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BRAMBLE-BEES AND OTHERS

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EAN 8596547361411

DigiCat, 2022
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CHAPTER 1. BRAMBLE-DWELLERS.

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The peasant, as he trims his hedge, whose riotous tangle threatens to encroach upon the road, cuts the trailing stems of the bramble a foot or two from the ground and leaves the root-stock, which soon dries up. These bramble-stumps, sheltered and protected by the thorny brushwood, are in great demand among a host of Hymenoptera who have families to settle. The stump, when dry, offers to any one that knows how to use it a hygienic dwelling, where there is no fear of damp from the sap; its soft and abundant pith lends itself to easy work; and the top offers a weak spot which makes it possible for the insect to reach the vein of least resistance at once, without cutting away through the hard ligneous wall. To many, therefore, of the Bee and Wasp tribe, whether honey-gatherers or hunters, one of these dry stalks is a valuable discovery when its diameter matches the size of its would-be inhabitants; and it is also an interesting subject of study to the entomologist who, in the winter, pruning-shears in hand, can gather in the hedgerows a faggot rich in small industrial wonders. Visiting the bramble-bushes has long been one of my favourite pastimes during the enforced leisure of the wintertime; and it is seldom but some new discovery, some unexpected fact, makes up to me for my torn fingers.

My list, which is still far from being complete, already numbers nearly thirty species of bramble-dwellers in the neighbourhood of my house; other observers, more assiduous than I, exploring another region and one covering

a wider range, have counted as many as fifty. I give at foot an inventory of the species which I have noted.

(Bramble-dwelling insects in the neighbourhood of Serignan [Vaucluse]:

1. MELLIFEROUS HYMENOPTERA.

Osmia tridentata, DUF. and PER.
Osmia detrita, PEREZ.
Anthidium scapulare, LATR.
Heriades rubicola, PEREZ.
Prosopis confusa, SCHENCK.
Ceratina chalcites, GERM.
Ceratina albilabris, FAB.
Ceratina callosa, FAB.
Ceratina coerulea, VILLERS.

2. HUNTING HYMENOPTERA.

Solenius vagus, FAB. (provisions, Diptera).
Solenius lapidarius, LEP. (provisions, Spiders?).
Cemonus unicolor, PANZ. (provisions, Plant-lice).
Psen atratus (provisions, Black Plant-lice).
Tripoxylon figulus, LIN. (provisions, Spiders).
A Pompilus, unknown (provisions, Spiders).
Odynerus delphinalis, GIRAUD.

3. PARASITICAL HYMENOPTERA.

A Leucopsis, unknown (parasite of Anthidium scapulare).
A small Scoliid, unknown (parasite of Solenius vagus).
Omalus auratus (parasite of various bramble-dwellers).
Cryptus bimaculatus, GRAV. (parasite of Osmia detrita).
Cryptus gyrator, DUF. (parasite of Tripoxylon figulus).
Ephialtes divinator, ROSSI (parasite of Cemonus unicolor).
Ephialtes mediator, GRAV. (parasite of Psen atratus).
Foenus pyrenaicus, GUERIN.
Euritoma rubicola, J. GIRAUD (parasite of Osmia detrita).

4. COLEOPTERA.

Zonitis mutica, FAB. (parasite of Osmia tridentata).

Most of these insects have been submitted to a learned expert, Professor Jean Perez, of Bordeaux. I take this opportunity of renewing my thanks for his kindness in identifying them for me.—Author's Note.)

They include members of very diverse corporations. Some, more industrious and equipped with better tools, remove the pith from the dry stem and thus obtain a vertical cylindrical gallery, the length of which may be nearly a cubit. This sheath is next divided, by partitions, into more or less numerous storeys, each of which forms the cell of a larva. Others, less well-endowed with strength and implements, avail themselves of the old galleries of other insects, galleries that have been abandoned after serving as a home for their builder's family. Their only work is to make some slight repairs in the ruined tenement, to clear the channel of its lumber, such as the remains of cocoons and the litter of shattered ceilings, and lastly to build new partitions, either with a plaster made of clay or with a concrete formed of pith-scrapings cemented with a drop of saliva.

You can tell these borrowed dwellings by the unequal size of the storeys. When the worker has herself bored the channel, she economizes her space: she knows how costly it is. The cells, in that case, are all alike, the proper size for the tenant, neither too large nor too small. In this box, which has cost weeks of labour, the insect has to house the largest possible number of larvae, while allotting the necessary amount of room to each. Method in the superposition of the floors and economy of space are here the absolute rule.

But there is evidence of waste when the insect makes use of a bramble hollowed by another. This is the case with Tripoxylon figulus. To obtain the store-rooms wherein to deposit her scanty stock of Spiders, she divides her borrowed cylinder into very unequal cells, by means of slender clay partitions. Some are a centimetre (.39 inch.—Translator's Note.) deep, the proper size for the insect; others are as much as two inches. These spacious rooms, out of all proportion to the occupier, reveal the reckless extravagance of a casual proprietress whose title-deeds have cost her nothing.

But, whether they be the original builders or labourers touching up the work of others, they all alike have their parasites, who constitute the third class of bramble-dwellers. These have neither galleries to excavate nor victuals to provide; they lay their egg in a strange cell; and their grub feeds either on the provisions of the lawful owner's larva or on that larva itself.

At the head of this population, as regards both the finish and the magnitude of the structure, stands the Three-pronged Osmia (Osmia tridentata, DUF. and PER.), to whom this chapter shall be specially devoted. Her gallery, which has the diameter of a lead pencil, sometimes descends to a depth of twenty inches. It is at first almost exactly cylindrical; but, in the course of the victualling, changes occur which modify it slightly at geometrically determined distances. The work of boring possesses no great interest. In the month of July, we see the insect, perched on a bramble-stump, attack the pith and dig itself a well. When this is deep enough, the Osmia goes down, tears off a few particles

of pith and comes up again to fling her load outside. This monotonous labour continues until the Bee deems the gallery long enough, or until, as often happens, she finds herself stopped by an impassable knot.

Next comes the ration of honey, the laying of the egg and the partitioning, the last a delicate operation to which the insect proceeds by degrees from the base to the top. At the bottom of the gallery, a pile of honey is placed and an egg laid upon the pile; then a partition is built to separate this cell from the next, for each larva must have its special chamber, about a centimetre and a half (.58 inch.—Translator's Note.) long, having no communication with the chambers adjoining. The materials employed for this partition are bramble-sawdust, glued into a paste with the insects' saliva. Whence are these materials obtained? Does the Osmia go outside, to gather on the ground the rubbish which she flung out when boring the cylinder? On the contrary, she is frugal of her time and has better things to do than to pick up the scattered particles from the soil. The channel, as I said, is at first uniform in size, almost cylindrical; its sides still retain a thin coating of pith, forming the reserves which the Osmia, as a provident builder, has economized wherewith to construct the partitions. So she scrapes away with her mandibles, keeping within a certain radius, a radius that corresponds with the dimensions of the cell which she is going to build next; moreover, she conducts her work in such a way as to hollow out more in the middle and leave the two ends contracted. In this manner, the cylindrical channel of the start is succeeded, in the worked portion, by an ovoid cavity flattened at both

ends, a space resembling a little barrel. This space will form the second cell.

As for the rubbish, it is utilized on the spot for the lid or cover that serves as a ceiling for one cell and a floor for the next. Our own master-builders could not contrive more successfully to make the best use of their labourers' time. On the floor thus obtained, a second ration of honey is placed; and an egg is laid on the surface of the paste. Lastly, at the upper end of the little barrel, a partition is built with the scrapings obtained in the course of the final work on the third cell, which itself is shaped like a flattened ovoid. And so the work goes on, cell upon cell, each supplying the materials for the partition separating it from the one below. On reaching the end of the cylinder, the Osmia closes up the case with a thick layer of the same mortar. Then that bramble-stump is done with; the Bee will not return to it. If her ovaries are not yet exhausted, other dry stems will be exploited in the same fashion.

The number of cells varies greatly, according to the qualities of the stalk. If the bramble-stump be long, regular and smooth, we may count as many as fifteen: that, at least, is the highest figure which my observations have supplied. To obtain a good idea of the internal distribution, we must split the stalk lengthwise, in the winter, when the provisions have long been consumed and when the larvae are wrapped in their cocoons. We then see that, at regular intervals, the case becomes slightly narrower; and in each of the necks thus formed a circular disk is fixed, a partition one or two millimetres thick. (.039 to.079 inch.—Translator's Note.) The rooms separated by these partitions form so

many little barrels or kegs, each compactly filled with a reddish, transparent cocoon, through which the larva shows, bent into a fish-hook. The whole suggests a string of rough, oval amber beads, touching at their amputated ends.

In this string of cocoons, which is the oldest, which the youngest? The oldest is obviously the bottom one, the one whose cell was the first built; the youngest is the one at the top of the row, the one in the cell last built. The oldest of the larvae starts the pile, down at the bottom of the gallery; the latest arrival ends it at the top; and those in between follow upon one another, according to age, from base to apex.

Let us next observe that there is no room in the shaft for two Osmiae at a time on the same level, for each cocoon fills up the storey, the keg that belongs to it, without leaving any vacant space; let us also remark that, when they attain the stage of perfection, the Osmiae must all emerge from the shaft by the only orifice which the bramble-stem boasts, the orifice at the top. There is here but one obstacle, easy to overcome: a plug of glued pith, of which the insect's mandibles make short work. Down below, the stalk offers no ready outlet; besides, it is prolonged underground indefinitely by the roots. Everywhere else is the ligneous fence, generally too hard and thick to break through. It is inevitable therefore that all the Osmiae, when the time comes to quit their dwelling, should go out by the top; and, as the narrowness of the shaft bars the passage of the preceding insect as long as the next insect, the one above it, remains in position, the removal must begin at the top, extend from cell to cell and end at the bottom. Consequently, the order of exit is the converse to the order

of birth: the younger Osmiae leave the nest first, their elders leave it last.

The oldest, that is to say, the bottom one, was the first to finish her supply of honey and to spin her cocoon. Taking precedence of all her sisters in the whole series of her actions, she was the first to burst her silken bag and to destroy the ceiling that closes her room: at least, that is what the logic of the situation takes for granted. In her anxiety to get out, how will she set about her release? The way is blocked by the nearest cocoons, as yet intact. To clear herself a passage through the string of those cocoons would mean to exterminate the remainder of the brood; the deliverance of one would mean the destruction of all the rest. Insects are notoriously obstinate in their actions and unscrupulous in their methods. If the Bee at the bottom of the shaft wants to leave her lodging, will she spare those who bar her road?

The difficulty is great, obviously; it seems insuperable. Thereupon we become suspicious: we begin to wonder if the emergence from the cocoon, that is to say, the hatching, really takes place in the order of primogeniture. Might it not be—by a very singular exception, it is true, but one which is necessary in such circumstances—that the youngest of the Osmiae bursts her cocoon first and the oldest last; in short, that the hatching proceeds from one chamber to the next in the inverse direction to that which the age of the occupants would lead us to presume? In that case, the whole difficulty would be removed: each Osmia, as she rent her silken prison, would find a clear road in front of her, the Osmiae nearer the outlet having gone out before her. But is this

really how things happen? Our theories very often do not agree with the insect's practice; even where our reasoning seems most logical, we should be more prudent to see what happens before venturing on any positive statements. Leon Dufour was not so prudent when he, the first in the field, took this little problem in hand. He describes to us the habits of an Odynerus (Odynerus rubicola, DUF.) who piles up clay cells in the shaft of a dry bramble-stalk; and, full of enthusiasm for his industrious Wasp, he goes on to say:

'Picture a string of eight cement shells, placed end to end and closely wedged inside a wooden sheath. The lowest was undeniably made first and consequently contains the first-laid egg, which, according to rules, should give birth to the first winged insect. How do you imagine that the larva in that first shell was bidden to waive its right of primogeniture and only to complete its metamorphosis after all its juniors? What are the conditions brought into play to produce a result apparently so contrary to the laws of nature? Humble yourself in the presence of the reality and confess your ignorance, rather than attempt to hide your embarrassment under vain explanations!

'If the first egg laid by the busy mother were destined to be the first-born of the Odyneri, that one, in order to see the light immediately after achieving wings, would have had the option either of breaking through the double walls of his prison or of perforating, from bottom to top, the seven shells ahead of him, in order to emerge through the truncate end of the bramble-stem. Now nature, while refusing any way of escape laterally, was also bound to veto any direct invasion, the brutal gimlet-work which would inevitably have

sacrificed seven members of one family for the safety of an only son. Nature is as ingenious in design as she is fertile in resource, and she must have foreseen and forestalled every difficulty. She decided that the last-built cradle should yield the first-born child; that this one should clear the road for his next oldest brother, the second for the third and so on. And this is the order in which the birth of our Odyneri of the Brambles actually takes place.'

Yes, my revered master, I will admit without hesitation that the bramble-dwellers leave their sheath in the converse order to that of their ages: the youngest first, the oldest last; if not invariably, at least very often. But does the hatching, by which I mean the emergence from the cocoon, take place in the same order? Does the evolution of the elder wait upon that of the younger, so that each may give those who would bar his passage time to effect their deliverance and to leave the road clear? I very much fear that logic has carried your deductions beyond the bounds of reality. Rationally speaking, my dear sir, nothing could be more accurate than your inferences; and yet we must forgo the theory of the strange inversion which you suggest. None of the Bramble-bees with whom I have experimented behaves after that fashion. I know nothing personal about Odynerus rubicola, who appears to be a stranger in my district; but, as the method of leaving must be almost the same when the habitation is exactly similar, it is enough, I think, to experiment with some of the bramble-dwellers in order to learn the history of the rest.

My studies will, by preference, bear upon the Three-pronged Osmia, who lends herself more readily to laboratory

experiments, both because she is stronger and because the same stalk will contain a goodly number of her cells. The first fact to be ascertained is the order of hatching. I take a glass tube, closed at one end, open at the other and of a diameter similar to that of the Osmia's tunnel. In this I place, one above the other, exactly in their natural order, the ten cocoons, or thereabouts, which I extract from a stump of bramble. The operation is performed in winter. The larvae, at that time, have long been enveloped in their silken case. To separate the cocoons from one another, I employ artificial partitions consisting of little round disks of sorghum, or Indian millet, about half a centimetre thick. (About one-fifth of an inch.—Translator's Note.) This is a white pith, divested of its fibrous wrapper and easy for the Osmia's mandibles to attack. My diaphragms are much thicker than the natural partitions; this is an advantage, as we shall see. In any case, I could not well use thinner ones, for these disks must be able to withstand the pressure of the rammer which places them in position in the tube. On the other hand, the experiment showed me that the Osmia makes short work of the material when it is a case of drilling a hole through it.

To keep out the light, which would disturb my insects destined to spend their larval life in complete darkness, I cover the tube with a thick paper sheath, easy to remove and replace when the time comes for observation. Lastly, the tubes thus prepared and containing either Osmiae or other bramble-dwellers are hung vertically, with the opening at the top, in a snug corner of my study. Each of these appliances fulfils the natural conditions pretty satisfactorily:

the cocoons from the same bramble-stick are stacked in the same order which they occupied in the native shaft, the oldest at the bottom of the tube and the youngest close to the orifice; they are isolated by means of partitions; they are placed vertically, head upwards; moreover, my device has the advantage of substituting for the opaque wall of the bramble a transparent wall which will enable me to follow the hatching day by day, at any moment which I think opportune.

The male Osmia splits his cocoon at the end of June and the female at the beginning of July. When this time comes, we must redouble our watch and inspect the tubes several times a day if we would obtain exact statistics of the births. Well, during the six years that I have studied this question, I have seen and seen again, ad nauseam; and I am in a position to declare that there is no order governing the sequence of hatchings, absolutely none. The first cocoon to burst may be the one at the bottom of the tube, the one at the top, the one in the middle or in any other part, indifferently. The second to be split may adjoin the first or it may be removed from it by a number of spaces, either above or below. Sometimes several hatchings occur on the same day, within the same hour, some farther back in the row of cells, some farther forward; and this without any apparent reason for the simultaneity. In short, the hatchings follow upon one another, I will not say haphazard—for each of them has its appointed place in time, determined by impenetrable causes—but at any rate contrary to our calculations, based on this or the other consideration.

Had we not been deceived by our too shallow logic, we might have foreseen this result. The eggs are laid in their respective cells at intervals of a few days, of a few hours. How can this slight difference in age affect the total evolution, which lasts a year? Mathematical accuracy has nothing to do with the case. Each germ, each grub has its individual energy, determined we know not how and varying in each germ or grub. This excess of vitality belongs to the egg before it leaves the ovary. Might it not, at the moment of hatching, be the cause why this or that larva takes precedence of its elders or its juniors, chronology being altogether a secondary consideration? When the hen sits upon her eggs, is the oldest always the first to hatch? In the same way, the oldest larva, lodged in the bottom storey, need not necessarily reach the perfect state first.

A second argument, had we reflected more deeply on the matter, would have shaken our faith in any strict mathematical sequence. The same brood forming the string of cocoons in a bramble-stem contains both males and females; and the two sexes are divided in the series indiscriminately. Now it is the rule among the Bees for the males to issue from the cocoon a little earlier than the females. In the case of the Three-pronged Osmia, the male has about a week's start. Consequently, in a populous gallery, there is always a certain number of males, who are hatched seven or eight days before the females and who are distributed here and there over the series. This would be enough to make any regular hatching-sequence impossible in either direction.

These surmises accord with the facts: the chronological sequence of the cells tells us nothing about the chronological sequence of the hatchings, which take place without any definite order. There is, therefore, no surrender of rights of primogeniture, as Leon Dufour thought: each insect, regardless of the others, bursts its cocoon when its time comes; and this time is determined by causes which escape our notice and which, no doubt, depend upon the potentialities of the egg itself. It is the case with the other bramble-dwellers which I have subjected to the same test (Osmia detrita, Anthidium scapulare, Solenius vagus, etc.); and it must also be the case with Odynerus rubicola: so the most striking analogies inform us. Therefore the singular exception which made such an impression on Dufour's mind is a sheer logical illusion.

An error removed is tantamount to a truth gained; and yet, if it were to end here, the result of my experiment would possess but slight value. After destruction, let us turn to construction; and perhaps we shall find the wherewithal to compensate us for an illusion lost. Let us begin by watching the exit.

The first Osmia to leave her cocoon, no matter what place she occupies in the series, forthwith attacks the ceiling separating her from the floor above. She cuts a fairly clean hole in it, shaped like a truncate cone, having its larger base on the side where the Bee is and its smaller base opposite. This conformation of the exit-door is a characteristic of the work. When the insect tries to attack the diaphragm, it first digs more or less at random; then, as the boring progresses, the action is concentrated upon an

area which narrows until it presents no more than just the necessary passage. Nor is the cone-shaped aperture special to the Osmia: I have seen it made by the other bramble-dwellers through my thick disks of sorghum-pith. Under natural conditions, the partitions, which, for that matter, are very thin, are destroyed absolutely, for the contraction of the cell at the top leaves barely the width which the insect needs. The truncate, cone-shaped breach has often been of great use to me. Its wide base made it possible for me, without being present at the work, to judge which of the two neighbouring Osmiae had pierced the partition; it told me the direction of a nocturnal migration which I had been unable to witness.

The first-hatched Osmia, wherever she may be, has made a hole in her ceiling. She is now in the presence of the next cocoon, with her head at the opening of the hole. In front of her sister's cradle, she usually stops, consumed with shyness; she draws back into her cell, flounders among the shreds of the cocoon and the wreckage of the ruined ceiling; she waits a day, two days, three days, more if necessary. Should impatience gain the upper hand, she tries to slip between the wall of the tunnel and the cocoon that blocks the way. She even undertakes the laborious work of gnawing at the wall, so as to widen the interval, if possible. We find these attempts, in the shaft of a bramble, at places where the pith is removed down to the very wood, where the wood itself is gnawed to some depth. I need hardly say that, although these lateral inroads are perceptible after the event, they escape the eye at the moment when they are being made.

If we would witness them, we must slightly modify the glass apparatus. I line the inside of the tube with a thick piece of whity-brown packing-paper, but only over one half of the circumference; the other half is left bare, so that I may watch the Osmia's attempts. Well, the captive insect fiercely attacks this lining, which to its eyes represents the pithy layer of its usual abode; it tears it away by tiny particles and strives to cut itself a road between the cocoon and the glass wall. The males, who are a little smaller, have a better chance of success than the females. Flattening themselves, making themselves thin, slightly spoiling the shape of the cocoon, which, however, thanks to its elasticity, soon recovers its first condition, they slip through the narrow passage and reach the next cell. The females, when in a hurry to get out, do as much, if they find the tube at all amenable to the process. But no sooner is the first partition passed than a second presents itself. This is pierced in its turn. In the same way will the third be pierced and others after that, if the insect can manage them, as long as its strength holds out. Too weak for these repeated borings, the males do not go far through my thick plugs. If they contrive to cut through the first, it is as much as they can do; and, even so, they are far from always succeeding. But, in the conditions presented by the native stalk, they have only feeble tissues to overcome; and then, slipping, as I have said, between the cocoon and the wall, which is slightly worn owing to the circumstances described, they are able to pass through the remaining occupied chambers and to reach the outside first, whatever their original place in the stack of cells. It is just possible that their early eclosion

forces this method of exit upon them, a method which, though often attempted, does not always succeed. The females, furnished with stronger tools, make greater progress in my tubes. I see some who pierce three or four partitions, one after the other, and are so many stages ahead before those whom they have left behind are even hatched. While they are engaged in this long and toilsome operation, others, nearer to the orifice, have cleared a passage whereof those from a distance will avail themselves. In this way, it may happen that, when the width of the tube permits, an Osmia in a back row will nevertheless be one of the first to emerge.

In the bramble-stem, which is of exactly the same diameter as the cocoon, this escape by the side of the column appears hardly practicable, except to a few males; and even these have to find a wall which has so much pith that by removing it they can effect a passage. Let us then imagine a tube so narrow as to prevent any exit save in the natural sequence of the cells. What will happen? A very simple thing. The newly-hatched Osmia, after perforating his partition, finds himself faced with an unbroken cocoon that obstructs the road. He makes a few attempts upon the sides and, realizing his impotence, retires into his cell, where he waits for days and days, until his neighbour bursts her cocoon in her turn. His patience is inexhaustible. However, it is not put to an over long test, for within a week, more or less, the whole string of females is hatched.

When two neighbouring Osmiae are released at the same time, mutual visits are paid through the aperture between the two rooms: the one above goes down to the floor below;

the one below goes up to the floor above; sometimes both of them are in the same cell together. Might not this intercourse tend to cheer them and encourage them to patience? Meanwhile, slowly, doors are opening here and there through the separating walls; the road is cleared by sections; and a moment arrives when the leader of the file walks out. The others follow, if ready; but there are always laggards who keep the rear-ranks waiting until they are gone.

To sum up, first, the hatching of the larvae takes place without any order; secondly, the exodus proceeds regularly from summit to base, but only in consequence of the insect's inability to move forward so long as the upper cells are not vacated. We have here not an exceptional evolution, in the inverse ratio to age, but the simple impossibility of emerging otherwise. Should a chance occur of going out before its turn, the insect does not fail to seize it, as we can see by the lateral movements which send the impatient ones a few ranks ahead and even release the more favoured altogether. The only remarkable thing that I perceive is the scrupulous respect shown to the as yet unopened neighbouring cocoon. However eager to come out, the Osmia is most careful not to touch it with his mandibles: it is taboo. He will demolish the partition, he will gnaw the side-wall fiercely, even though there be nothing left but wood, he will reduce everything around him to dust; but touch a cocoon that obstructs his way? Never! He will not make himself an outlet by breaking up his sisters' cradles.

It may happen that the Osmia's patience is in vain and that the barricade that blocks the way never disappears at

all. Sometimes, the egg in a cell does not mature; and the unconsumed provisions dry up and become a compact, sticky, mildewed plug, through which the occupants of the floors below could never clear themselves a passage. Sometimes, again, a grub dies in its cocoon; and the cradle of the deceased, now turned into a coffin, forms an everlasting obstacle. How shall the insect cope with such grave circumstances?

Among the many bramble-stumps which I have collected, some few have presented a remarkable peculiarity. In addition to the orifice at the top, they had at the side one and sometimes two round apertures that looked as though they had been punched out with an instrument. On opening these stalks, which were old, deserted nests, I discovered the cause of these very exceptional windows. Above each of them was a cell full of mouldy honey. The egg had perished and the provisions remained untouched: hence the impossibility of getting out by the ordinary road. Walled in by the unsurmountable obstacle, the Osmia on the floor below had contrived an outlet through the side of the shaft; and those in the lower storeys had benefited by this ingenious innovation. The usual door being inaccessible, a side-window had been opened by means of the insect's jaws. The cocoons, torn, but still in position in the lower rooms, left no doubt as to this eccentric mode of exit. The same fact, moreover, was repeated, in several bramble-stumps, in the case of Osmia tridentata; it was likewise repeated in the case of Anthidium scapulare. The observation was worth confirming by experiment.

I select a bramble-stem with the thinnest rind possible, so as to facilitate the Osmiae's work. I split it in half, thus obtaining a smooth-sided trough which will enable me to judge better of future exits. The cocoons are next laid out in one of the troughs. I separate them with disks of sorghum, covering both surfaces of the disk with a generous layer of sealing-wax, a material which the Osmia's mandibles are not able to attack. The two troughs are then placed together and fastened. A little putty does away with the joint and prevents the least ray of light from penetrating. Lastly, the apparatus is hung up perpendicularly, with the cocoons' heads up. We have now only to wait. None of the Osmiae can get out in the usual manner, because each of them is confined between two partitions coated with sealing-wax. There is but one resource left to them if they would emerge into the light of day, that is, for each of them to open a side-window, provided always that they possess the instinct and the power to do so.

In July, the result is as follows: of twenty Osmiae thus immured, six succeed in boring a round hole through the wall and making their way out; the others perish in their cells, without managing to release themselves. But, when I open the cylinder, when I separate the two wooden troughs, I realize that all have attempted to escape through the side, for the wall of each cell bears traces of gnawing concentrated upon one spot. All, therefore, have acted in the same way as their more fortunate sisters; they did not succeed, because their strength failed them. Lastly, in my glass tubes, part-lined with a thick piece of packing-paper, I

often see attempts at making a window in the side of the cell: the paper is pierced right through with a round hole.

This then is yet another result which I am glad to record in the history of the bramble-dwellers. When the Osmia, the Anthidium and probably others are unable to emerge through the customary outlet, they take an heroic decision and perforate the side of the shaft. It is the last resource, resolved upon after other methods have been tried in vain. The brave, the strong succeed; the weak perish in the attempt.

Supposing that all the Osmiae possessed the necessary strength of jaw as well as the instinct for this sideward boring, it is clear that egress from each cell through a special window would be much more advantageous than egress through the common door. The Bee could attend to his release as soon as he was hatched, instead of postponing it until after the emancipation of those who come before him; he would thus escape long waits, which too often prove fatal. In point of fact, it is no uncommon thing to find bramble-stalks in which several Osmiae have died in their cells, because the upper storeys were not vacated in time. Yes, there would be a precious advantage in that lateral opening, which would not leave each occupant at the mercy of his environment: many die that would not die. All the Osmiae, when compelled by circumstances, resort to this supreme method; all have the instinct for lateral boring; but very few are able to carry the work through. Only the favourites of fate succeed, those more generously endowed with strength and perseverance.

If the famous law of natural selection, which is said to govern and transform the world, had any sure foundation; if really the fittest removed the less fit from the scene; if the future were to the strongest, to the most industrious, surely the race of Osmiae, which has been perforating bramble-stumps for ages, should by this time have allowed its weaker members, who go on obstinately using the common outlet, to die out and should have replaced them, down to the very last one, by the stalwart drillers of side-openings. There is an opportunity here for immense progress; the insect is on the verge of it and is unable to cross the narrow intervening line. Selection has had ample time to make its choice; and yet, though there be a few successes, the failures exceed them in very large measure. The race of the strong has not abolished the race of the weak: it remains inferior in numbers, as doubtless it has been since all time. The law of natural selection impresses me with the vastness of its scope; but, whenever I try to apply it to actual facts, it leaves me whirling in space, with nothing to help me to interpret realities. It is magnificent in theory, but it is a mere gas-bubble in the face of existing conditions. It is majestic, but sterile. Then where is the answer to the riddle of the world? Who knows? Who will ever know?

Let us waste no more time in this darkness, which idle theorizing will not dispel; let us return to facts, humble facts, the only ground that does not give way under our feet. The Osmia respects her neighbour's cocoon; and her scruples are so great that, after vainly trying to slip between that cocoon and the wall, or else to open a lateral outlet, she lets herself die in her cell rather than effect an egress

by forcing her way through the occupied cells. When the cocoon that blocks the way contains a dead instead of a live grub, will the result be the same?

In my glass tubes, I let Osmia-cocoons containing a live grub alternate with Osmia-cocoons in which the grub has been asphyxiated by the fumes of sulphocarbonic acid. As usual, the storeys are separated by disks of sorghum. The anchorites, when hatched, do not hesitate long. Once the partition is pierced, they attack the dead cocoons, go right through them, reducing the dead grub, now dry and shrivelled, to dust, and at last emerge, after wrecking everything in their path. The dead cocoons, therefore, are not spared; they are treated as would be any other obstacle capable of attack by the mandibles. The Osmia looks upon them as a mere barricade to be ruthlessly overturned. How is she apprised that the cocoon, which has undergone no outward change, contains a dead and not a live grub? It is certainly not by sight. Can it be by sense of smell? I am always a little suspicious of that sense of smell of which we do not know the seat and which we introduce on the slightest provocation as a convenient explanation of that which may transcend our explanatory powers.

My next test is made with a string of live cocoons. Of course, I cannot take all these from the same species, for then the experiment would not differ from the one which we have already witnessed; I take them from two different species which leave their bramble-stem at separate periods. Moreover, these cocoons must have nearly the same diameter to allow of their being stacked in a tube without leaving an empty space between them and the wall. The

two species adopted are Solenius vagus, which quits the bramble at the end of June, and Osmia detrita, which comes a little earlier, in the first fortnight of the same month. I therefore alternate Osmia-cocoons and Solenius-cocoons, with the latter at the top of the series, either in glass tubes or between two bramble-troughs joined into a cylinder.

The result of this promiscuity is striking. The Osmiae, which mature earlier, emerge; and the Solenius-cocoons, as well as their inhabitants, which by this time have reached the perfect stage, are reduced to shreds, to dust, wherein it is impossible for me to recognize a vestige, save perhaps here and there a head, of the exterminated unfortunates. The Osmia, therefore, has not respected the live cocoons of a foreign species: she has passed out over the bodies of the intervening Solenii. Did I say passed over their bodies? She has passed through them, crunched the laggards between her jaws, treated them as cavalierly as she treats my disks. And yet those barricades were alive. No matter: when her hour came, the Osmia went ahead, destroying everything upon her road. Here, at any rate, is a law on which we can rely: the supreme indifference of the animal to all that does not form part of itself and its race.

And what of the sense of smell, distinguishing the dead from the living? Here, all are alive; and the Bee pierces her way as through a row of corpses. If I am told that the smell of the Solenii may differ from that of the Osmiae, I shall reply that such extreme subtlety in the insect's olfactory apparatus seems to me a rather far-fetched supposition. Then what is my explanation of the two facts? The explanation? I have none to give! I am quite content to

know that I do not know, which at least spares me many vain lucubrations. And so I do not know how the Osmia, in the dense darkness of her tunnel, distinguishes between a live cocoon and a dead cocoon of the same species; and I know just as little how she succeeds in recognizing a strange cocoon. Ah, how clearly this confession of ignorance proves that I am behind the times! I am deliberately missing a glorious opportunity of stringing big words together and arriving at nothing.

The bramble-stump is perpendicular, or nearly so; its opening is at the top. This is the rule under natural conditions. My artifices are able to alter that state of things; I can place the tube vertically or horizontally; I can turn its one orifice either up or down; lastly, I can leave the channel open at both ends, which will give two outlets. What will happen under these several conditions? That is what we shall examine with the Three-pronged Osmia.

The tube is hung perpendicularly, but closed at the top and open at the bottom; in fact, it represents a bramble-stump turned upside down. To vary and complicate the experiment, the strings of cocoons are arranged differently in different tubes. In some of them, the heads of the cocoons are turned downwards, towards the opening; in others, they are turned upwards, towards the closed end; in others again, the cocoons alternate in direction, that is to say, they are placed head to head and rear to rear, turn and turn about. I need not say that the separating floors are of sorghum.

The result is identical in all these tubes. If the Osmiae have their heads pointing upwards, they attack the partition

above them, as happens under normal conditions; if their heads point downwards, they turn round in their cells and set to work as usual. In short, the general outward trend is towards the top, in whatever position the cocoon be placed.

We here see manifestly at work the influence of gravity, which warns the insect of its reversed position and makes it turn round, even as it would warn us if we ourselves happened to be hanging head downwards. In natural conditions, the insect has but to follow the counsels of gravity, which tells it to dig upwards, and it will infallibly reach the exit-door situated at the upper end. But, in my apparatus, these same counsels betray it: it goes towards the top, where there is no outlet. Thus misled by my artifices, the Osmiae perish, heaped up on the higher floors and buried in the ruins.

It nevertheless happens that attempts are made to clear a road downwards. But it is rare for the work to lead to anything in this direction, especially in the case of the middle or upper cells. The insect is little inclined for this progress, the opposite to that to which it is accustomed; besides, a serious difficulty arises in the course of this reversed boring. As the Bee flings the excavated materials behind her, these fall back of their own weight under her mandibles; the clearance has to be begun anew. Exhausted by her Sisyphean task, distrustful of this new and unfamiliar method, the Osmia resigns herself and expires in her cell. I am bound to add, however, that the Osmiae in the lower storeys, those nearest the exit—sometimes one, sometimes two or three—do succeed in escaping. In that case, they unhesitatingly attack the partitions below them, while their

companions, who form the great majority, persist and perish in the upper cells.

It was easy to repeat the experiment without changing anything in the natural conditions, except the direction of the cocoons: all that I had to do was to hang up some bramble-stumps as I found them, vertically, but with the opening downwards. Out of two stalks thus arranged and peopled with Osmiae, not one of the insects succeeded in emerging. All the Bees died in the shaft, some turned upwards, others downwards. On the other hand, three stems occupied by Anthidia discharged their population safe and sound. The outgoing was effected at the bottom, from first to last, without the least impediment. Must we take it that the two sorts of Bees are not equally sensitive to the influences of gravity? Can the Anthidium, built to pass through the difficult obstacle of her cotton wallets, be better-adapted than the Osmia to make her way through the wreckage that keeps falling under the worker's feet; or, rather, may not this very cotton-waste put a stop to these cataracts of rubbish which must naturally drive the insect back? This is all quite possible; but I can say nothing for certain.

Let us now experiment with vertical tubes open at both ends. The arrangements, save for the upper orifice, are the same as before. The cocoons, in some of the tubes, have their heads turned down; others, up; in others again, their positions alternate. The result is similar to what we have seen above. A few Osmiae, those nearest the bottom orifice, take the lower road, whatever the direction first occupied by the cocoon; the others, composing by far the larger number,