risks to which a spider is exposed during the whole course of its life it seems at first a little surprising that the whole tribe has not long ago been exterminated. Spiders continue to flourish, however, and it is very clear that however careless Nature may be of the individual she is extremely solicitous about the race.

The infant mortality among these creatures must be appalling. There is first their cannibalistic propensity to be reckoned with. Newly hatched spiders while still within the cocoon seldom attack each other, but as soon as ever each sets up for itself, no quarter is given. It often happens that members of a brood of sedentary spiders spin their first snares in close contiguity, and if food is scarce they eat one another without compunction. It is said that a few

individuals of a brood may be reared to maturity on no other food than their sisters and brothers! The case of the survivor of the "Nancy Bell" in the Bab Ballads would be exceedingly commonplace in the aranead world. We have seen, too, how, on occasion, *Atypus* will devour her young if they do not leave the nest with due expedition. Then if the weather conditions chance to be unfavourable just at the period of departure from the cocoon broods are liable to perish wholesale, washed away and destroyed by deluges of rain; myriads, too, must be carried out to sea in the course of their ballooning operations, and never come safely to land.

But the mortality is probably even greater at a still earlier stage, for hosts of spiders' eggs never hatch at all, and this for two reasons. In the first place, the silk of spiders is a favourite material with many birds for the lining of their nests, and many of them use the cocoons for this purpose. Secondly, there are numerous Ichneumon flies which attack and parasitise spiders' cocoons, piercing them with their ovipositors and laying their eggs inside. The eggs of the Ichneumon fly hatch first and feed upon the eggs of the spider. Two such flies are known to attack the cocoons of the garden-spider, and not a single spider will emerge from a cocoon thus parasitised. The spiders whose cocoons are most subject to these attacks belong, as might perhaps

be expected, to the sedentary groups, and the most elaborate but unavailing precautions are often taken to render them Ichneumon-proof. The cocoons of the peripatetic wolf-spiders have never been observed to be parasitised.

Even if a spider has survived these early perils there are still many dangers ahead. During its period of growth it has to moult some eight or nine times, and the operation is at least as dangerous as, say, an attack of measles to the human infant. For some time beforehand feeding ceases, and the animal becomes inert and apparently dead, but presently the integument splits, and out struggles the spider, pale and soft, and leaving behind it not only the outer skin but the lining of most of its alimentary canal and of its breathing tubes. Sometimes, as we have said, it fails to extricate itself and dies; quite often it emerges with the loss of a limb, which will re-appear—reduced in size—at the next moult. It is necessary to go into retreat for a time after moulting, till strength has returned and the integument has hardened.

But the dangers of moulting, though not negligible, are insignificant beside others to which the spider is exposed during its later stages, nor is a prolonged dearth of food necessarily fatal, for, as we have seen, a spider can fast for an astonishing time and yet retain its health if it has a fair supply of water. But there

are terrible enemies at hand from which it has little or no protection. Birds, of course, come first, for to most insectivorous birds spiders are acceptable morsels. I have seen a hedge sparrow going conscientiously over a trellis work and picking out all the spiders from the nooks and corners. Then insectivorous mammals make no distinction between the Insecta and the Arachnida, and often eat spiders with avidity, as also will toads and lizards.

Moreover, Ichneumon flies do not confine their attention to cocoons, but often attack well-grown spiders. They invariably lay their eggs on one spot—at the very front of the abdomen, near the cephalothorax, where the spider is powerless to dislodge them. The egg hatches out to a grub which is a veritable "old man of the sea" on the spider's back, and there it remains until it causes the death of its victim by feeding on the contents of the abdomen. Four such Ichneumon flies have been found to attack the garden-spider, and no kind of spider seems exempt. How they contrive to deposit their eggs in the proper place without great danger of themselves falling a prey to their victims is a mystery. To venture into a garden-spider's web for the purpose would seem a fool-hardy proceeding. The actual deposition of the egg has seldom been witnessed, but in one of the few cases that have come under observation the spider made little resistance and

appeared quite demoralised. It was hanging from a thread, down which the Ichneumon fly was seen to crawl. When it reached the spider the latter dropped an inch lower on two or three occasions but then remained passive, and the parasite on nearing it, turned round, backed down the line, and with great care and deliberation attached an egg at the usual spot.

But no enemies of spiders are more terrible than some of the solitary wasps, and gruesome indeed is the fate of any creature that falls into their clutches. The social wasps often capture spiders to feed their young but in their case the proceeding is summary and without any finesse. They merely catch a spider, sting it to death, cut it to pieces with their jaws, and feed it into the mouths of their expectant grubs. The treatment is brutal enough, but at all events it is expeditious. Now the solitary "digger" wasps never see their young. They make cells, either by burrowing in the ground or by agglomerating particles of mud or gravel, and in each cell is placed an egg together with sufficient food to last the grub which hatches out for the whole of its larval existence. The mother will not be at hand—as is the social worker-wasp—to supply new food as required, and it is therefore necessary so to arrange matters that the food provided may retain its fresh condition for at least a fortnight. On the other hand the victims must

be deprived of all power of motion, otherwise the egg will stand a great chance of being displaced and crushed, and even if it hatches it will be unable to commence its meal upon the struggling spider.

Now in the whole range of animal instinct there is nothing more remarkable than the manner in which the solitary wasps have learnt to solve this problem. The solution lies in so stinging the victim that it is paralysed but not killed, and though quite unable to move, it neither shrivels nor decays, but remains perfectly sound and edible for two or three weeks. To accomplish this result the wasp acts as though it possessed a knowledge of the minute anatomy of its victim, and knew to a hair's breadth the position of the principal nerve ganglia which control its actions. Into these it unerringly thrusts its sting. But even accuracy of aim is not everything; there must be the finest discrimination in the severity of the wound. A slight excess, and the animal is killed; too timid a thrust will not destroy movement. When the delicate operation has been successfully performed, the paralysed spider is dragged into the cell, placed on its back, and an egg carefully deposited at the base of its abdomen, after which the cell is sealed up. Some wasps, instead of providing a single large spider, store their cells with a number of smaller victims, all rendered limp and motionless.

In attacking a spider the first action of one of

these wasps is to remove it from its natural environment. A garden-spider in its web, or a burrowing spider in its tunnel are more or less formidable, but if the one can be thrown down, or the other dragged forth into the open, they are well-nigh defenceless. Therefore in attacking an Epeirid the wasp first darts at it, seizes a leg, and attempts to jerk it out of the web. If unsuccessful, the spider will now be on its guard, and the wasp leaves it and tries the same manœuvre on another individual. Taken by surprise, it is instantly thrown to the ground, and can then offer no effectual resistance. Even the large "bird-eaters" fall victims to these terrible foes.

CHAPTER XV

SOME CONCLUDING REFLEXIONS

In the foregoing pages we have been able to deal with very few out of the vast number of known spiders; yet the examples we have chosen for study are fairly typical of some of the more important groups, and calculated to give a tolerably just idea of the general economy of the tribe. In any case even such a fragmentary study as the present gives us food for thought. There is a question which the writer has so often been asked that he is inclined to deal

with it in anticipation, though perhaps he is wronging his readers in supposing that they desire to propound any such conundrum. This question is: What is the *use* of spiders?

Now underlying this question there is surely a very unwarranted assumption that all the myriad creatures which exist have, as a reason for their existence, some reference to the activities and desires of mankind. As far as it has any meaning at all it amounts to this: What benefit does man derive from spiders? But it seems to take for granted that some benefits must accrue to man from these creatures, or they would not have the audacity to persist in living. Well, if the question in this amended form is in urgent need of an answer, the reply must be: very little if any. Certainly spiders prey as a rule on insects and no doubt kill many which might injure us, and in the constant battles between man and insect pests, instances have been recorded where particular species of spider have fought on the side of man with appreciable effect. But then they are as likely to devour our insect friends as our insect enemies, impartially slaying the just together with the unjust, so that little stress can be laid on their utility on this score. Indeed there is quite as good a case to be made out of man benefiting spiders as of spiders benefiting man, for his architectural proclivities have provided some species with secure homes from which

most of their enemies—except man himself—are excluded, and where they are sheltered from the storms which are so fatal to their relatives outside, protected from extremes of temperature, and rendered so independent of times and seasons that the number of broods they produce in the year has increased. Whether a creature is useful or injurious is entirely a matter of the point of view. There are several animals with regard to which the opinions of the farmer and the gamekeeper are diametrically opposed!

But if anything emerges from the study in which we have been engaged, it is surely this fact: that wherever there is a niche in nature capable of sustaining life, to that niche some animal will sooner or later adapt itself without any reference to man's desires or interests. We have seen spiders, all built on the same ground-plan, so to speak, and with the same essential organs, so modified in the details of structure and inherited instincts as to be able to thrive under the most diverse conditions. Think, for instance, of the water-spider and the desert Tarantula, or consider the difference in mode of life between the sedentary garden-spider and the hunting Attid.

Incessant competition in the struggle for life no doubt urged on primeval spiders to strike out new modes of existence. Under slightly novel conditions the best adapted or most adaptable survived and were pioneers in the occupation of a new territory

till the widely different capacities and habits which we now wonder at were slowly evolved.

Another point to ponder on is the wonderful complexity of the instincts which govern the actions of spiders; the extraordinary operations they can perform, entirely untaught, and of the object of which it is impossible to believe they are aware. We have seen that, in the most highly organised species, the sense organs—except perhaps that of touch—are but moderately developed, and the power of memory, the basis of intelligent action, but feeble; yet their inherited impulses suffice for all ordinary emergencies, and recur with unfailing precision at the proper periods of their lives. They are machine-like, perhaps, but what extraordinarily competent machines! The light of what we call intelligence burns low, but a glimmer of it can be detected here and there.

If one comes to think of it, the egg of a creature of complex instincts is a particularly wonderful atom; it contains not only the germs of all the complicated bodily structure, but there are bound up in it also the impulses that are to come into play at certain definite periods only of the spider's life-history. And these impulses are not mere vague reminders that now is the time to spin a snare, or to weave an egg-cocoon; they prescribe precisely how it is to be done, involving perhaps a dozen different spinning operations in one unvarying order. Viewed in this

light, the germ of an insect or a spider would seem in a sense to be more complex than that of an animal whose vague instinctive impulses are under the direction of intelligence, and can be carried out in a variety of ways according to circumstances.

One of the most surprising things about the egg of a spider is the amount of *energy* stored up in it. A bird's egg, huge in comparison, contains material sufficient to build up the body of a fledgeling just sufficiently active to be able to accept from the mother that first nutriment without which it will speedily die.

But turn back to the account of the tarantula-spider. Its egg is small—perhaps the twelfth of an inch in diameter; yet it not only produces a spiderling complete in form, and provided with all the complex instincts of its tribe, but there is so much energy to spare that, for months, without any new food-supply, the young spider can lead an active life, frequently descending from and remounting its mother's back, and can even put forth silk on its own account! The objects which a conjuror produces from a hat seem trifles in comparison with the outcome of a spider's egg—the actual material seems astonishing from so small a source, but whence comes all this surprising surplus of energy? Fabre suggests that it is supplied by the direct rays of the sun, to which the Tarantula exposes in turn all parts of the egg-cocoon.

All through their lives spiders seem to be gifted in a high degree with the power of extracting the utmost value, in substance and in energy, from their food. Consider the great Theraphosid spiders—the so called bird-eaters. They have a massive body, and great muscular power to sustain; yet they are never heavy feeders and can go for many months without any food at all. And it is not as though they were dormant during this period of abstention; their vital processes seem to be going on as usual the whole time, and they are ready at any moment to resent attack, or to employ their spinning organs during their long fast. True hibernation, as we have seen, does not occur in this group; if it did, there would be nothing remarkable in the occasional long abstention from food. The vitality of a hibernating animal is practically at a standstill; all its vital operations—breathing, blood-circulation, muscular action—are reduced to the lowest possible limit, and it very likely expends no more energy during its winter sleep than it would during a day or two of active summer life.

But of such reflexions there is no end, and many such will doubtless arise spontaneously in the mind of the thoughtful reader, and it is for that very reason that the study of the life-history of any animal is of such absorbing interest. It is not contended that spiders are any more wonderful than any other

group that might have been selected. There is, of course, a special interest attaching to the study of animals very much nearer to man in bodily structure and mental equipment, but the endeavour to understand the actions and appreciate the outlook on nature of creatures far remote from man, however unsuccessful, has its own fascination.

And this is what the mere collector entirely misses. Collecting is of course necessary, for a complete examination is never possible in the living specimen, and moreover without examples kept as types for reference we should lose our way in the multitude of living forms. But as an end in itself it is of vastly inferior value. The writer will be well content if he has succeeded in arousing the curiosity of some with regard to the humble life that surrounds us, and in stimulating a few who possess the requisite keenness and patience to add to our store of knowledge by new observations of their own.

LITERATURE

Most of the large publications on the Arachnid fauna of different countries give some preliminary account of the habits of spiders, but the only considerable work entirely devoted to that subject is McCook's *American Spiders and their Spinning-work* (Philadelphia, 1893). A small but interesting book on *The Structure and Habits of Spiders* was published ten years previously by Emerton (Boston, 1883). But the reader who wishes to pursue further the study of some point to which his attention has been called in the foregoing pages may desire to be referred, for fuller details, to the original papers.

Many writers have described the spinning of the circular snare, and indeed it is quite easy for any one to watch the operation for himself; but McCook goes into the matter in great detail and figures many interesting variants of its normal form. J. H. Fabre's delightful *Souvenirs entomologiques* (Delagrave, Paris) have been issued at intervals for many years past, and mostly deal with insects. In Series 9, however, he has an entertaining chapter on "Les Epeires." That the "viscid globules" arranged themselves mechanically was first demonstrated by C. V. Boys (*Nature*, xl, 1889, p. 250). The same writer experimented on the sense of hearing in spiders (*Nature*, xxiii, 1880, p. 149). The interesting paper by G. and E. Peckham on the mental powers of spiders is to be found in the *Journal of Morphology* (Boston U.S.A.) i, 1887, p. 403.

The aeronautic habit has engaged the attention of many arachnologists. Blackwall dealt with it in various papers in the *Transactions of the Linnaean Society* between 1833 and 1841, but the most complete account is to be found in McCook's original papers which are summarised in his book already cited.

With regard to the spinning operations of *Agelena* the reader

may consult a paper by the present writer in the *Annals and Magazine of Natural History*, August, 1891.

The habits of the Water Spider were first described by de Lignac in a *Mémoire* published in 1749. Since that date many writers, notably Wagner and Plateau, have dealt with the subject. The paper by the last named in the *Annales des Sciences naturelles*, 1867, p. 345, is particularly worth reading.

E. Peckham deals with "Protective Resemblances in Spiders" in the publication of the *Natural History Society of Wisconsin* for 1889.

The reader interested in the habits of the Wolf-spiders must certainly consult the chapters on "La Lycose de Narbonne" in Series 9 of Fabre's *Souvenirs entomologiques.*

The classical account by the Peckhams, of the love dances of jumping spiders appeared conjointly with the paper by E. Peckham on "Protective Resemblances" cited above.

For the habits of *Atypus affinis* (or *piceus*) the reader is referred to the very complete account given by Enock in the *Transactions of the Entomological Society* (London, 1885, p. 394) of observations extending through several years.

The larger Avicularíidae have been dealt with in various papers by Pocock, and the particulars given with regard to *Dugesiella* were taken from a paper by Petrunkevitch in the *Zoologischen Jahrbüchern*, xxxi, 1911.

In the *Archiv für Naturgeschichte*, i, 1889, Apstein published an admirable piece of research on the structure and function of the spinning glands of spiders. He investigated the glands present in the various families, and the particular arrangement of the spools and spigots on the spinnerets.

A paper by the present writer in the *Quarterly Journal of Microscopical Science* for April 1890 continued this investigation, and shewed the special operations in which the various glands participated in the case of the Garden Spider.

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