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CONTENTS.

SECTION I.—SENSES OF INSECTS.

CHAPTER V.—Vision of Insects.

SECTION II.—FOOD OF INSECTS.

CHAPTER VI.—Eating Insects.

SECTION IV.

CHAPTER XIV.—On the Collection and Preservation of Insects for the Purposes of Study.

CHAPTER XV.—Systematic Arrangements of Insects.

INSECT MISCELLANIES.

SECTION I.

SENSES OF INSECTS.

IT was well said by the distinguished Danish naturalist, Fabricius, that "nothing in natural history is more abstruse and difficult than an accurate description of the senses of animals *." This inherent complexity of the subject appears to have induced Lehmann to undertake the investigation of the senses of insects †. He collected into a focus all that was known previous to his time, though he has added very little from his own observation; but since that period much has been done by Marcel de Serres, Wollaston, Müller, and others.

The chief difficulty of the subject arises from the great physical differences which exist between animals furnished with bones and warm blood, and insects that have neither, rendering all inference from analogy much less to be depended on than if the physical structure of each were similar. When we see an elephant, for example, use his trunk to lift a small piece of money from the ground, we cannot doubt but that he feels the coin as plainly as we should do in lifting it with the hand, and hence the inference

* Nye Samling af det Danske, &c. ii. 375.

† De Sensibus Externis Insectorum, p. 1, 4to., Gottingæ, 1798,

that the trunk of the elephant is an organ of touch follows of course. But when we see an ichneumon fly vibrating its long antennæ before the entrance of a bee's nest, and sometimes even inserting one or both of them into the hole as if to explore its contents, we are not thence entitled to conclude that the antennæ are organs of touch, for they may, with as much probability, be inferred to be organs of hearing employed to listen to sounds produced by the inhabitant of the nest. It would also be too hasty, as it appears to us, to infer that flies, gnats, and moths, are endowed with eyes of very quick sight, because we find it difficult to approach them without putting them to flight; for the earth-worm (*Lumbricus terrestris*, LINN.) will retreat with similar rapidity into its hole when the light of a candle is thrown upon it at night *, though no anatomist has ever discovered its eyes, nor believes that it has any; and the insects alluded to may be warned of the approach of danger by smell, by hearing, or by touch from slight changes in the currents of air, as probably as by sight. Analogy, it would thence appear, is very apt to mislead; and as we have little else to go upon in the subject of the senses in insects, we can seldom ascertain the facts with minute accuracy, and must rest contented with probabilities and approximations to the truth.

Respecting one point there can be no doubt,—namely, that an object must always be present in order to produce a sensation or feeling; light and colours being in this manner the objects of the sense of seeing, and sound of the sense of hearing. In man the impression made by light upon the eye or by sound upon the ear passes along peculiar nerves to the brain, as the signal from a distant telegraph is communicated to a metropolis. In insects we may

* J. R.

suppose that such impressions upon the eye or the ear are only conveyed to the next nervous centre (*ganglion*), since they possess no general brain similar to ours, but a number of central points in different parts of the body where the adjacent nerves unite *. Whether, also, insects possess one set of nerves for feeling and another set for motion, as Mr. Charles Bell has recently discovered to be the case among larger animals, remains to be ascertained, though analogy would lead us to conclude that they must have something at least similar. Be this as it may, the most obvious mode in which we can discuss the subject before us, is to examine the structure of the organs, and the probable action of objects upon these. It appears to be the most convenient order to begin with the Sense of Touch, and then to take up Taste, Smell, Hearing, and Vision, in succession.

* See Insect Transformations, pp. 400 and 139.

Chapter I.

SENSE OF TOUCH.

Though we may entertain considerable doubts of the accuracy of the poet's observation, when he says the spider

"Lives in each thread, and feels along the line,"

there can be no question that the legs of spiders possess considerable powers of touch, so far as resistance is concerned; for in constructing, and still more in repairing, their webs, they never advance a step without making sure of the strength of what has been already completed. They are not even always content with pulling the threads for this purpose, but frequently let themselves down like a plummet from the thread whose strength they wish to try, and bob backwards and forwards with the whole weight of the body. But that the acuteness with which the motion of the threads is felt, when a fly is caught in the net, chiefly governs the motions of the spider in seizing it, we doubt for several reasons. Spiders, for example, are furnished with not less than six, though more commonly with eight, eyes of sparkling brilliancy, and placed in a very prominent situation; and these we should be apt to look upon as in part superfluous, were the sense of touch so exquisite as is generally believed. We have tried numerous experiments by moving and vibrating the lines of the webs of many species, so as to imitate as nearly as possible the entrapment of a fly; but in no case have we succeeded in bringing the spider to the spot, because, as we inferred, her eyes always detected our attempted deception. But when a fly is held near a web and made to buz, the spider in most cases will peep from her lurking-hole, to look whether it has not been caught in some of the lines or meshes not under her view, proving that the sense of hearing is as acute and useful in such cases as either vision or touch. It appears, further, that a small spider ascertains by touch the superior strength of a blow-fly or a large syrphus which may chance to be caught in its web, hesitating long before venturing to attack it, and sometimes never venturing at all,—a circumstance we have often remarked, and we have frequently, besides, repeated the experiment of putting large flies in the webs of small spiders with similar results *.

The stretching out of the legs of the long-bodied spider (*Tetragnatha extensa*, LATR.), when it places itself in the centre of its geometric web, appears to have given origin to the opinion under review: though it may be remarked that it does not spread its legs around so as to take cognizance of as many lines as possible, but, on the contrary, huddles them into a close bundle, more apparently with the view of making them appear motionless and lifeless than actively on the alert. This view is still more strongly proved by the circumstance, that when this spider is not on its web watching for prey, but resting on a wall, or in the fold of a leaf, it stretches out its legs in the same manner.

The long-legged house spider (*Pholcus phalangioides*, WALCK.) may be referred to as giving more countenance to the opinion, because it not only spins a very loose irregular web in the corners of walls, but keeps its legs spread about as if on purpose to feel the more readily when any thing is caught. We

* J. R.

may remark, however, that both its sight and hearing seem to be still more acute than its touch, for its eyes are more than usually prominent and closely grouped, and the faintest hum of a gnat puts it on the alert. It requires, indeed, no little agility to seize these, particularly the vibrating gnat (*Chironomus motitator*, FABR.), which we have observed to be its chief prey, as the slightest movement or the faintest noise puts these gnats to flight; and hence we infer that the very long legs of this spider are intended more for pursuit than for feeling*.

Long-legged house spider (*Pholcus phalangioïdes*).

It appears to us, that a much stronger proof of the acuteness of touch in spiders may be derived from the manner in which they construct their webs. They must use their eyes indeed, in planning their frameworks; but they cannot be guided by sight in the details, for the spinneret, whence they draw their threads, being situated behind, they must depend in a great measure on the tact of this organ for the accuracy of their workmanship. The soft yielding consistency, and the papillary form of this wonderful organ, indeed, seems to indicate its being well adapted for an instrument of touch†. But the claws them-

* J. R.

† See Insect Architecture, page 336—8.

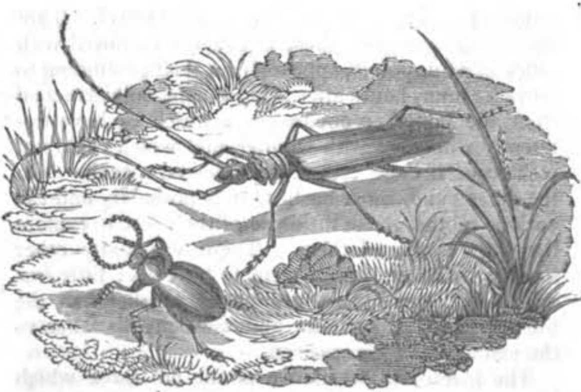
selves must also have this sense in perfection; for in making the various rays as well as the cross lines of a geometric net, the spider always guides the thread from the spinneret by one of its hind claws, which it cannot possibly see with any one of its eyes, as these are all placed forwards on the head. The exquisite workmanship of these webs, thus woven as it were in the dark, indicates that the sense of touch by which alone it can be accomplished must be peculiarly delicate.

In the family of the harvest spiders (*Phalangioïdæ*), which have only two eyes, and do not spin webs, the long legs are used not only to escape from enemies and pursue prey, but to explore, by touch, the objects among which they travel. That the very long legs of these insects are endowed with much nervous power, appears from their continuing to move for many hours after being accidentally detached from the body*, a circumstance which we have frequently witnessed with wonder, and which could not well occur if these creatures possessed a brain. On the other hand, most beetles, it is probable, and the various moths, make little use of their feet to explore the things around them. There are many other insects, however, which seem to have feet little less exquisitely formed, as organs of touch, than the human hand, if softness and elasticity be taken as the standards of comparison.

The insects to which we allude are those which live among grass and herbage, comprehending a few beetles (*Chrysomelidæ, &c.*), most two-winged flies (*Diptera*), and, if we mistake not, all the crickets and grasshoppers (*Gryllidæ, &c.*) The foot of the common fly has been shown by Sir Everard Home and Mr. Bauer to be admirably adapted for climbing upon

* Latreille, Monographie des Faucheurs, Hist. des Fourmis, page 371.

glass, even when the body hangs downwards *, and it is also finely adapted, both as a brush and as a comb, for cleaning the body and wings †; but it is no less fitted for being an organ of touch, from its softness and flexibility. Amongst the locusts (*Locustidæ*), however, this structure is more conspicuous from the greater size of the insects, the terminal portion of the foot being not only furnished with a moveable claw, but with two soft round palms, if we may call them so, which must greatly assist in feeling the nature of the surface over which the insect walks. Even in insects of smaller size, as the musk beetle (*Cerambyx odoratus*, De Geer), and the catch-weed



a Musk beetle (*Cerambyx odoratus*).
b Catch-weed beetle (*Timarcha tenebricosa*).

* See Insect Transformations, p. 390-1. It is right to mention that a paper has been recently read at the Linnæan Society, in which the principle of suction, by which the fly is said to hold on against gravity, is disproved. See Taylor's Philosophical Magazine.

† J. Rennie, in Journal of Royal Institution, for Oct. 1830.

beetle (*Timarcha tenebricosa*, MEGERLE), this structure of the feet is very obvious without the aid of a glass, which is required in observing the palms of the two-winged flies (*Diptera*).

In some other beetles, again, whose horny covering would seem to preclude them from possessing the means of touch over the surface of their body like the softer animals, and which even have their legs equally horny and stiff, we may observe, that a beautiful provision is made for the sense of touch in a long, many-jointed, flexible claw at the termination of the foot. This is particularly remarkable in the common dung beetle (*Geotrupes stercorarius*), in which the flexibility and easy motion of the jointed claw contrasts strikingly with the apparently awkward stiffness of the other joints, and indeed of the whole body.

According to the greater number of naturalists, however, the two chief organs of touch in insects are the antennæ and palpi, both of which have been in popular language termed *feelers*. Latreille calls the palpi *antennules**. Leaving the antennæ to be discussed in our chapter on Hearing, we shall only at present attend to the palpi, which are usually four in number. These organs are small and generally cylindrical, consisting of from one to six joints, one palpus being implanted in each of the two lower jaws, and the remaining two being attached to the lower lip, as exhibited in p. 43, fig. *a*. The former, or upper pair, are, in most cases, a joint longer than the under, so as that they may all four, when bent down, reach to the ground at the same time. They are most commonly smooth, and end in a softish point; but in some cases they are covered with hair (*Copris*, *Cicindela*, *&c.*). The only organs, in the higher animals, which seem analogous to these, are the whiskers (*Vibrissæ*) in the cat, the seal, and the night-

* Règne Animal, iv. 301, edit. 1829.

jar (*Nytichelidon Europæus*, RENNIE), and the appendages at the lips of the cod-fish (*Gadus morhua*), the surmullet (*Mullus barbatus*), and some others. This want of analogous organs in other animals of course renders our investigation of the use of the palpi in insects much more difficult.

Stag beetle (*Lucanus Cervus*) on the wing.

a a The four palpi, or antennules.

Bonsdorf, in his singular tract upon the use of the palpi, endeavours to show that they are organs of smell *; Knoch imagined that the upper pair were

* De Fabr. et Usu Palporum in Insectis.

for smelling, and the lower pair for tasting; while Lehmann says, that "whoever undertakes to deny that they are organs of touch, proves thereby that he has not observed living insects*." Cuvier† and Duméril‡ express a similar opinion, supported chiefly by the observation, that most insects, when they walk, apply their palpi incessantly, or very often, to the surface upon which they are moving; while spiders sometimes employ them as legs, and scorpions as hands. They are always put in great activity when the insect is feeding.

To us the most probable opinion appears to be, that the palpi may be used somewhat in the same way as we employ our lips and tongue, both as instruments of touch and of taste; their situation near the mouth suggesting this, though they are otherwise little analogous in site or structure. This opinion is supported by the consideration that one of the chief employments of insects being the search after food, they are thence led to apply their palpi incessantly for its discovery, and also for ascertaining its capability of being consumed, should the discovery be originally made by means of smell. In this respect insects act much in the same manner as the human infant. Every body must have remarked, that a young child carries every thing to its mouth, whether it be hungry or not, and the only design of this seems to be the examination of the object. We may often, indeed, see a child pressing its gums with whatever comes in its way, to allay the uneasy sensations occasioned by the protruding teeth; but even when this is not the case, it carefully tries every thing both with the mouth and with the hands, holding the object at different distances from the eye,

* De Sensibus Externis, page 38.

† Anatomie Compar. ii. 676.

‡ Considérations générales, p. 9.

and grasping it in various directions and positions. In a word, instead of being, as most people suppose, engaged in an idle and unprofitable amusement, the infant is employed in eager study and examination, in order to learn the effects of the qualities of objects upon its senses. The insects, on the other hand, are too short-lived to require the same multifarious knowledge of hardness, softness, distance, and form, and hence they only employ their palpi in examining what may be proper or improper for food.

An important organ of touch in insects, as it appears to us, has been altogether overlooked by naturalists. We refer to the surface of the wings, minutely furnished, as they appear to be, with nerves for this express purpose. It must be this, indeed, which, in a great measure, serves to direct their flight, as the focus of their eyes appears, according to our ideas of senses, to be too short for this purpose. We have elsewhere remarked, that the marsh fritillary butterfly (*Militæa Artemis*, OCHSENH.) seldom flies beyond the field in which it is produced*; but this is not so remarkable in insects of slow and heavy flight, and in a field hedged in, as in those of rapid flight and restless disposition, in the open country. We remarked, for several weeks, near St. Adresse, in Normandy, a very limited spot, close by the sea, to be daily frequented by about half a dozen of the clouded yellow butterfly (*Colias Edusa*, STEPHENS), which seemed to make a regular circuit, and return again, altogether independent of the direction of the wind, against which they often made way. Now, as they often rose to so considerable a height that they must have lost sight of the ground, we conclude that they guided their flight more by the weight of the superincumbent air than by the direction of the wind—an inference rendered more probable by

* See Chapter on Migrations.

their never being seen on the heights which there rise steeply from the shore *.

a Clouded yellow butterfly (*Colias Edusa*), male.
b Pale-clouded butterfly (*Colias Hyale*), female.

It is, probably, in part through the information derived from the varied impression of air on the wings that bees can return so unerringly to their hives; and hence the reason of their flying in curves and circles both when they depart and return, a circumstance

* J. R.

which Huber more particularly remarked in the queen-bee, when she left the hive for the purpose of pairing. Carrier pigeons, we have also remarked, employ the same circular mode of flight, both in departing from an unknown station and in arriving at their home from a distance.

These facts are strikingly illustrated by the extraordinary delicacy of touch possessed by bats, which made Spallanzani conceive that they had a peculiar sense distinct from any found in other animals; and, to satisfy himself upon this point, he performed many cruel experiments. He found that bats, when blindfolded, and even when their eyes are destroyed altogether and leather glued over the sockets, can fly nearly as well as before, and can avoid in their flight the smallest threads and other objects hung up to interrupt them. They can even dart through a hole in a net or curtain, large enough only to admit their passage, and that without previous examination. They can likewise thread the mazes of a cavern, without hurting themselves on the walls, and go directly to their nest-holes. When Spallanzani destroyed the ears and nostrils, as well as the eyes, of bats, he found that they could direct their flight equally well.

The correctness of these statements was verified by Professor Jurine, of Geneva, and by Sir A. Carlisle, who repeated the experiments; but it was Cuvier, if we mistake not, who first gave a plausible explanation of them. He considers the wing of the bat analogous to the hand, with the fingers very much elongated, and united by membrane; and as it is not only of great extent, compared with the body, but is one continued tissue of exquisitely sensible nerves, covered with a fine skin, furrowed like that on the human fingers, the delicacy of its touch is by no means marvellous. If this be correct, the blinded bat is guided wholly by the impression of the air on its wings: and yet we have observed bats, confined in a house, beat themselves against the windows, as wild birds and bees will do, though never against the walls*. Man has the same means of knowledge in a slight degree: for it is easy in the dark to say when one approaches a wall, by the impression of the air on the face. The faculty in the bat of perceiving, and being able to avoid such obstructions, is a provision of creative wisdom well worthy of our notice, as the creature, always flying in the twilight and in the night, could not well depend on its eyes in avoiding objects during its rapid flight in pursuit of nocturnal moths. Moths, and most night-flying insects, possess this faculty in an inferior degree. Beetles, indeed, seem to be deficient either in the power of perceiving objects or of avoiding them, as they often, during the twilight, dash against the traveller, (from which originated the proverb of "blind as a beetle"); but we have never observed any of the night moths thus deceived.

The feeling of the various degrees of temperature, whether hot or cold, is so different from the other perceptions of touch, that some naturalists, among whom are Darwin and Fleming, refer it to a peculiar sense. As insects appear to be extremely susceptible of varying temperature, we must not pass it over without notice. Dr. Fleming distinguishes what he terms the sense of heat from touch by its not requiring, like the latter, any muscular effort for its exercise†. That there are peculiar nerves in various parts of the skin appropriated to the perception of heat, Dr. Darwin thinks is proved by the heat of a furnace giving no pain to the nerve of the eye, while it scorches and pains the parts adjacent. Warm water, again, or warm

* J. R. † Philosophy of Zoology, i. 171.

oil, when poured into the ear, gives no pain to the nerves of hearing, and its warmth is not even perceived by them, though it may be hot enough to scald the external orifice. He evidently does not, in this, make any account of these nerves being deep-seated.

Whether these facts, and others of a similar kind, are sufficient to authorise us to consider the sense of heat distinct from that of touch, we shall not here stop to determine, but content ourselves with mentioning a few circumstances upon the subject, derived from the observation of insects. Ants, for example, are so delicately sensible of cold, that the finest day will not tempt them to place their eggs, or pupæ, at the top of the nest, should the air be chill; and it was remarked so long ago as the time of Pliny, that, previously to bad weather, they are all in a bustle to secure their eggs, forewarned, no doubt, by the perception of an altered temperature. In the interesting proceedings of bees when swarming, as we shall afterwards see, temperature, it would appear, is of the utmost importance, so much so that Huber ascribes to increased heat, arising from the agitation of bees in a hive, the immediate cause of a body of emigrants leaving the parent hive*; and even on ordinary occasions the working bees, while collecting honey in the fields, are so feverishly afraid of bad weather, that a single cloud passing over the sun will cause them to make a precipitate retreat homewards.

The only analogous circumstance which we recollect as occurring in man with regard to the foresight of bad weather, is found in the wandering pains in the limbs experienced by persons subject to gout or rheumatism, which are felt so distinctly, some time before rain or increased cold, as to enable the patients to predict a change with the utmost certainty; and we

* Huber on Bees, p. 184.

doubt not that it is from some such feelings that ants, bees, and other insects, are observed to provide for a coming change.

According to Brez, his friend D'Isjonval observed spiders to have so good a knowledge of the weather that when it was wet and windy they spun only very short lines; "but when a spider spins a long thread there is a certainty of fine weather for at least ten or twelve days afterwards *." "Without going the length," says Kirby, "of deeming this important enough to regulate the march of armies or the sailing of fleets, or of proposing that the first appearance of these barometrical spiders in spring should be announced by the sound of trumpet, I have reason to suppose, from my own observations, that his statements are in the main accurate, and that a very good idea of the weather may be formed from attending to these insects †."

This theory, as it appears to us, may be supported so far as the winds are concerned at the time the frame-work of the web is constructed, but not farther. This framework, being the most difficult part of the structure, is always taken much care of, and strengthened from time to time with additional lines; so that, when not accidentally broken, it may last for many days, and serve for the basis of many successive nets destroyed by entrapped insects, or other causes. In such cases, it is not of course varied to suit the varying weather. The longest line of frame-work we remember to have seen, was that of the orange spider (*Aranea aurantia*, Olivier), which was thrown from the branch of an elm on the Boulevard du Mont Parnasse at Paris, a distance of four or five yards, and fixed to the ground. The spot being sheltered by the adjacent trees, it would appear that the spider could not other-

* Flore des Insectophiles, Notes suppl. p. 134. † Intr. i. 420.

wise form a base line than by dropping itself down from the branch; but, unfortunately for the theory, a high wind, accompanied by rain, set in within a few hours after we had observed the web, which must have been rent by the first blast. In the case of a long-bodied spider (*Tetragnatha extensa*), whose proceedings we watched every day for more than a month in a garden at Lee, the base line of the web was uniformly placed between two posts, about five feet high, so long as the wind was either north or sonth, the direction in which they stood; and of conrse the line was always of the same length, whether the wind was light or boisterous. From the line lying across the garden path, it was broken every day and renewed at night. When the wind changed to east or west, however, there being no elevated object quite near to which to attach the base line, it was floated in a sloping direction till it fixed on some of the plants in the flower borders, and in that case was often more than thrice its former length, whether it was calm or not. The only probable reason of these base lines being short in windy weather is, that the floating line is carried more rapidly to an adjacent object, and when that object is distant, the spider by repeated trials finds that it cannot stand against the storm, and, as in all other cases of insufficient strength, it is broken by her and abandoned. We have never observed anything, in a long acqnaintance with spiders, to indicate that they have any other knowledge of the weather than this*.

One circumstance in the economy of spiders, connected with this subject, we may mention as curious. It is well known that the whole tribe are, essentially, night insects, though we might imagine they would be more successful in their captures during the day, when more insects are abroad and on the alert. It

* J. R.

would not, indeed, be then so easy to secure a fly, when animated with the enlivening influence of the sunshine, and the web would stand the chance of more frequent and extensive breaches. But be the causes what they may, spiders most usually hunt in the night; and, as we have remarked, also in the day, during cloudy weather; for during bright sunshine, it is rare to see one making or mending a web*. Whether this singularity arises from the effect

Red underwing (*Catocala Nupta*).

* J. R.

produced by moist air on their organs of touch, or whether it arises from the diminution of light upon their eyes, we cannot tell.

That it is not the quantity of light alone which regulates the movements of many insects by day or by night, appears from several facts. Some insects, for example, appear only during particular hours of the day, though the light before and after is much the same. We have thus observed that the clouded yellow butterfly (*Colias Edusa*) does not fly before ten, and goes to rest soon after four o'clock *. The red underwing moth (*Catocala Nupta*, SCHRANK), again, has always been observed only about six or seven o'clock in the morning, and never at any other time.

Some of the smaller beetles (*Hopliæ*) are only to be observed swarming before noon, when they all disappear †; as do most of the gnats, after dancing for an hour or two at sunset. That these movements are rather periodical than depending on either the degree of light or heat, is rendered probable by close analogies derived from plants. The Star of Bethlehem (*Ornithogalum umbellatum*), for example, expands its flowers about eleven, and closes them at three in the afternoon, displaying its beauties about two hours less than the clouded yellow butterfly. The goats' beard (*Tragopogon pratensis*) is still more remarkable from closing its petals at mid-day, and hence its provincial name of Go-to-bed-at-noon. That light, however, is one of the most common agents of these changes appears from the ingenious experiments of Decandolle, made at the Jardin des Plantes in an underground cellar, illuminated by lamps giving a light equal to fifty-four ordinary wax candles. By lighting these lamps he was able to produce the opening of the flowers of the Star of Bethlehem at pleasure, and also of the sea chamomile (*Anthemis*

* J. R. † Linn. Trans. v. 256.

maritima), which keeps its flowers closely shut in the night; but he could produce no artificial effect with the strongest light upon several species of wood sorrel (*Oxalis stricta* and *Oxalis incarnata*), whose flowers and leaves are both folded up at night. With the sensitive plant (*Mimosa pudica*) again he succeeded in so completely changing the hour of closure, that on the third day from being placed in the lighted cellar, it began to fold its leaves in the morning and open them in the evening*.

Insects are also peculiarly sensible to electric changes in the atmosphere, though we do not find facts sufficient to bear out all the speculations of M. D'Isjonval upon this subject. Kirby and Spence tell us, that "when the atmosphere is in a highly electrified state, and a tempest is approaching, insects are usually most abundant in the air, especially towards the evening; and many species may then be taken which are not at other times to be met with: but before the storm comes on, all disappear, and you will scarcely see a single individual upon the wing." They conjecture, that the organs destined for perceiving these electric changes are the antennæ, particularly those furnished with a lateral bristle, and the plumose and pectinated ones, from this form seeming to be calculated to act on the electricity and moisture of the atmosphere, "which, in certain states and proportions, may certainly indicate the approach of a tempest, or of showers, or a rainy season, and may so affect these organs as to enable the insect to make a sure prognostic of any approaching change; and we know no other organ that is so likely to have this power †."

This conjecture is, no doubt, ingenious, though there is no plausible circumstance to support it besides

* Medical Review, vol. vi.

† Intr. iv. 246.

the peculiar forms of the antennæ. We should be more disposed to refer to the hairs with which the bodies of most insects are beset, and which, from the analogy of quadrupeds, may be presumed to be acted on by atmospherical electricity. This is rendered more probable from the feelings which most persons experience during a thunder-storm, which cannot be referred to any circumscribed organ as light is to the eye, but to a certain vague sensation of nervous languor or uneasiness diffused through the body. Bees, it may be remarked, which exhibit the most acute feelings of electric changes, are among the most hairy of all insects, while their thick bent antennæ do not correspond to those which Kirby deems best adapted for detecting electricity. It is but right to state, however, that it is added by the author—"upon this head I wish to make no positive assertion, I only suggest the probability of the opinion*."

* Intr. iv. 246.

Chapter II.

TASTE IN INSECTS.

It has been concluded by several naturalists that birds are destitute of the faculty of taste, because the tongue of some is in part formed of bone or gristle, and in all is rigid and dry, particularly in birds which feed on grain *. By the same mode of inference we might be led to decide that insects are also without taste, because the organs in them, which appear analogous to the tongue and palate, are, in many cases, dry and horny. But, unfortunately for these conjectures, the habits of the animals demonstrate that they are endowed with this sense, in many cases, in as great perfection as the theorists themselves. Without taste, indeed, no animal could continue its existence; and, consequently, it is indispensable to all organized beings, though its peculiarities cannot always be traced to the structure or form of the organs. In cattle, and animals which feed on green herbs, the tongue is both large and studded with large tasters (*Papillæ*), abundantly moistened with saliva, and also, as Blumenbach discovered, with a peculiar mucus †. In herbivorous animals this is more necessary than in those which feed upon flesh; for the variety of herbs is so great, and they often grow so promiscuously together, that, had cattle not an acuteness and nicety of taste in distinguishing, they might frequently be poisoned. This, however, rarely

* Montagu, Ornith. Dict., Intr.

† Specimen Hist. Nat., p. 4, &c. 4to. Gottingæ, 1816.

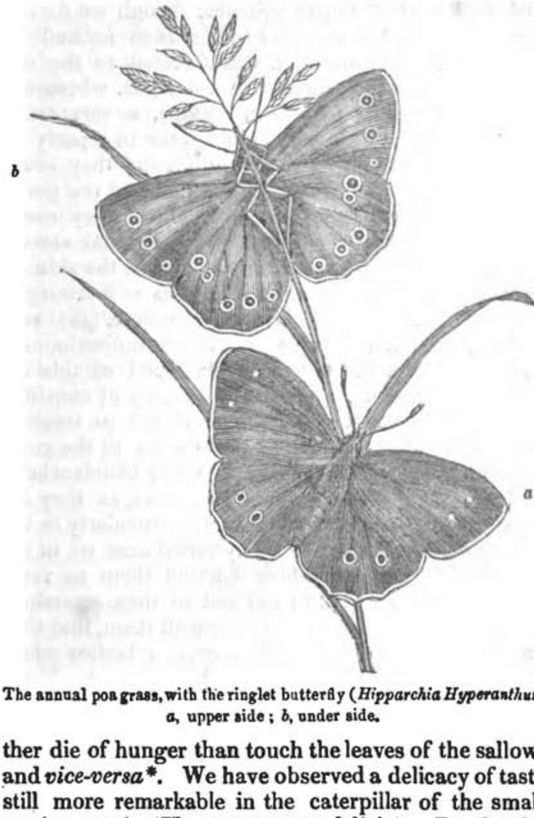
happens, for (with a few exceptions, such as the propensity of some quadrupeds to crop the young shoots of the yew,) nothing will induce them to eat any plant which is not their natural food; and we have frequently remarked that when cut herbage was given to domestic animals they would toss aside the species they did not like, and even reject them when they accidentally got into their mouths with others. Grass is very commonly eaten by them all; but of other plants, the horse, the cow, the sheep, the goat, and the hog make each their favourite selections,—the goat, for example, feeding greedily on the water-hemlock (*Cicuta virosa*), which is a deadly poison to cows *.

Insects, it would appear, are still nicer than cattle in their selection of food, and of course in the acuteness of their taste. The caterpillar of the antler moth (*Charæas graminis*, STEPHENS), though it feeds on a variety of grasses, and sometimes commits such ravages in the meadows of Sweden as to endanger the lives of the cattle for want of food, does not touch the fox-tail grass (*Alopecurus*); yet to us the leaves of this grass taste little, if anything, different from some of those which it so greedily devours. The caterpillar of the ringlet-butterfly (*Hipparchia Hyperanthus*, FABR.), again, feeds only on one species of grass, the annual poa (*Poa annua*), while the caterpillar of the gate-keeper (*H. Pamphilus*) confines itself to the dog's-tail grass (*Cynosurus cristatus*) †.

De Geer remarked that a sort of caterpillar, found indifferently on the poplar and the sallow, would only eat the leaves of the sort of tree on which it was hatched; for those hatched on the poplar would ra-

* See Linnæus, Lachesis Lapponica; Horticultural Journ. p. 242; and Insect Transformations, p. 78.

† Stewart's Elements, ii. 131—69.



The annual poa grass, with the ringlet butterfly (*Hipparchia Hyperanthus*). *a*, upper side ; *b*, under side.

ther die of hunger than touch the leaves of the sallow, and *vice-versa**. We have observed a delicacy of taste still more remarkable in the caterpillar of the small ermine moth (*Yponomeuta padella*)†. By far the most striking fact, however, connected with this seeming fastidiousness occurs among insects which

* Memoires, i. 319.

† See Insect Transformatious, p. 205.

suck the blood of larger animals; though we do not recollect that what we refer to has been noticed by naturalists. Our attention was directed to the circumstance many years ago in Scotland, where the midge (*Culicoides punctata*, LATR.), a very small kind of gnat, was so very troublesome to a party of hay-makers, that it was with difficulty they could continue their work; yet, notwithstanding the general attack made by the insects wherever they could find a spot of uncovered skin, one individual among the hay-makers was never touched, while the skin of his companions was covered with bites as if scourged with nettles. It was evident, therefore, that the midges, though otherwise apparently indiscriminate in their attacks, did not relish the blood of this individual, from some unknown peculiarity of constitution or of disease*. The midge is not so troublesome in the neighbourhood of London as the gnat. Derham says, "these gnats are greedy bloodsuckers, and very troublesome where numerous, as they are in some places near the Thames, particularly in the breach waters that have lately fallen near us in the parish of Dagenham, where I found them so vexatious that I was glad to get out of these marshes: yea, I have seen horses so stung with them, that they have had drops of blood all over their bodies where they were wounded by them. Among us in Essex they are called *Nidiots*†."

A similar selection of individuals even of the same species is very remarkable in the ox-breeze fly (*Hypoderma Bovis*, LATR.), which always prefers young cattle of two or three years old, and avoids old cattle in depositing its eggs, as if aware that her progeny would find it harder to penetrate an old, tough hide,

* J. R.

† Physico-Theology, Book iv. c. 11, No. u. See also Mouffet, Theatr. Insect., xiii. 82.

while they would likewise fare worse after they had effected a lodgment *; but whether this selection is made through the medium of taste, smell, touch, or vision, we have no means of ascertaining.

The midge, however, is by no means peculiar in its apparent capriciousness of taste; for the same preference and antipathy is exhibited by most of the other blood-sucking insects. Of two individuals, for example, who had been together for a whole day on a nutting expedition, and who slept in the same bed-chamber, next morning one was covered all over with red blotches from the attacks of the harvest-bug (*Leptus autumnalis*, LATR.), while the other was quite untouched †. Stewart says that this mite chiefly attacks women and children ‡.

Harvest-bug (*Leptus autumnalis*), greatly magnified.

A species of this family (*Acarina*), probably the red tick (*Pediculus coccineus*, SCOPOLI), or a mite (*Leptus Phalangii*), described by De Geer, appears to be much more indiscriminate in its tastes; for

* Insect Architecture, page 412.
† J. R. ‡ Elements, ii. 324.

during the summer of 1830 we found it at Havre de Grace, infesting insects of the most different families. It particularly abounded on the marbled butterfly (*Hipparchia Galathea*, LEACH), so that many of them were scarcely able to fly from the exhaustion caused by these little blood-suckers; and so pertinaciously did they retain their hold, that several of them now adhere to the specimens of the butterfly in our cabinet.

Marbled butterfly (*Hipparchia Galathea*) and caterpillar.

What was most remarkable, although the ringlet butterfly (*H. Hyperanthus*) was plentiful at the same time, and is similar in food and habits, not one of the parasites was found on some hundreds which we caught expressly to ascertain the fact. This appears the more strange, that several dragon flies (*Libellulina*, MAC LEAY) were found as much infested with them as the marbled butterfly. We also more than once found them on field crickets, ants, and beetles, and once on a harvest spider (*Phalangium Opilio*)*. Another species (*Gamasus Coleoptratorum*, FABR.) indiscriminately infests the common dung-beetle and the humble-bee (*Bombus terrestris*), so as often to destroy them; a circumstance which, from its frequent occurrence, may have caught the observation of persons who otherwise pay little attention to insects.

The parasite which thus infests the bee and the dung-beetle, however, is not so pertinacious in adhering to its victim as those which died of hunger rather than quit our butterfly specimens. The bee mite, on the contrary, though not very easily dislodged while the insect is alive, immediately scampers off as soon as it dies, and even long before, when it becomes sickly from the irritation of the numbers by which it is infested, as we have often witnessed by confining insects thus attacked. Whether this arises from their finding it more difficult to penetrate the skin, or from their not relishing the diseased fluids, we cannot tell. That the latter is the more probable reason, appears from another curious fact connected with our immediate subject, namely, that fleas and other parasitic insects never infest a person who is near death; and so frequently has this been observed, that it has become one of the popular signs of approaching dissolution. This is in all probability caused by the alteration in the state of the fluids immediately under the skin, either in quality or quantity. It must be upon the same principle that women and children are always more infested with the bed-bug (*Cimex lectularius*) and other parasitic insects, than old men,

* J. R.

whose subcutaneous fluids are scanty, and their skin, in consequence, more rigid and dry.

That insects correct their sense of smell by means of taste appears from numerous observations. Lehmann, for example, tells us, that being taken ill while he was eagerly studying the senses of insects, and was using a bitter decoction of wormwood, he observed a fly (*Musca domestica*) pounce upon a bit of sugar which had been accidentally moistened with the medicine. It began to suck the sugar, but upon tasting the bitter it instantly flew off to a contiguous vase, and endeavoured to reject the nauseous drug *. It is in a similar way that flies, when they become troublesome in apartments by their great numbers, are lured to their destruction by poisoned waters sweetened with honey or sugar. Corrosive sublimate (*Perchloride of Mercury*) and king's yellow (*Sesqui Sulphuret of Arsenic*) are the poisons most usually employed for this purpose; and we cannot too strongly warn our readers that it is dangerous to leave them in the way of children, or even to have any sort of food near upon which the poisoned flies may alight. Infusion of quassia, however, is equally effectual, and quite safe. The fact of the flies sucking up the poisoned water at all, may be adduced to prove that the flies are destitute of taste, in the same way as it may be said that birds or fishes who poison themselves with food drugged with nux vomica do not taste what they are eating; but the argument will not apply, for the taste of the poison is artfully disguised, and it might as justly be argued that Majendie's maid-servant was destitute of taste when she poisoned herself with prussic acid, deceived by its fine nutty flavour into the notion that it was something very nice †.

* De Sensibus Externis, p. 36.

† See Insect Transformations, p. 77.

As the goat relishes the taste of the poisonous water-hemlock, so our soft-billed birds will also feed on poisonous berries. We have not heard of any bad consequences to those who eat goat's flesh, nor to the Italian amateurs of beca-ficos, though the latter have been partly fattened on the deleterious berries of the laurel or the nightshade; but in America, birds eaten after they have fed on the fruit of the kalmia are reported to have produced fatal consequences *. The flowers of the latter plant also, and several others ranked as virulent poisons, are frequently robbed of their honey by bees, whose taste does not seem to intimate the existence of any deleterious quality, no more than does the taste of people who afterwards partake of such honey to their cost. It is not mentioned, indeed, that this honey, so fatal to man, is at all injurious to the bees by which it is collected; though Dr. Darwin tells us, that the bees are well aware of the sorts of honey which would injure themselves, and will not therefore touch it †.

"Perhaps," says the elder Huber, "the sense of taste is the least perfect of those enjoyed by bees; for, contrary to the received opinion, they display little choice in collecting honey; nor do they testify greater nicety in the quality of their water, for the most corrupted marshes and ditches seem to be preferred to the most limpid streams, nay, even to dew itself. Nothing, therefore, is more unequal than the quality of honey, the produce of one district differing from another, and the honey of spring being unlike that of autumn; while even the contents of one hive do not always resemble those of the one which is contiguous. But though bees are thus not

* See Dr. Schumacher's Cases in Anderson's Journ. iii. 456.
† Temple of Nature.

very choice in their nutriment, and are by no means delicate in regard to the quality of honey, they are far from being indifferent with regard to quantity. They soon discover, and consequently frequent the places where most is to be found, and they quit their hive much less in regard to the fineness or temperature of the weather, than according to their prospects of a plentiful or a scanty collection. When the lime-tree and black-thorn blossom, they brave the rain, departing before sun-rise, and returning later than ordinary; but this activity soon relaxes: when the flowers begin to fade, and when the scythe has cut down the fields of clover, the bees are seldom tempted to go from their home by the most brilliant sunshine*."

With respect to poisonous honey, the earliest notice of it we have met with is given by Xenophon, who tells us that, during the memorable retreat of the ten thousand Greeks from Persia, the soldiers, on coming to a place near Trebizonde, where there was a great number of bee-hives, sucked some of the combs, and in consequence became intoxicated, and were seized with a virulent cholera morbus†. Tournefort, the celebrated French botanist, when in the vicinity of Trebizonde, was anxious to ascertain the facts mentioned by Xenophon, and obtained good reason to be satisfied with his inquiries. He concluded that the poisonous honey is collected from a flowering shrub, abundant in that neighbourhood, the very odour of whose blossoms, smelling like honey-suckle, produce intoxicating effects‡. It is not very clear, from his description, whether it is the rose-laurel (*Rhododendron ponticum*) or the yellow

* Huber on Bees, page 258.

† Memorabilia.

‡ Voyage du Levant; 4to, Paris, 1717.

Rose-laurel (*Rhododendron ponticum*).

azalea (*Azalea pontica*), both of which are poisonous and indigenous in Asia Minor. Father Lamberti also found the same plants and poisonous honey in Mingrelia*.

During the autumn and winter of 1790, the honey collected near Philadelphia was found to be so fatally deleterious to those who partook of it, that it attracted the attention of the American Government, and a minute inquiry was ordered to be instituted. The result was, that the poisonous honey was traced to the flowers of the Kalmia latifolia. Dr. Barton

* Mission to Mingrelia, in Thevenot's Collection.

Yellow azalea (*Azalea pontica*).

enumerates several other species of Kalmia, Azalea, Rhododendron, and Andromeda, which produce poisonous honey that proves injurious to dogs, as was ascertained by experiment. Upon man it produces vertigo, dimness of sight, delirium, ebriety, pain in the stomach and bowels, convulsions, profuse perspiration, foaming at the mouth, vomiting, purging, and sometimes temporary palsy of the limbs, though it seldom proves fatal *. Recently, however, two persons at New York are said to have lost their lives by eating wild honey, supposed to have been collected

* Barton, in Amer. Phil. Trans.

from the flowers of the dwarf laurel, which abounds in the American woods*.

"It may seem," says Mouffet, "to be not so much to Dame Nature's honour, that she should bring forth a thing so desired of all men, as honey is, and so ordinarily to temper it with poyson. Nay, but in so doing she did not amiss, so to permit it to be; that she might thereby make men more cautious and lesse greedy, and to excite them not only to use that which should be wholesome, but to seek out for antidotes against the unwholesomeness of it: and for that cause she hath hedged the rose about with prickles, given bees a sting, hath infected the sage with toad-spittle, and mixed poyson (and that very deadly too) with honey, sugar, and manna."

The remarks of Dr. Evans, upon the probability of our British honey being poisoned, are worthy of attention. "As most of the plants," he says, "enumerated as producing poisonous honey, are now introduced into our gardens, and the thorn apple (*Datura stramonium*) has long become perfectly naturalized, they might be supposed to injure the British honey. Most probably, however, their proportion to the whole flowers in bloom is too small to produce any such inconvenience; whereas, on their native continent, they exclusively cover whole tracts of country, as in the Jerseys†."

That vegetable poisons are sometimes fatal to bees themselves, however, appears from the following notice:—A large swarm of bees having settled on a branch of the poison ash (*Rhus vernix*), in the county of West Chester, in America, was taken into a hive of fir, at three o'clock in the afternoon, and removed to the place where it was to remain, at nine. About five the next morning the bees were found dead,

* Bevan on Bees, p. 68.

† The Bees, a Poem, ii. 95, Note.

swelled to double their natural size, and black, except a few, which appeared torpid and feeble, and soon died on exposure to the air*.

It may be, that the honey collected from deleterious plants is only noxious in considerable quantity, which we may illustrate by the instance of the oxalic acid. In small proportions this is not uncommonly used to acidulate punch, and to make an acidulous beverage similar to lemonade, of which we ourselves have frequently drunk without the slightest bad consequences; but when taken in the quantity of an ounce or more, as it usually is when mistaken for Epsom salts, it but too often produces death †. Captain Beaufort furnishes a still more striking illustration in his excellent account of Karamania. In an excursion to the country, his people, fatigued with heat and thirst, were about to drink of a river of pure-looking water, but were told by the guides that it was certain poison, though, upon a cautious trial, they found it well tasted. The ingenious rules, therefore, which Dr. Abercrombie, of Edinburgh, has devised for judging of the qualities of food and medicine, by taste alone, would in these cases be quite at fault.

It is a remark which will be found to hold good, both in animals and vegetables, that no important motion or feeling can take place without the presence of moisture. In man, the part of the eye which is the seat of vision is always bedewed with moisture; the skin is softened with a delicate oil; the sensitive part of the ear is filled with a liquid; but moisture is still more abundant in our organs of taste and smell than in any of the other senses. In the case of taste, moisture is supplied to our mouth and tongue

* Nicholson's Journal, xxiii. 234.

† See Rennie's New Supplement to the Pharmacopœias,—*Art.* OXALIC ACID.

from several reservoirs (*glands*) in their neighbourhood, whence pipes are laid and run to the mouth. The whole surface, indeed, of the mouth and tongue, as well as the other internal parts of our body, give out more or less moisture; but besides this, the mouth, as we have just mentioned, has a number of fountains expressly for its own use. The largest of these fountains lies as far off as the ear on each side, and is formed of a great number of round, soft bodies, about the size of garden-peas, from each of which a pipe goes out, and all of these uniting together form a common channel on each side. This runs across the cheek nearly in a line with the lap of the ear and the corner of the mouth, and enters the mouth, opposite to the second or third of the double teeth (*molares*), by a hole, into which a hog's bristle can be introduced. There are, besides, several other pairs of fonntains, in different parts adjacent, for a similar purpose.

We have been thus particular in our description, in order to illustrate an analogous structure in insects, for they also seem to be furnished with salivary fountains for moistening their organs of taste. One of the circumstances that first awakened our curiosity with regard to insects, was the manner in which a fly contrives to suck up through its narrow sucker (*haustellum*) a bit of dry lump sugar; for the small crystals are not only nnfitted to pass, from their angularity, but adhere too firmly together to be separated by any force the insect can exert. Eager to solve the difficulty, for there could be no doubt of the fly's sucking the dry sugar, we watched its proceedings with no little attention; but it was not till we fell upon the device of placing some sugar on the outside of a window, while we looked through a magnifying glass on the inside, that we had the satisfaction of repeatedly witnessing a fly let fall a drop of fluid upon the sugar, in order to melt it, and thereby render it fit to be sucked up, on precisely the same principle that we moisten with saliva, in the process of mastication, a mouthful of dry bread to fit it for being swallowed—the action of the jaws, by a beautiful contrivance of Providence, pressing the moisture along the channels at the time it is most wanted*. Readers, who may be disposed to think the circumstance of the fly thus moistening a bit of sugar fanciful, may readily verify the fact themselves, in the way we have described. At the time when we made this little experiment, we were not aware that several naturalists of high authority had actually discovered, by dissection, the vessels which supply the saliva in more than one species of insect, as we shall now describe.

Swammerdam seems to have been the first to observe these in the small tortoiseshell butterfly (*Vanessa urticæ*); but as he could not trace their termination, he says, with his usual scrupulous caution, "what the office of these vessels is, and whether they may not be the salivary ducts, I cannot take upon me to determine†." Lyonnet afterwards discovered a conspicuous pair of these vessels in the caterpillar of the goat-moth (*Cossus ligniperda*), distinct from the silk reservoirs‡, with which Swammerdam, as well as Ramdohr, was inclined to confound them; an opinion which Heroldt has also disproved in his admirable anatomy of the cabbage caterpillar (*Pontia brassicæ*). The following are a few of the more interesting facts given by Ramdohr, whose work we have studied with much pleasure.

The pipes which carry the saliva do not always open into the mouth, but sometimes into the gullet,

* J. R. † Book of Nature, part ii. page 21.
‡ Traité Anatomique, page 112.

as in a sort of bug (*Pentatoma*), and sometimes into the stomach itself, as in the bee flies (*Syrphi*, *Bombylii*). It is remarkable that the latter insects, from feeding exclusively on the nectar of flowers, do not require a supply of saliva to moisten their food in the first instance, though it appears to be indispensable to digestion; while in bugs (*Reduvius*, *Pentatoma*), which feed on vegetable and animal juices, one pipe opens into the sucker (*haustellum*), to enable the animal to soften, if necessary, the skin it has to pierce through, and another into the stomach or gullet to aid digestion. In the common flies (*Muscæ*), again, and the gad-fly (*Tabanus*), both pipes open into the sucker, and we have already seen the ingenious use which is made of this when the insects feed on dry sugar. In the water-scorpion (*Nepa cinerea* *), there are no fewer than six of these vessels, though it is rare that there are more than two in other insects. It is worthy of remark, that the exterior double pair in the *Nepa*, is found, when highly magnified, to consist of little globules resembling a bunch of currants; and a similar structure has also been detected in one of the bee flies (*Syrphus arcuatus*), precisely like what we have above described, as occurring in our own salivary fountains.

In the case of drinking thin fluids, like water, saliva is not wanted; and, it may be remarked, when we drink cold water it actually astringes and shuts up the openings of the salivary pipes: hence it is that drinking does not quench thirst when the saliva is rendered viscid and scanty by heat, by fatigue, or by the use of stimulant food and liquor; and sometimes a draught of cold water, by carrying off all the saliva from the mouth, and at the same time astringing the orifices of the ducts, may actually

* Figured in Insect Transformations, page 121.

produce thirst. Ices produce this effect on many persons. It is, no doubt, in consequence of their laborious exertions, as well as of the hot nature of their acid fluids producing similar effects, that ants are so fond of water. We have seen one quaff a drop of dew almost as large as its whole body; and when we present those in our glass formicaries with water, they seem quite insatiable in drinking it*; a circumstance which is well illustrated by the following anecdote from Huber:—

"The feet," he says, "of my artificial formicary were plunged in vessels constantly filled with water. This, which was originally adopted to prevent their escape, proved to them a fruitful source of enjoyment, by supplying them with a plentiful beverage during the heats of summer. One day, while they were assembled at this fosse of the formicary, occupied in licking up the little drops which filtered between the fibres of the wood, which they preferred to taking it from the basin itself, I amused myself in disturbing them, upon which the greater number ascended; but a few remained, whom my presence had not alarmed, and who continued carousing. One of those, however, who had regained the nest, came back, and approached another apparently quite absorbed in the pleasure of drinking. It pushed the drinker with its mandibles several times successively, raising and lowering its head alternately, and at length succeeded in driving it off. The officious ant then reached another, similarly engaged, with whom it found no less difficulty; but at length, being persuaded of the necessity of withdrawing, the drinker passed precipitately to the bell glass. A third, warned in the same manner and by the same ant, quickly regained the nest; but a fourth remained alone at the water's

* J. R.

edge, and would not retire, nor pay any attention to the reiterated blows of its friendly monitor, who at length seized it by one of its legs and dragged it away rather roughly. The toper, however, returned, keeping his large mandibles extended with all the appearance of rage, and again stationed himself to quaff the delightful beverage; but its companion would give it no quarter, and, coming in front, it seized it and dragged it by main force to the nest*."

The deficiency of fluids in butterflies, so different in this their mature or rather old age†, from their youth in the caterpillar state,—a deficiency which is no doubt rendered still greater by their sporting so actively in the sun,—renders them no less thirsty than the ants. We have often remarked accordingly, and more particularly in the autumnal months, that crowds of the small garden white butterfly (*Pontia Rapæ*, Haworth), during sunny weather, congregate around the margins of ponds and other moist places. At Compton Basset, in Wiltshire, we once counted above fifty of these butterflies all assembled within a space of a few yards on the sludge which had just been left by the water of a pond, partially dried up by the sun. What was most remarkable, they seemed to have quite lost the pugnacious disposition which they are affirmed to display when they meet with their congeners on the wing. At the pond, on the contrary, all was harmony among these light-winged belligerents, no one disturbing its neighbour, though they stood side by side, and almost touching one another. They were, indeed, too intent on quenching their thirst to think of attack or defence. We remarked, in the autumn of 1829, a similar congregating of the same species of butterflies on the watered

* Huber on Ants, page 150.

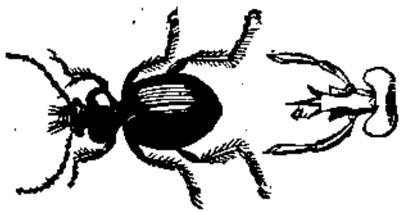
† See Insect Transformations, page 49.

roads in the vicinity of London*. They do not seem to be more choice in the quality of their water than bees, who, most naturalists tell us, prefer that which is stagnant and putrescent †.

The tongue, which analogy points out as the chief organ of taste, is, in insects, frequently very different from the same organ in the larger animals; but in the locusts, grasshoppers, and crickets (*Orthoptera*, Olivier), and in the dragon-flies (*Libellulina*), it is rounded and fleshy, somewhat resembling that of quadrupeds ‡. The dragon-flies have, besides, a sort of palate, consisting of a square fleshy cushion, beset, like the upper surface of their tongue, with minute black tasters (*papillæ*) ending in a short bristle. The same may be observed in many beetles (*Geotrupes, Dytiscus, &c.*), and it is probable it exists in most if not all other insects, though hitherto unexamined, or, from the minuteness of the parts, undiscovered. The hairs, which have just been mentioned as arising from the tasters, occur on the tongues of many insects, as in all the bees (*Apidæ*, Leach), and generally in the predacious beetles (*Adephaga*, Clairville), and are supposed by Kirby and Spence to be mechanically useful for securing food §. It is more probable that, by penetrating into a morsel, they aid in distinguishing its flavour. It is worthy of notice that the dung-beetle (*Geotrupes stercorarius*), and some others, have the hairs on their tongues bent back, like the tubercles on the tongue of the cat and the lion, which we know to be used mechanically in filing down, as it were, portions of their food ||. In some insects there are also projections on the tongue, similar to teeth; and

* J. R. † Réaumur, v. 697.
‡ Cuvier, Anatomie Compar. iii. 347. § Intr. iii. 454.
|| See Menageries, vol. i. page 179.

in the wasp it is forked, somewhat like the tongue of a serpent. In the saw-flies (*Tenthredinidæ*) it is divided into three, and in a predacious beetle (*Leistus*) it is formed like a trident.



Leistus fulvibarbus; *a*, its trident-shaped tongue, highly magnified.

In bees the tongue is very long and tubular, as we shall afterwards notice; and in the bugs (*Cimicidæ*) it is bristle-shaped and sharp.

Chapter III.

SMELL IN INSECTS.

When a brood of the large tortoiseshell butterfly (*Vanessa polychlorus*) is observed frequenting a row of elm trees, they may all be speedily attracted to a particular branch by putting a little honey on the leaves, and thus the collector may secure as many as he shall require. This circumstance is to be attributed wholly, as it appears to us, to the acute scent of the insects, who no doubt mistake it for some melliferous flower. We have observed, indeed, that butterflies of all species, though far from being voracious feeders, will often dart down from a considerable height upon a flower beneath their track, even when their leading object seemed to be very different from searching for food. This struck us more particularly in a narrow garden at Hâvre de Grace, enclosed with stone walls fifteen feet high; for no butterfly, in passing over it, omitted to descend for the purpose of visiting the blossoms of an alpine bluebottle (*Centaurea montana*), whose smell, however, to our organs, is far from being powerful enough to be perceived at the distance of one foot, much less at fifteen or twenty feet, as it must have been by the butterflies; for we often saw the painted lady (*Cynthia Cardui*), and other high flying species, alight there*. These facts will appear more remarkable, if we believe, with M. Le Cat,—though he gives no reason for his opinion, but puts us off with a simile—that odours,

* J. R.

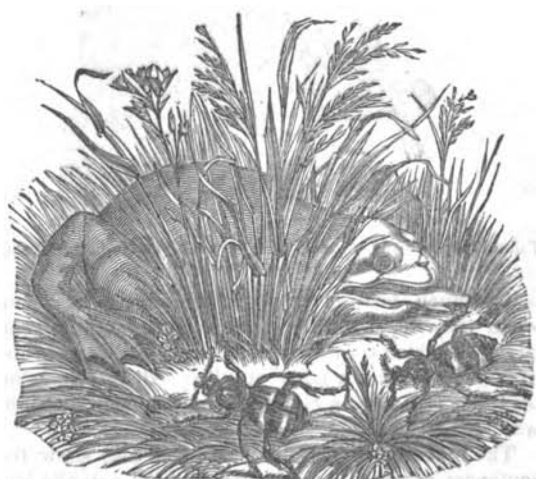
Painted lady butterfly (*Cynthia Cardui*); and Alpine bluebottle (*Centaurea montana*).

being much heavier than air, seldom rise in it, and when they do, it is only in consequence of the velocity with which they are ejected from bodies,—in the same manner that a horse at full speed, and the wind together, will raise a cloud of heavy dust on a highway *.

The ingenious experiments of Redi also show the acuteness of smell in blow-flies, which actually laid their eggs on the silk covering of the meat he em-

* Traité des Sensations, Paris, 1767.

ployed, deceived by the very sense given them by Providence to direct their instinct*. Upon the sea-beach, we have often been struck with the almost instantaneous appearance of clouds of stercorarious flies attracted by a recent horse-dropping, though not one had been in sight an instant before; and many of these we have observed trooping on towards the place of rendezvous, even in the face of the strong breeze which had wafted to them the intelligence that put them in motion. We once observed a pair of the burying beetles (*Necrophorus sepultor*, DE JEAN) in Copenhagen fields, flying at the height of about twenty feet from the ground; when they suddenly descended, and crept under the body of a dead frog,



Burying beetles (*Necrophorus sepultor*), and dead frog.

* See Insect Transformations, page 6.

hid amongst the grass, though this was so dried up with the extreme heat of the weather (1825) that we could perceive little or no smell, even when close to the place, and it was in the forenoon, when the sun was bright and powerful,—a time when scents are much less diffusable than in the cool of a dewy evening *. Few circumstances, we think, could more strikingly illustrate the acuteness of smell in these useful insects.

In bees, the odour of honey produces the most obvious influence. Mr. John Hunter mentions that he has seen great commotion produced in a recent swarm, in wet weather, when he supposed the bees to have been hungry, by placing honey on the floor of a glass hive, which gave him a good opportunity of observing their proceedings. All of them appeared to be eagerly on the scent, and even those which were weak and hardly able to crawl, threw out their tongues as far as possible to get at the honey †. The elder Huber instituted some experiments still more interesting.

"In order," he says, "to ascertain whether the appearance of the flowers or the odour of the honey apprises bees of its presence, we placed honey in a window, near a hive, where the shutters, almost close, still permitted them to pass if they wished. Within a quarter of an hour four bees and a butterfly had insinuated themselves, and we found them feeding thereon. For the purpose of a still more accurate experiment, I had four boxes, different in size, shape, and colour, made with small card shutters, corresponding to apertures in the covering. Honey being put into them, they were placed at the distance of two hundred paces from my apiary. In half an hour bees were seen trooping thither, and by carefully tra-

* J. R. † Phil. Trans.

versing the boxes, they soon discovered the openings through which they might introduce their bodies, and, pressing against the valves, reached the honey. Their extreme delicacy of smelling is hence most obvious, for not only was the honey quite concealed from view, but its very effluvia, from being purposely covered and disguised, could not be much diffused.

"It is worthy of remark that some flowers have a structure resembling the valves in the experiment. The honey-vessel of several species is situated at the bottom of a tube, enclosed or concealed among the petals; yet, in spite of this concealment, the bee finds it out, though its instinct, less refined than that of the humble-bee (*Bombus*), affords fewer resources. The latter, when unable to penetrate the flowers by their natural cavity, drills an aperture at the base of the tube, through which it insinuates its sucker into the place where nature has placed the reservoir of honey. By means of this stratagem, and favoured by the length of its sucker, the humble-bee can obtain honey which the hive-bee could reach with great difficulty, if at all *."

We have frequently observed with much interest the method taken by various species of bees to open the operculated flower of the common snapdragon (*Antirrhinum majus*). Resting upon the lower lip of the flower, the insect insinuates its tongue between the upper lip and the valve, and then thrusting in its head, acts with it as a wedge to force the shut edges asunder. In this manner it speedily accomplishes an entrance, and the flower shuts over it with a *snap;* hence, perhaps, the popular name. When the bee has obtained the honey at the bottom of the flower, it makes its exit in the same way as it entered.

Contrary to what we understand Huber to affirm

* Huber on Bees, p. 261.

Snapdragon (*Antirrhinum majus*), and bees entering the flowers.

in the above quotation, we have, in some hundreds of instances, seen the hive-bee open these flowers as dexterously as the humble-bees, and the latter uniformly opened the spring valve of the flower, and never attempted a perforation at the bottom*. Our opinion seems to be partly corroborated by what is stated by Kirby and Spence. "Several flowers,' say they, "that produce much honey, the bees pass

* J. R.

by, in some instances from inability to get at it. Thus, for this reason probably, they do not attempt those of the trumpet honey-suckle, which, if separated from the germen after they are open, will yield two or three drops of the purest nectar; so that, were this shrub cultivated with that view, much honey in its original state might be obtained from a small number of plants*." Were Huber's remarks correct, this is the very flower which the humble-bees would select to perforate. The humming-bird moth (*Ma-*

Humming-bird moth (*Macroglossa stellatarum*); and trumpet honey-suckle (*Caprifolium sempervirens*).

* Intr. ii. 180.

croglossa stellatarum, STEPHENS) fares the better for this neglect of the bees, as, by means of its long sucker, it can get to the very bottom of the honey-vessel, while it poises itself on the wing at the opening of the flower. The younger Huber, however, we find, expresslys tates that he has *seen* humble-bees pierce the large tubes of the flowers of beans to get at the honey, when, by trial, they found they could not otherwise reach it*. M. Aubert du Petit Thouars, also, a respectable French naturalist, observed humble-bees, as well as the violet carpenter-bee (*Xylocopa violacea*), pierce the nectaries of the snapdragon, toad flax (*Linaria vulgaris*), and marvel of Peru (*Mirabilis Jalapa*), as the bees of the Isle of France perforate the flower-tubes of the common Indian shot (*Canna Indica*†). Kirby has observed holes in the nectaries of columbiue (*Aquilegia vulgaris*), which he attributes to the same agency ‡.

A similar experiment to that of Huber's is said to prove successful upon fishes, particularly eels, by enclosing a piece of meat or fish in a box perforated with holes, and sinking it in deep water, where, in a short time, the eels discover it, no doubt by the sense of smelling, and crowd into the box §. In the case of smelling at a distance, vultures and birds which feed on carrion have long been famous; for, "where the carcass is, there will the vultures be gathered together." Dr. James Johnson, however, has stated several facts, which render it more probable that this ought to be attributed to acuteness of vision. He was led, he tells us, to doubt the received opinion, while observing, some years ago, a concourse of birds of prey, from every point of the horizon, towards a corpse floating down

* Linn. Trans. vol. vi.

† Nouv. Bulletin des Sciences, i. 45.

‡ Intr. ii. 523

§ Monro, Anatomy of Fishes.

the river Ganges, and that during the north-east monsoon, when the wind blew steadily from one point of the compass for months in succession. It was extremely difficult to imagine that the effluvium from the body in the water could stream off in direct opposition to the wind, so as to be perceived by birds many miles distant. It has been ascertained, by direct experiments, that where very putrid carrion was enclosed in a basket, through which the effluvium could penetrate, while it was concealed from sight, it attracted not the notice of birds of prey; but when it was exposed to view, crowds of them came rapidly from different quarters of the horizon, where they were invisible a few minutes before. This is most rationally accounted for from their soaring at an altitude beyond our sight, though they can thence discern their prey*.

The discovery of distant water by the camel seems to depend on the sense of smell †. In Dr. Stewart Traill's account of the captivity of Scott among the Moors of the Sahara, we are told that the camels of the caravan discovered the approach of a wolf at the distance of half a mile; and that they can also smell a tiger at a great distance, which is known by their refusing to advance, and their putting themselves in an attitude of defence ‡. The elephant is said to have a similar faculty of smelling out a tiger. The late Lord Clive exhibited a combat between two of these animals, at Calcutta; but at first nothing could allure or force the elephant to advance along the road, where the cage containing the tiger had passed, till a gallon of arrack was given, when, his horror suddenly turning to fury, he broke down the paling to get at his enemy, and killed him without difficulty.

* Medico-Chirurgical Review for Dec. 1828.

† See Menageries, vol. i. ‡ Edinb. Phil. Journ. 1820.

It is by no means improbable that many insects employ the offensive odours which nature has enabled them to discharge, to produce effects of terror upon their enemies. Perhaps the most familiar instance of this occurs in the extensive family of bugs (*Cimicidæ*), the fœtor of which is always similar, though their food is so various; and the pretty little beetles, the lady-birds (*Coccinellidæ*), of which children are so fond, emit a similar, though not quite so offensive an odour. The rove-beetles (*Staphylinidæ*), in addition to their threatening and formidable attitudes, emit a very disagreeable odour, though it is not quite so bad as that of others (*Silphidæ*) which feed on carrion. The church-yard beetle* (*Blaps mortisaga*) has been noted for the same circumstance since the time of Pliny†. Some bees (*Andrenidæ*), again, have a strong smell of garlic, which may probably be disagreeable to their various enemies‡. We have had an opportunity of examining the curious organ, supposed to be intended for the similar purpose of defence, in the very beautiful caterpillar of the swallow-tailed butterfly (*Papilio Machaon*, LINN.), three of which we took upon fennel in the Jardin des Plantes, at Paris. The caterpillar itself is of a fine green, banded with black. The instrument in question§ is of a dark orange, and is always concealed within one of the rings on the shoulders, unless the creature be irritated, when it darts it out to the extent of about an inch, and at the same time emits a strong odour resembling fennel. This may be intended to intimidate the ichneumons from depositing their parasite eggs in its body, or warning off the thrushes or the carnivorous locust (*Acrida verrucivora*) from devouring it. On the

* Figured in Insect Transformations, p. 241, 281.
† Hist. Nat. xxix. 6. ‡ Kirby, Monographia, i. 136.
§ Figured in Insect Transf. p. 281, *a*.

same plant, indeed, where these caterpillars were feeding, we saw one of the latter lurking about, no doubt with evil intent*.

A small green beetle (*Anchomenus prasinus*, BONELLI), not uncommon near London, gives battle to its most formidable enemies by repeated discharges of smoke and noise. This species, however, is not perhaps so well known as another, called by Latreille the bombardier (*Brachinus crepitans*, WEBER), known by its head and thorax being brick-red, and the rest of the body a deep blackish-blue.

a, Bombardier (*Brachinus crepitans*). *b*, *Calosoma inquisitor*.

When we attempt to catch it, we are surprised by a discharge resembling a pop-gun, accompanied with a sort of smoke, of which it is furnished with a bladder sufficient to fire off, according to Rolander, twenty shots in succession. If this chance to get into the eyes, it will make them smart as if they had been bathed with brandy. Its chief enemy is a beetle

* J. R.

(*Calosoma inquisitor*, WEBER), larger than itself, which hunts it without mercy. As it finds it impossible to escape by speed of foot, it stops short, and awaits its pursuer; but just as he is about to seize it, he is saluted with a discharge, and while he is for a moment stupified with surprise, the bombardier endeavours to gain a hiding-place. Another species (*B. displosor*) can direct its smoke, according to report, to any particular point, by bending itself in the required direction. M. Leon Dufour says the smoke has a pungent odour, similar to nitric acid, and it reddens white paper *.

It is right to inform our younger readers, who may be desirous of witnessing the performance of this Lilliputian artilleryman, that he is not always prepared, or at least in the humour, to fire his guns; for we have in several instances been disappointed when we wished to exhibit the phenomena †. It may have been in consequence of such accidental disappointment that Millard, a practical collector of insects, has been led to treat the whole as little better than a fable ‡. "I presume," says Stephens, "that this author must have laboured under some delusion, or has not paid that attention to the subject which appears requisite before attempting to controvert a well established fact. So far as my experience leads me, I have invariably found that the insects are ready to discharge their ammunition at all times, especially if roughly handled; and Mr. Cooper informs me that one he met with at Cobham, in the beginning of the present spring, performed the operation no less than thirteen times in rapid succession §." The whole proceedings of these beetles strikingly resemble those of the American weasel, called the skunk (*Viverra*

* Annales du Museum, xviii. 70. † J. R.
‡ Outlines of British Entomology, p. 221.
§ Illustr. i. 35.

putorius, LINN.), which discharges a fœtid vapour upon its pursuers *.

Many of the ants (*Formica fœtens*, *F. fuliginosa*, *&c.*) exhale a powerful and unpleasant smell, which may, perhaps, be given them as a means of defence; though it also appears to furnish them with the means of following the routes of their companions to and from their encampments. We once observed, on Hampstead Heath, a track of the negro ant (*F. fusca*) several yards in length, leading to a numerous colony, and crowded through its whole extent with foragers. By simply drawing a walking-stick across this track in several places, so as to obliterate the scent, the whole train of foragers were instantly thrown into confusion, and wandered about as if blindfolded or tipsy; and though we remained upon the spot for a considerable time to observe their proceedings, they did not succeed in reuniting the points of the track which we had dissevered, though most of them found their way to the nest by circuitous and zig-zag routes †. The track in question was not visibly hollowed out, as Huber says is done by the wood-ant (*F. rufa*), to the extent sometimes of a hundred feet in length, and several inches in breadth, or of the emmet (*F. fuliginosa*) which is said to cut the grass in its pathways; but marked solely by the effluvia of the insects. The odour of the wood-ant is so powerful, that a frog thrown into one of their encampments will be suffocated in five minutes ‡.

The preceding statements show that ants are endowed with an acute sense of smell, which is more remarkably proved, as it appears to us, from some other facts which have been otherwise explained. Professor Bradley tells us that a nest of ants in a

* Kalm's Travels. † J. R.

‡ Nouv. Dict. d'Hist. Naturelle, xii. 24.

nobleman's garden discovered a closet, many yards within the house, in which conserves were kept, which they constantly attended, till the nest was destroyed. It was remarked that they always went to it by the same track, scarcely varying an inch from it, though they had to pass through two apartments; nor could the sweeping and cleaning of the rooms discomfit them, or cause them to pursue a different route*. It is inferred that some in their rambles must have discovered this depôt of sweets, and informed the next of it: we should rather say they were successively led thither by smell, or at least that the road was pointed out not so much by gesticular signs as by the smell of the conserves left on the track of the first who had been at the pots.

Dr. Franklin made an observation upon ants for the purpose of ascertaining their capability of imparting intelligence. He put a little earthen pot, containing treacle, into a closet, and soon found a number of ants feasting upon it; upon which he shook them out, and suspended the pot by a string from the ceiling of the room. By accident there remained in the pot a single ant, which, after gorging itself, found with some difficulty the way to the ceiling along the string. It had scarcely been gone half an hour, when a swarm of ants issued forth, got up to the ceiling, and crept along the string to the pot, and a regular march and counter-march of foragers was soon established between the nest and the pot. This we are disposed to explain as we have done the facts mentioned by Bradley—an explanation rendered probable by some experiments which we have tried.

We laid a bruised raisin, dipped in moist sugar, upon a grass-plot, where a few ants of various species were observed straggling about; and it was not

* Account of the Works of Nature.

long before one of them discovered the prize. Our object, however, being to prevent this individual from informing the rest, we seized it, as we did several others as they successively arrived; but although we were not aware of any ant-hill within a good many yards of the spot, we speak within compass when we say that we could have caught several hundreds within an hour at the raisin, none of which could by possibility have been informed by their companions, whom we kept close prisoners. That they were led to it by smell also appeared from those of the same nest arriving usually by the same straight track. We admit, indeed, that when we allowed the prisoners their liberty, a much greater number came to the feast; but that, as we imagine, was occasioned, as in Franklin's experiment, not by mutual communication, but by the scent of the sugar left on their path *.

We do not see how our first experiment could be explained otherwise; and though some readers may accuse us of refining too much on the second, it is corroborated by many analogical facts. It is credibly reported, for example, of the Negroes in the Antilles, that they can follow their master as a dog does, by smelling the track of his feet;—nay more, that they can distinguish the track of a Frenchman from that of a Negro †. Humboldt expressly states, that the American Indians have distinct terms to express the odour of a Negro, a European, and a native American ‡. Sir Kenelm Digby mentions a boy whose smell was equally acute with that of the Antilles Negroes; and a monk, who could distinguish different persons in the dark by smell, began a treatise on odours, but did not live to execute the task. The

* J. R.

† Journ. des Sçavans, pour 1667, p. 60.

‡ Political Essay on New Spain, London, 1811.

singular boy, Mitchel, born deaf and blind, had the same faculty of distiguishing persons by smell *.

The most close analogy, however, to the smell of ants, is furnished by various hounds, which can track unerringly, by the odour left on the grass, the path of hares, foxes, and other animals, and by that means discover their lurking-place. An instance of the almost miraculous acuteness of smell in the blood-hound is related by Boyle. "A person of quality," he says, "to make trial whether a young blood-hound was well instructed, caused one of his servants to walk to a town four miles off, and then to a market-town three miles farther. The dog, without having seen the man he was to pursue, followed him by the scent to the above-mentioned places, notwithstanding the multitude of market people that went along the same way, and of travellers that had occasion to cross it; and when the blood-hound came to the chief market-town, he passed through the streets, without taking notice of any of the people there, and left not till he had gone to the house where the man he sought rested himself, and found him in an upper room, to the wonder of those that followed him †." The very subtle nature of odours, however, tends to strip these instances of sagacity of their apparent magic; for a particle of camphor, less than the two-millionth part of a grain, has been found distinctly perceptible to smell ‡. This has led Von Walther and others into the opinion, that odours are analogous to heat, light, and magnetism; in support of which they urge many very curious and plausible arguments. The French chemists, on the other hand, consider *aroma* as a distinct element §.

* See Wardrop's Account.

† Boyle on the Nature of Effluvia, chap. iv.

‡ Haller, Elementa Physiol., vol. v. p. 58, 4to.

§ Rennie's Supp. to the Pharmacop, *Art. Aroma*.

M. Bomare relates an experiment to prove that the bed-bug (*Cimex lectularius*) is not attracted, as is popularly supposed, by heat, but by smell. He put a bug into an empty bed-chamber, and throwing himself upon the bed, perceived that the insect did not at first know whither to turn; but it was not long in smelling him out, and ran right towards his face *; but we can infer nothing certain from so clumsy an experiment, and only mention it because it is quoted as an authority by Lehmann † and others. We know not whether the proposition of Goze to expel bugs by the odour of horses (*sudore equino*), is any better founded ‡, though they certainly dislike the smell of coal-gas, coal-tar, turpentine, rosin, and camphor, as most insects do.

ORGAN OF SMELL.

As insects breathe in a very different manner from the larger animals, namely, by a number of spiracles along each side of the body, it becomes a question of some difficulty, where their organs of smell are situated. We cannot, indeed, easily conceive of smell being produced except by a current of air, in which odoriferous particles are diffused, passing through a moistened channel, as was first so admirably described two hundred years ago by Schneider §; but though it would be bad reasoning to infer that this must be the case in insects, because we cannot conceive any other, yet, as the analogy is strong, we ought at least to investigate the point.

Baster || seems to have been the first who conceived that the spiracles, or breathing-holes of insects

* Dict. Raisonné d'Hist. Nat., *Art. Punaise.*

† De Sensibus Extern. 29.

‡ Natur. Menschenleben und Vors, ii. 213.

§ De Sensu ac Organo Odoratus, 12mo. Witteb. 1655.

|| Opusc. subs.

are their organs of smell; and the opinion has been adopted by Cuvier, Dumeril, and Lehmann, chiefly for the reason already mentioned, that the inspiration of air seems to be an indispensable condition ot smelling. If it should be objected, that it is no less requisite for this organ to be near the mouth to serve for a guide as to the quality of food, Lehmann answers, that this is not so requisite in insects, because they are usually so much smaller than their food, and frequently even reside in what they eat, and may therefore smell as advantageously with the tail as the head *. To us, this appears quite as vague and conjectural as the argument of Cuvier †, who thinks, from the wind-pipes (*tracheæ*) being lined with a soft and moist membrane, that organ calculated, like the Schneiderian membrane of our nostrils, to perceive odours; but though this was really soft and moist, as it is not ‡, it would no more prove this point, than would the soft, moist surface of our inner eyelids, or of our tongue and palate, prove them to be organs of smell.

M. De Blainville decides more positively than the facts seem to authorize that the antennæ are the organs of smell. The modification, he remarks, of the skin which invests them, is in general olfactory only in a small degree, this power appearing to be more vivid in the thickest portion of the organ, where it is more soft and tender, as in the carrion beetles (*Necrophaga*), which possess so delicate a sense of smelling. From spiders being destitute of antennæ, he thinks it very difficult to conceive where the seat of their organ of smell is placed, if indeed they possess one, which he is disposed to doubt. Crabs and lobsters on the

* De Usu Antennarum, p. 31.
† Anatomie Comparat. ii. 675.
‡ Sprengel, Commentar. 14; and Lyonnet, Traité Anatomique, 103.

other hand, whose scent is very delicate, are furnished with no less than two pairs of antennæ*. It is obvious, however, that all this is pure conjecture, unsupported by any sort of proof, direct or analogical.

It is probable that M. De Blainville was influenced to adopt these opinions from the high authority of Latreille, whose reasoning on the subject it may be worth while to quote. "The exercise of smell," he says, "consists only in the action of air impregnated with odoriferous particles, on the nervous or olfactory membrane, which transmits the sensation. If insects be endowed with an organ furnished with similar nerves, and with which air charged with odoriferous particles comes in contact, such an organ may be regarded as that of smell. Should the antennæ present a tissue of many nerves, what inconvenience can result from supposing that this tissue is capable of transmitting odour? Would not this hypothesis, on the contrary, be more simple and more consonant to anatomical principles, than that which fixes the seat of smell at the entrance of the stigmata? Besides, this last mode of explanation will not, I presume, suit the crustaceous animals, which so nearly approach to insects. Many male insects have their antennæ more developed than the females; a fact easily explained, if we admit that these organs are the seat of smell. It is certain that most of those insects which live or deposit their eggs on putrid animals, or vegetable matters, stagnant waters, or any substance, in short, which for a time affects peculiar localities, are almost uniformly distinguished by a greater development of the antennæ. Such for example are the Scarabæus, Dermestes, Silpha, Clerus, Tenebrio, Tipula, Bibio, &c. These require a more perfect sense of smell, and are organized accordingly. A great many insects which are entirely

* De l'Organisation des Animaux, vol. i.; Paris, 1823.

predaceous have simple antennæ; and those which are characterized by similar manners, and which are sedentary, have none at all; as, for instance, the Acari, and a considerable portion of Lamarck's arachnida discover their habitation and food by the sense of smell. I have deprived several insects of their antennæ, when they instantly fell into a state of stupor or derangement, and seemed to be incapable of recognizing their haunts or their food, though just beside them. Such experiments deserve to be prosecuted. I would recommend, for example, the varnishing or covering the antennæ of dung beetles, and placing them near animal excrements, of which they are particularly fond, to observe if they would repair to them as usual. The nerves terminate at the antennæ; and their articulations, though externally covered with a pretty thick membrane, are hollow, lined within by a soft substance, which is often of a watery consistency, and whose extremity, when opposed to the air, may receive its impressions." Mr. Kirby, in speaking of the Eucera (or long-horned bee), says: "A singular circumstance distinguishes their antennæ, which to the best of my knowledge has never before been noticed, and which may possibly lead to the discovery of the use of these organs. Placed under a powerful magnifier, the last ten joints appear to be composed of innumerable hexagons, similar to those of which the eyes of these insects consist." If we reason from analogy, this remarkable circumstance will lead us to conjecture, that the sense, of which this part so essential to insects is the organ, may bear some relation to that conveyed by the eyes. As they are furnished with no instrument for receiving and communicating the impressions of sound similar to the ear, that deficiency may be supplied by extraordinary means of vision. That the stemmata are of this description seems very probable; and the antennæ may, in some degree, answer a similar purpose: the circumstance just mentioned furnishes some presumption that they do this, at least in the case of these males; else why do they exhibit that peculiar structure which distinguishes the real eyes?

We are indebted to the elder Huber for several ingenious experiments which appear to bring the difficulties of the question within a narrower compass, and render it probable that the organ of smell, in bees at least, is situated in the head.

"A pencil," he tells us, "dipped in oil of turpentine, one of the substances most disliked by insects, was presented successively to all parts of the body of a bee, which did not appear in the least affected even when it was brought near the spiracles of the chest. We then took a very fine pencil, that we might try every minute point of the head, and approached it to the antennæ, the eyes, and sucker while feeding, but without the least effect. When, however, we put it near the cavity of the mouth, above the insertion of the proboscis, the bee instantly started back, left the honey on which it was feeding, beat its wings with great agitation, and would have taken flight had not the pencil been withdrawn. Having renewed its repast, we again brought the pencil near the mouth as before, when the bee quitted the honey, fixed upon the table, and fanned itself with its wings as if to blow away the turpentine. It appears obvious, therefore, that the organ of smell resides either within the mouth or the parts contiguous.

"As bees not occupied in feeding appeared more sensible of the odour of turpentine, being affected with it at a greater distance, but when their sucker was immersed in honey, several parts of the body might be touched by the pencil without annoying them, we inferred that their attention was either absorbed by the smell of the honey or their organs less exposed. To ascertain this, we tried the following experiment:—We seized several bees, and obliging them to stretch out their sucker, we filled their mouths with flour paste, and when it was dry enough to prevent their rubbiog it off, we set them at liberty. They did not appear to suffer any inconvenience, and breathed and moved with the same facility as their companions. But now honey failed to attract them, for they neither approached it, nor, so far as we observed, were they affected by odours in other cases offensive to them. We dipped pencils in oil of turpentine and cloves, in ether, in fixed and volatile alkalies, and insinuated their points very near the mouth, where we had previously found them so sensitive; but the odour of these fluids, which would have occasioned a sudden shock to bees in their natural state, had no effect upon them. On the contrary, several mounted on the impregnated pencils, and even traversed them with impunity: consequently their sense of smelling was obstructed by the paste put into their mouths*."

Humboldt, in referring to Lyonnet's admirable anatomy of the caterpillar of the goatmoth, takes occasion to blame authors for drawing general conclusions from one insect to another †, and certainly in some cases this might lead to error; but, in many others, the converse might be equally illogical, as appears, for example, from the singular opinions of Comparetti ‡. He supposes that the organs of smell are situated in different organs in different families of insects. In beetles (*Geotrupes stercorarius*, *&c.*) he thinks it resides in the knob of the antennæ;

* Huber on Bees, p. 264.

† Ueber die gereizte Muskelfaser, i. 273, Not.

‡ De Aure Interna Compar. p. 288—304.

in butterflies and moths in the sucker, and in flies (*Muscidæ*) and locusts, in certain cells in the forehead. M. Christ, again, supposed that insects smell near objects with their antennules (*palpi*), and remote ones with their antennæ*. Réaumur, conceiving the antennæ to be the organs of smell, concluded that they inspired air, and upon immersing the knobs of the antennæ of a butterfly in water, he actually perceived minute bubbles of air issuing from them †; but Lehmann disproved the conclusion by removing the bubbles, formed as he thinks merely from the air in the exterior sculpture, for it could not penetrate the interior, and no more bubbles were formed after the first ‡.

Kirby and Spence, on the other hand, carrying the argument from analogy farther than their predecessors, assign several reasons, chiefly from anatomy and from the preceding experiments of Huber, that the organ of smell in insects is "the extremity of the *nose*, between it and the upper lip, or under those parts:" and "that the nose corresponds with the so named part in Mammalia, both from its situation and often from its form, must be evident," they think, "to every one who looks at an insect §." They afterwards describe what they call the "nostril piece (*rhinarium*)" in the burying beetle (*Necrophorus Vespillo*), the water-beetle (*Dytiscus marginalis*), and one of the dragon-flies (*Æshna varia*, SHAW).

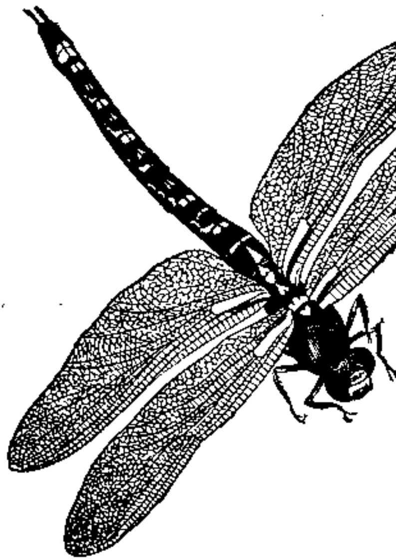
Did insects breathe by any part of their head the mystery of smell would be less; but so far as researches have hitherto been made, this is not the case, for no spiracles have been discovered in the head,

* Naturgeschichte der Hymenopterorum, p. 24.

† Memoires, i. 224.

‡ De Sensibus Externis, 31.

§ Intr. iv. 256.



Green dragon-fly (*Æshna varia*).

though there is a pair in the first segment of the trunk obvious enough in most caterpillars and grubs *, but seldom observed in perfect insects. It may be seen, however, in the common rove-beetle (*Goërius olens*, STEPHENS), and in the mole-cricket, just behind the arms. From some experiments of Huber, however, it appears not improbable that we have still much to learn respecting the upper spiracles, at least in bees. Swammerdam had ascertained the existence of three pair of spiracles in the chest, and seven in the abdomen of bee pupæ; and Huber, anxious to learn whether these were continued in the adult state,

* See Insect Transformations, pp. 138, 175, 200.

Rove beetle (*Goërius olens*) on the wing.

immersed a number of bees in water, slightly heated to prevent any effect from torpidity in consequence of cold.

"When only the head of a bee," he says, "was plunged in mercury or water, it did not seem to suffer; but if the head alone remained out of the fluid, the insect stretched out its sucker and gradually swooned away; if the head and thorax were immersed, leaving the abdomen free, it struggled a few minutes and quickly died. The mouths of the spiracles appearing from this to be in the chest, that was left free, while the head and the abdomen were immersed. A bee supported this experiment very patiently, and took flight when released. The action of the spiracles can be best observed by the suffocation of bees in water. Four air-bubbles then become conspicuous,—two between the origin of the neck and the root of the wings, a third on the neck *at the origin of the tongue*, and a fourth on the opposite extremity of the chest close to its junction with the abdomen. The bee seems to have some power in the retention of air, as the bubbles do not rise to the surface till they acquire sufficient size to overcome the resistance of inspiration or adherence to the sides of the cavities. By the third and fourth bubbles, the existence of spiracles, not observed by Swammerdam, is indicated. As other experiments showed that one orifice remaining free is sufficient for carrying on respiration, some internal communication must subsist between the spiracles *." It would appear, indeed, that the orifice mentioned at the origin of the tongue is in or near the spot indicated by his preceding experiments as the organ of smell; and even should we say this organ is in the pair of spiracles on the second ring, we have an analogy to support it in the gills of fish, which are situated behind and not before the mouth.

The connexion of smell and taste is much closer in man than most persons are aware of; and this, taken in conjunction with the experiments of Huber, gives additional weight from analogy to the opinion that the organ in insects is near the mouth. The connection in question seems to have been first observed by Willis, who found that if a sapid substance is put into the mouth when the nostrils are closed, the sensation of taste is suspended †. According to some recent experiments by Dr. Rousseau, of the United States, the operation of poisonous and inebriating effluvia is prevented by the same means. One man, after his nostrils were stuffed, was made to breathe the vapour of boiling brandy for an hour without producing any effect, except a little smarting of the throat. Next day he breathed the vapour with his nostrils open, and in less than half an hour was thereby rendered so intoxicated that he could not stand. A delicate lady, who could not bear the smell of tobacco without being sick, voluuteered to try a similar experiment upon herself. Some tobacco accordingly was kept boiling in a saucepan, and she breathed the vapour for half an hour, keepiug all the while her nostrils closely pressed, and she experienced no in-

* Huber on Bees, p. 293. † De Anima Brutorum.

convenience. Dr. Rousseau comes to the conclusion that without smell we could have no taste; and he proved his opinion by successively blind-folding some young physicians, who were sceptical respecting it, and closing their nostrils made them guess onions to be apples, and camphor to be bread *. This doctrine appears not a little plausible, but it will only hold in case of *flavours*, that is, when odour accompanies taste, the two sensations being as distinct as their causes,—a distinction first pointed out, we believe, by Dr. Prout †.

The varied effects of different odours on bees were experimentally ascertained by the elder Huber in numerous instances. He found that the mineral acids and volatile alkali acted still more powerfully than spirit of turpentine. "On our presenting musk," he says, "to bees feeding before the entrance of their hive, they ceased, and partially dispersed, but without precipitation or beating their wings. We sprinkled some powdered musk on a drop of honey, into which some bees thrust their suckers as if by stealth, for they kept as far back from it as possible; but although they often appeared to suck it, we did not perceive it to become less in a quarter of an hour, long before which it would have disappeared had it not been mixed with musk. Pounded assafœtida, whose odour is so disagreeable to us, upon being mixed with honey and put at the entrance of a hive, did not seem to annoy the bees; for they greedily sucked all the honey, neither attempting to withdraw, nor vibrating their wings, till they only left the particles of the gum.

"Having had remarked, that bees going out to the fields and coming home, turned aside in the air to avoid passing immediately over a piece of cam-

* Philadelphia Journ., edit. by Dr. Chapman, No. 7.

† London Med. and Phys. Journ. for 1812.

phor laid before the entrance of their hive, I tried the effect of bringing some camphor towards their mouths while their tongues were plunged into some honey placed on a card. All of them took flight, but after flying about for some time, they ventured to alight near the honey. While they were tempted again to try it, I threw some bits of camphor on the surface. They drew back a little, still keeping the tip of their tongues amongst the honey, and carefully avoided the camphor. One vibrated its wings as it fed, while some were less affected, and others not at all; but when I covered the honey entirely with camphor, they all instantly flew away. I had this card carried to my hives, while some honey was put on another clean one within reach of the bees. The latter was soon discovered, and the honey consumed in a few minutes; but an hour elapsed before a single bee came near the camphorated card, when, at length, two ventured to alight on it, and thrust their tongues into the edge of a drop of honey. Others followed, and two hours after it was covered with them, and all the honey consumed, the camphor alone remaining, whence it was proved, that the attraction of honey overcomes their repugnance to the smell of camphor*."

Huber also tried the effect of alcohol upon bees shut up in a close vessel. Having allowed a small glass of spirits of wine to evaporate under a receiver, he placed in it a bee that had just been satiated with honey. It endeavoured to escape, and vibrated its wings incessantly for an hour, when a continued tremor of the limbs, the wings, and the sucker became perceptible, and, at length, unable to stand, it lay down on its back, and began to use its wings like oars or feet, at the same time disgorging all the honey it had previously swallowed. Window

* Huber on Bees, p. 267.

flies and wood-lice (*Onisci*) were destroyed by the same vapour, but it did not seem to affect a large spider.

We shall only mention the effect of the odour of one other substance on bees, namely, their own poison, which Huber was curious to ascertain. The sting of one was accordingly extracted, and presented to some workers before the entrance of a hive. Although they had previously been quiet and tranquil, they became all at once much agitated. None flew away, but two or three darted against the sting, and one furiously assailed the experimenters. That it was the odour of the sting-poison alone which produced these violent emotions, was obvious from their appearing insensible of its presence when it lost its scent by drying. In another instance, bees were confined in a glass tube and irritated with an awn of barley, till they protruded their stings and left some poison on the sides of the glass. The mouth of the tube was then presented to a group of bees at the entrance of a hive, and it soon produced the agitation of rage obviously unaccompanied with fear *.

* Huber, p. 269.

Chapter IV.

HEARING IN INSECTS.

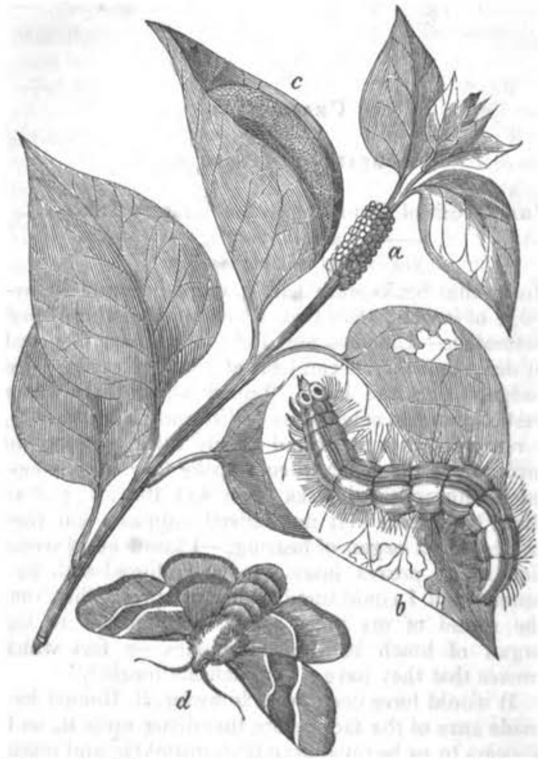
The speech of Mamilius, in the Winter's Tale,—

——— I will tell it softly,
Yon crickets shall not hear it *,

shows that Shakspeare had a more accurate knowledge of insects, than two of our most distinguished naturalists—Linnæus and Bonnet, who are disposed to deny that insects can hear at all. "Passing by a hedge," says the latter, "upon which there was a nest of common caterpillars (*Clisiocampa neustria?*), I remarked that the sound of my voice appeared to incommode them, for when I spoke they briskly agitated with repeated jerks (*reprises*) the fore-part of their bodies. I did not indeed suppose that they possessed an organ of hearing,—I know no observation which proves insects to be endowed with this sense,—but I conjectured with more probability, that the sound of my voice was communicated to the organ of touch in the caterpillars,—a fact which proves that they have a very delicate touch †."

It would have been well, however, if Bonnet had made sure of the fact before theorizing upon it, as it appears to us he must have been mistaken, and might have seen the lackeys jerking themselves in the same way, altogether independent of the sound of his voice. We have repeatedly watched by the hour these caterpillars repeating the jerks in question, when it could

* Winter's Tale, Act ii., Sc. 1.
† Bonnet, Œuvres, ii. 36.



Lackey moth (*Clisiocampa neustria*), in all its stages. *a*, spiral chain of eggs; *b*, larva; *c*, pupa, in a cocoon; *d*, moth.

not possibly be in consequence of any sound. It seemed more for the purpose of producing a rent in the skin near the head *, as it was more remarkable

* See Insect Transformations, p. 169.

just before their moulting than at any other time*. This also, as it happens, was the very period when Bonnet made his observation, as he expressly says, "some of them had undergone, and others were about to undergo their first moult."

Bonnet imagined, however, that he had proved his opinion by a similar experiment upon caterpillars of another species, which also live in society a part of their lives. "While they were exposed," he says, "to a burning sun, and ran quickly from one side to another, I bethought myself of ringing a small bell at a very short distance from the nest: some of them stopt instantly and briskly agitated the fore-part of their bodies, as if they felt the sound of the bell disagreeable†." It is unfortunate that, from Bonnet's inattention to system, we cannot tell the species of the caterpillars on which the experiment was tried; but we have repeated it in a number of cases, both with social and solitary caterpillars, without being able to verify his observations. At the time of writing this, we tried the effect of a great variety of sounds upon a nest of the brown-tail moth (*Porthesia auriflua*)—most probably Bonnet's species—soon after their first moult, but we were unable either in the sun or the shade to produce any effect upon them by sounds; and several full-grown caterpillars of the fox-moth (*Lasiocampa Rubi*, SCHRANK) in a box beside them appeared equally insensible.

We are thus inclined to explain Bonnet's second experiment as we did the first, though his own account is not improbable; for all caterpillars are rather sensitive, and jerk themselves when touched, particularly should any of their companions come upon them. In most cases the jerk succeeds in driving away the intruder; but in the cannibal species it only serves as a cause of irritation which leads them to plunge

* J. R. † Œuvres, ii. 37.

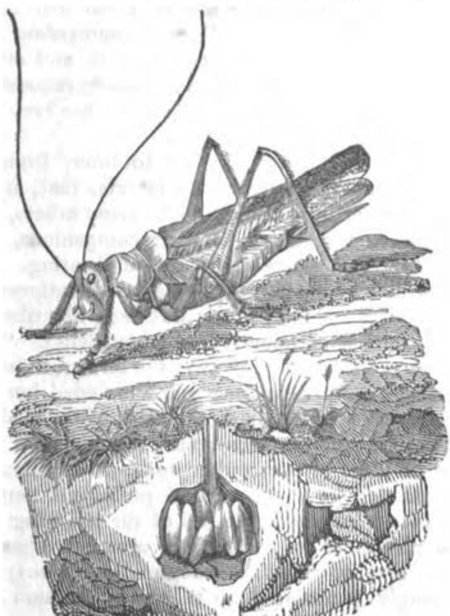
Fox-moth (*Lasiocampa rubi*), and caterpillar.

their mandibles into the offender's body. We have had a brood of the caterpillars of the cinnabar moth (*Callimorpha Jacobææ*, STEPHENS), which, notwithstanding their jerking and writhing, devoured one another, till only one out of ten remained *.

To return to Shakspeare's cricket, it is well known to every boy that the field one, of a fine green colour (*Acrida viridissima*), which during the summer

* J. R.

months is by no means sparing of its stridulous music, instantly ceases to crink the moment it hears a foot fall; and hence it is not easy to discover the spot where it is, unless it be approached in the most cautious manner, for it is silent if a person approach within several yards of it. Brunelli, an Italian naturalist, tried some experiments upon this insect, more satisfactory than the preceding ones of Bonnet. He kept several in a chamber, which continued their crinking song through the whole day; but the instant they heard a knock at the door, they were silent.



Green field-cricket (*Acrida viridissima*), with its nest and eggs.

He subsequently invented a method of imitating their sounds, and when he did so outside the door, at first a few would venture upon a soft whisper, and by and bye the whole party burst out in chorus to answer him; but upon repeating the rap at the door, they instantly stopped again as if alarmed. He likewise confined a male in one side of his garden, while he put a female in the other at liberty, which began to leap as soon as she heard the crink of the male, and immediately came to him, an experiment which he frequently repeated with the same result *. It is remarkable that the males alone of these insects are musical; for "the females," as Swammerdam long ago observed, "of locusts, grasshoppers, and others, make no noise †." We may in passing request our readers to remark, that Brunelli's insect has very long antennæ.

It seems to be not illogical to infer, from the variety of sounds produced by insects, that, in the instance in question, as well as in many others, they are intended for signals to their companions, who, of course, must possess organs of hearing. The drum or instrument by which the last-mentioned insect produces its loud music has been described by De Geer, and subsequently by Lichtenstein ‡. "Our male green field-hoppers," says the former, "in that part of the right wing case which is folded horizontally over the trunk, have a round plate, made of very fine transparent membrane, resembling a little mirror or piece of talc, and as tense as a drum. It is surrounded by a strong and prominent nervure, but is concealed under the fold of the left wing case, where also there are strong nervures corresponding to what may be called the hoop of the drum. It is exceedingly probable that the quick motion with

* Comment. Instit. Bonon. vii. 199, &c., apud Lehmann.
† Biblia Naturæ, i. 217. ‡ Linn. Trans. iv. 51.

which the insect rubs these nervures against each other, produces a vibration in the membrane, whence the sound is augmented*." By alternating the motion rapidly from right to left, the sound is produced in an almost continued strain, as we have remarked in those we have kept in our study†; while in the crickets, who alternate the motion more slowly, the sound is emitted at interrupted intervals,—a remark which any person may readily verify.

The grasshoppers and locusts (*Locustidæ*) produce their chirp by applying the hind shank to the thigh, rubbing it smartly against the wing-case, and alternating the right and left legs. They have also a drum like the preceding family (*Gryllidæ*) for augmenting the sound. "On each side," says De Geer, "of the first segment of the abdomen, immediately above the origin of the hind thighs, there is a large deep opening, somewhat oval in form, and partly closed by an irregular flat plate or lid, of a hard substance, but covered by a flexible, wrinkled

A

B

Drum of the grasshopper.

A, Part of the first ring of the abdomen, greatly magnified. *a*, Deep cavity, partially covered by the plate *b*.

B, The cavity with the parts as they appear when the plate *b* is removed. *c*, White membrane, stretched across the bottom of the cavity. *d*, Oval hole.

* De Geer, Mémoires, iii. 429. † J. R.

membrane. The opening left by the lid is in form of a half-moon, and at the bottom of the cavity is a white membrane, shining like a mirror, and tensely stretched. On the side of the opening, towards the head, there is a small oval hole, into which the point of a pin may easily pass; and when the membrane is removed a large cavity is brought into view. The whole of this apparatus seems to contribute much both to produce and to increase the sound caused by the insects *."

We have examined the hole mentioned by De Geer in a number of individuals, and have been struck with its resemblance to the hole in a military drum, as well as in violins and guitars. We found, indeed, upon stopping up this hole with a bit of wafer, that the insect could no longer produce its peculiar sound, but only a sort of muffled scraping †. Swammerdam was acquainted with this instrument, though he does not mention the hole. "The grasshopper," he says, "has two peculiar small drums, like the drum of our ear, which being struck by the help of two lunulated cartilages, vibrate the air in such a manner as to produce the sound ‡."

The crickets (*Achetidæ*, Leach), another family of this order of insects, are well known for their chirping-song, which, associated as it is either with the snug chimney-corner or the sunshine of summer, affords a pleasure which certainly does not arise from the intrinsic quality of its music. "Sounds," it is well observed by White, "do not always give us pleasure according to their sweetness and melody; nor do harsh sounds always displease. Thus the shrilling of the field-cricket (*Acheta campestris*, Fabr.), though sharp and stridulous, yet marvellously delights some hearers, filling their minds with a train

* De Geer, Mémoires, iii. 471.
† J. R.
‡ Biblia Naturæ, ii. 217.

of summer ideas of every thing that is rural, verdurous, and joyous *."

> "Sounds inharmonious in themselves and harsh,
> Yet heard in scenes where peace for ever reigns,
> And only there, please highly for their sake."
>
> COWPER, *Task*, book i.

This circumstance, no doubt, causes the Spaniards to keep them in cages, as we do singing-birds. White tells us, that, if supplied with moistened green leaves, they will sing as merrily and loud in a paper cage as in the fields; but he did not succeed in planting a colony of them in the terrace of his garden, though he bored holes for them in the turf to save them the labour of digging.

Swammerdam entertained a different notion of their music. "I remember," says he, "that I once saw a whole field full of these singing crickets, each of which had dug itself a hole in the earth two fingers deep, and then, sitting at the entrance thereof, they made a very disagreeable noise with the creaking and tremulous motion of their wings: when they heard any noise they immediately retired with fright into their little caverns †."

The hearth-cricket (*Acheta domestica*), again, though we hear it occasionally in the hedge-banks in summer, prefers the warmth of an oven or a good fire, and thence, residing as it were always in the torrid zone, is ever alert and merry, a good Christmas fire being to it what the heats of the dog-days are to others. Though crickets are frequently heard by day, yet their natural time of motion is only in the night. As soon as it becomes dark, the chirping increases, and they come running forth, and are often to be seen in great numbers, from the size of a flea to that of their full stature. Like the field-

* Nat. Hist. of Selborne, ii. 73.

† Biblia Naturæ, i. 95.

cricket, they are sometimes kept for their music; and the learned Scaliger took so great a fancy to their song that he was accustomed to keep them in a box in his study. It is reported that in some parts of Africa they are kept and fed in a kind of iron oven, and sold to the natives, who like their chirp, and think it is a good soporific *. Milton chose for his contemplative pleasures a spot where crickets resorted:—

> "Where glowing embers through the room
> Teach light to counterfeit a gloom,
> Far from all resort of mirth,
> Save the cricket on the hearth."—*Il Penseroso.*

We have been as unsuccessful in transplanting the hearth-cricket as White was with the field-crickets. In two different houses we have repeatedly introduced crickets, but could not prevail on them to stay. One of our trials, indeed, was made in summer, with insects brought from a garden wall, and it is probable they thought the kitchen fireside too hot at that season †.

The instrument upon which the male cricket plays (for the female is mute) consists, as in the preceding case, of strong nervures or rough strings in the wing-cases, by the friction of which against each other a sound is produced and communicated to the membranes stretched between them, in the same way that the vibrations caused by the friction of the finger upon the tambourine are diffused over its surface. We deem this explanation the more necessary, as it is erroneously stated in a popular work, "That the organ is a membrane, which in contracting, by means of a muscle and tendon placed under the wings of the insect, folds down somewhat like a fan;" and this being "always dry, yields by its motion a sharp piercing sound ‡."

* Mouffet, Theatrum Insect. 136. † J. R.

‡ Bingley, Anim. Biog. iv. 54; 6th ed.

Insects of a very different order (*Homoptera*, LEACH), but which our translators have confounded with the grasshoppers, have been famous for their singing from the earliest antiquity. We allude to the insects which we have called tree-hoppers (*Cicadæ*), so remarkable for the instrument with which they cut grooves in wood for depositing their eggs *.

Under side of the cicada.

Drum of the cicada.

a a, The outer drums; *b*, the muscular strings; *c c*, the inner drums.

Their musical organ is no less interesting, as it has been described by Réaumur, whose account we shall follow. It is only the male tree-hopper which is musical, and for this purpose he is furnished with a pair of drums, one on each side, consisting of two large plates, oval or circular in some, and triangular in other species, fixed to the trunk between the belly and the hind legs. When this exterior membrane

* See Insect Architecture, p. 150.

is raised, a cavity is brought into view, part of which seems to open into the belly, and another part to be covered with a second membrane, much more delicate than the exterior one, tensely stretched, and iridescent, and in the middle there is a horny plate, placed horizontally along the bottom. All this, however, seems only a secondary portion of the instrument; for the sound is in the first instance produced by a bundle of muscular strings, which are attached at one extremity to another membrane in the interior, obviously the true drum; for when Réaumur pulled the strings and let them go again, the sound was produced even after the insect had been a long while dead. These muscles, indeed, are so attached to the under concave surface of the drum, that when they pull it downwards and let it jerk quickly back again, a vibration is produced; the sound issues through an opening contrived on purpose, like the opening in our own larynx, or the sound-hole in a violin*.

As in the case of the field cricket, very different opinions appear to have been held of the music of the celebrated tettix (Τεττιξ) of the Grecian poets. "In the hotter months of summer," says Dr. Shaw, "especially from midday to the middle of the afternoon, the cicada, tettix, or grasshopper (as we falsely translate it), is perpetually stunning our ears with its most excessively shrill and ungrateful noise. It is in this respect the most troublesome and impertinent of insects, perching upon a twig, and squalling sometimes two or three hours without ceasing, thereby too ofteo disturbing the studies or short repose that is frequently indulged in these hot climates at those hours. The tettix of the Greeks must have had a quite different voice, more soft, surely, and melodious, otherwise the fine orators of Homer, who are com-

* Réaumur, Mem. v. 178.

pared to it, can be compared to nothing better than loud loquacious scolds*." Dr. Shaw appears to forget that a loud clear voice was one of the highest excellences of a warlike orator in addressing a body of troops in the open air, and that Virgil seems to be much of the same opinion with himself as to their musical powers†, which Sir J. E. Smith calls a most disagreeable dull chirping‡.

One would suppose from this, that instead of the tuneful cicada, celebrated by the Greek poets, our authors were referring to another family (*Fulgoridæ*), who appear, however, to sing by night rather than by day, such as the great lantern-fly (*Fulgora lanternaria*, LINN.), which makes a noise somewhat between the grating of a razor-grinder and the clang of cymbals, so loud also that it is called *scare-sleep*, by the Dutch, in Guiana§. It is probably the same or a similar species which Ligon tells us makes a great noise in the night at Barbadoes. They "lie," he says, "all day in holes and hollow trees, and as soon as the sun is down begin their tunes, which are neither singing nor crying, but the shrillest voices I ever heard: nothing can be so nearly resembled to it as the mouths of a pack of small beagles at a distance." This author, however, thought this sound by no means unpleasant. "So lively and chirping," he continues, "the noise is, as nothing can be more delightful to the ears, if there were not too much of it, for the music hath no intermission till morning, and then all is hushed||." Possibly he may allude to another insect (*Tettigonia septendecim*), which is said to visit Philadelphia, in the month of May, every seventeen years, in numbers almost incredible, and makes so loud a noise that

* Travels in Barbary, p. 186.
† Georgics, iii. 328. ‡ Tour on the Continent, iii. 95.
§ Stedman, Surinam, ii. 37. || History of Barbadoes, p. 65.

people are stated not to be able to hear each other speak*.

In the latter case recourse might be had to a remedy, recorded by Ledelius to have been effectual in the case of crickets. A woman, who disliked their music, and had in vain tried to banish or silence them, at length succeeded by accident. Having one day invited several guests to her house to celebrate a wedding, she procured a band of music, with drums and trumpets, to entertain the company. This music was so much greater than the crickets had been used to or could imitate, that they instantly took to flight, and were never afterwards heard in the house†.

That the real cicadæ are very noisy, however, there can be no doubt, from the testimonies above quoted: besides, Smeathman, who has given so interesting a history of the white ants, says that a cicada may be heard to the distance of half a mile, and that the singing of one in a room will immediately silence a whole company‡; and the Swedish naturalist, Thunberg, tells us that a Javanese species makes a noise as shrill and piercing as if it proceeded from a trumpet§. Yet there cannot be a doubt that these loud songsters were the *tettiges* of the Greeks, and were placed upon a harp as the emblem of music, because, as Mouffet gives the legend, when two rival musicians (Eumonius and Ariston) were competing upon the harp, a *tettix*, flying to the former, and sitting upon his harp, supplied the place of a broken string, and so secured to him the victory‖. Madam Merian says that the music of another species (*Tettigonia tibicen*) is thought to resemble the sound of the harp so nearly, that the Dutch actually call it the harper.

* Stoll, Cigales, p. 26.
† Goldsmith, Animated Nature, iv. 238.
‡ Bingley, Anim. Biogr. iv. 64.
§ Travels, iv. 201.
‖ Theat. Insect.

Amidst all this variety of conflicting opinions, we need the less wonder that the Grecian poets should praise the music of the cicada, and imagine it to feed on dew, and live in perpetual youth,—fictions, however, altogether poetical and visionary; for, like the rest of this order, it feeds on herbage and leaves, and so far from being long-lived, it does not, we believe, survive its arrival at maturity more than a week or two.

The preceding are the most celebrated of our insect musicians, but there are numerous others, which, though less celebrated, are not unworthy of notice, and frequently attract the notice of the most incurious:

> "Nor undelightful is the ceaseless hum,
> To him who muses through the woods at noon,
> Or drowsy shepherd as he lies reclined."
>
> THOMSON.

Yet none of these sounds appear to proceed from the same organs as the voice in larger animals, from the throat and mouth; for the buz of flies, the hum of bees, the drone of beetles, and the ominous click of the death-watch, are all produced, as we have already explained, (together with the sounds of the cricket and the cicada,) by the wings or other organs beating or fretting on some vibratory substance. It may prove interesting to mention a few of the more curious facts connected with this subject.

In the case of bees, Swammerdam correctly remarks that none of their air-tubes open into the mouth; and even if they did, or should air be impelled thither out of the stomach, the narrowness of the tube is ill fitted to produce sound. Their humming, therefore, he thinks proceeds from the wings alone, particularly the small membranous wings at the shoulder, when played upon by air propelled from the subjacent air-tubes or spiracles*. In another

* Biblia Naturæ, i. 217.

place he says, " Bees make a noise by the motion of their wings, which is increased by the internal air propelled out of their bodies through the air-tubes at the same time; for some of these pipes open with wide apertures under the wings. Certain cavities, also, fit for receiving and vibrating the air, and formed under and between the wings, contribute to this. Nor must the shoulder-blades be excluded from their share in this music, since they are placed just above the wings, joined to the chest, and having under their breadth the openings of several air-pipes. It is thus the motion of the wings, with the assistance of all these parts, and by force of the propelled air, makes the humming noise peculiar to that insect *." M. Chabrier has in part adopted this opinion as to the effect of the air †.

Réaumur observed that the various sounds of bees, whether more or less grave or shrill, are produced by the wings beating more or less rapidly against the air, according also, it may be, to the different angles at which it is struck ‡. The latter observation reminds us of the toy called the *hummer* (in Scotland a *Whunner-spale*), which produces a sound nearly resembling the hum of a bee, though rather deeper, and more loud. It consists of a thin piece of deal, about six inches by two, deeply notched all round the edge, to one end of which a string is tied for the purpose of whirling it rapidly round, as is done in slinging, when the sonnd alluded to is produced. But it is indispensable that it have two motions,—one round the boy who whirls it, and another round its own axis; in the same way as we presume the vertical vibration of the bees' wings, combined with its passage through the air, may cause the hum.

Réaumur expressly says, that a bee whose wings

* Biblia Naturæ, i. 168.

† Essai sur le Vol des Insectes.

‡ Mémoires, p. 617.

are eradicated is perfectly mute; but John Hunter affirms, that though the wings be cut off and the legs held fast, they can still emit a shrill, peevish sound, as they can also do when their wings are smeared over with honey, and even when they are held under water, which he observed to vibrate at the point of contact with the air-holes at the root of the wings*. A French naturalist infers from Hunter's experiments, that the hum is rather caused by a tremulous affection of the entire body, than by the strong vibration of the upper wings†. That it is not the wings alone which produce the sound is proved by the well-known fact, that many insects of the same order fly silently‡.

White, of Selborne, observed a sound like that of bees, for which he could not account. "There is," he tells us, "a natural occurrence to be met with in the highest part of our down, on the hot summer days, which always amuses me much, without giving me any satisfaction as to the cause of it; and that is a loud audible humming of bees in the air, though not one insect is to be seen. Any person would suppose that a large swarm of bees was in motion and playing about over his head§." We have frequently observed this humming in the neighbourhood of London, in Copenhagen Fields, on Hampstead Heath, and at Shooters' Hill, and for some time were as much puzzled to explain it as White; till we, on several occasions, remarked a troop of swallows busily hawking high overhead where the humming was heard. There could be no doubt, therefore, that it was occasioned by insects, invisible to us in consequence of their distance. In another instance, we could plainly see numbers of bees passing and repassing at a very considerable height, in their way to and from some blossomed lime-trees, as we supposed,

* Phil. Trans. for 1792. † Dict. des Sciences Naturelles.
‡ Kirby and Spence, Intr. ii. 379. § Nat. Hist. ii.

which were at a good distance from the spot where we stood,—the primary cause, perhaps, of their flying high *.

"That purely rural, little noticed, and, indeed, local occurrence," says Mr. Knapp, "called by the country people 'hummings in the air,' is annually heard in one or two fields near my dwelling. About the middle of the day, perhaps from twelve o'clock till two, on a few calm, sultry days in July, we occasionally hear, when in particular places, the humming of apparently a large swarm of bees. It is generally in some spacious open spot that this murmuring first arrests our attention. As we move onward the sound becomes fainter, and by degrees is no longer audible. That this sound proceeds from a collection of bees, or some such insects, high in the air, there can be no doubt; yet the musicians are invisible. At these times, a solitary insect or so may be observed here and there, occupied in its usual employ, but this straggler takes no part in our aërial orchestra †."

The buz of flies has been found no less difficult to explain than the hum of bees. That it is not produced by the wings alone striking upon the air, is proved from the fact of many insects of rapid flight, such as the dragon flies (*Libellulina*) and the crane flies (*Tipulidæ*), flying silently. Some flies, again, are able to produce a loud buz when not on the wing. Of this, an instance has recently occurred to us in the wasp fly (*Chrysotoxum fasciolatum*, Meigen), which had got into our study, and kept up its peculiar buz when resting, apparently motionless, on the window-frame; yet, when we observed it minutely, there was still a perceptible vibratory tremor in the wings, similar to that of a harp-string, but so rapid as at first to escape the eye. The same buz

* J. R.

† Journ. of a Naturalist, p. 376, 3d edit.

Wasp fly (*Chrysotoxum fasciolatum*).

was continued when we held the insect by the feet; but, on placing a slip of card loosely over the wings, it became so muffled as to be almost imperceptible, and, on laying hold of the wings, it ceased altogether. From all we could observe respecting this sound, it appeared that it could not be referred simply to any muscular movement, but must have arisen either from air playing on the membranous edges of the wings at their origin, as in the case of an Eolian harp-string, or by the stroke or friction of some internal organ upon the roots of the nervures*.

Latreille seems to have overlooked the vibrating tremor to which we have alluded, when he contends that the noise of flies on the wing cannot be the result of friction, because the wings are then expanded†. But, even if the tremor were invisible to the eye, we should not be authorized to conclude that it was not produced; for the ingenious experiments devised by Dr. Chladni, of Berlin, and recently extended by M. Savart, distinctly exhibit the existence of vibrations in metallic plates when their edges are played upon by a violin bow, in the curious forms into which sand spread on the plates arranges itself; though otherwise these vibrations are for the most part imperceptible. We may also refer to Dr. Wollaston's

* J. R. † Hist. Génér. des Insectes.

remarks on inaudible sounds, to which we shall afterwards advert.

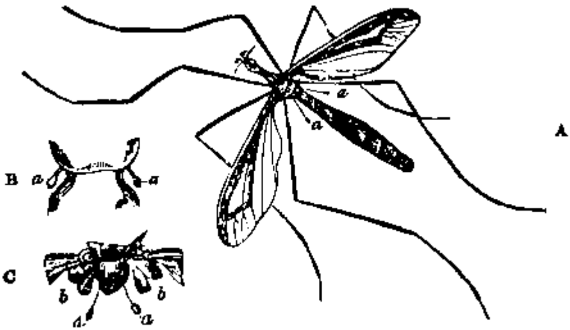
In another place, Latreille, in mentioning the singular organs called balancers, or poisers (*halteres*), says, they occupy exactly the situation of the spines in bees and wasps, with spiracles in the same manner situated behind them, whence it is evident that the hinder part of the chest, where the balancers are, corresponds to the part which, in the male cicada and the cricket, contains the organs of sound*. From the form of these balancers, as they have been called, being much like a drum-stick, we might be led to suppose them to be the very instrument employed to produce the sound; but, as they have been viewed in a different light, it may be proper to take notice of it. Derham, accordingly, thinks that both these and the winglets (*alulæ*) in two-winged flies (*Diptera*), are for rendering the flight more steady. "If one of the poisers," he says, "or one of the lesser auxiliary wings be cut off, the insect will fly as if one side overbalanced the other, until it falleth on the ground; so if both be cut off they will fly awkwardly and unsteadily, manifesting the defect of some very necessary part. The use, no doubt, of these poisers, and secondary lesser wings, is to poise the body, and to obviate all the vacillations thereof in flight, serving to the insect, as the long pole, laden at the ends with lead, does to the rope-dancer†." Schelver, however, found that any mutilation of either one or all of the winglets, or the poisers, in a crane-fly (*Tipula crocata*) prevented it from flying at all, and he conjectures that the poisers are air-holders‡.

Schelver, however, found that a fly continued to buz when the poisers were cut off,—an experiment he

* Règne Animal, v. 429, Note, ed. 1829.

† Physico Theology, ii. 169, Note (i).

‡ Wiedemann, Archiv. ii. 210.



A Father long-legs (*Pedicia rivosa*): *a a*, the poisers. B, The poisers, *a a*, separate. C, the poisers, *a a*, and the winglets, *b b*. From De Geer.

often repeated with the same result; but when he mutilated or removed either one or both winglets, the buzzing ceased*.

De Geer, upon examination of one of the wasp-flies (*Syrphidæ*), satisfied himself that the buzzing was produced by the friction of the root or base of the wings against the sides of the hollow in which they are inserted. For this purpose, he took hold of each wing with his fingers and thumb, and stretching them out in opposite directions, to prevent their motion, and at the same time taking care not to hurt the insect, no sound was produced. Not contented with this, he cut off both wings of a syrphus very near their roots; but this did not prevent it from buzzing any more than the excision of both the poisers and the winglets, for, on examining the parts with a microscope, he perceived that the remaining roots of the wings continued to vibrate, and the buzzing to go on, nor did it cease till he completely eradicated the wings†.

* Wiedemann, Archiv., ii. 210—17. † Mémoires, vi., 13.

In the spirit of banter, Aristophanes makes Chærephon ask Socrates whether gnats buz with their mouth or their tail*. Mouffet pronounces that the sound comes from the mouth, because the sound is louder when they approach than when they retire†. "After all," says Kirby, "the friction of the base of the wings against the chest (*thorax*) seems to be the sole cause of the alarming buz of the gnat, as well as of the other two-winged flies (*Diptera*)." This explanation however seems not to accord well with Mr. Kirby's additional remark, that gnats do not always hum when they fly; for he ought to be prepared to show that the wings do not rub on the thorax when they are silent. "I have observed," says he, "that, early in the spring, before their thirst for blood seizes them, gnats when flying emit no sound. At this moment (February 18th) two females are flying about my windows in perfect silence. The warmer the weather the greater is their thirst for blood, the more forcible their flight, the motion of their wings more rapid, and the sound produced by that motion more intense. In the night—but perhaps this may arise from the universal stillness that then reigns—their hum appears louder than in the day: whence its tones may seem modified by the will of the animal‡." There can be no doubt of the fact that gnats sometimes fly in silence, however it may be explained: we have observed that in a house where the hum of gnats was not a little annoying in August, we could not hear one in the end of September, though we listened carefully to every individual which we saw on the wing§. The "jarring hum" (*asper, acerba sonans*), as Virgil expresses it, of the gad-fly is no less annoying to cattle than that of the gnat and the

* Nubes. † Theatrum Insectorum, 87.
‡ Intr. ii., 383. § J. R.

mosquito (*Culex* ——) is to us, but probably for a different reason *.

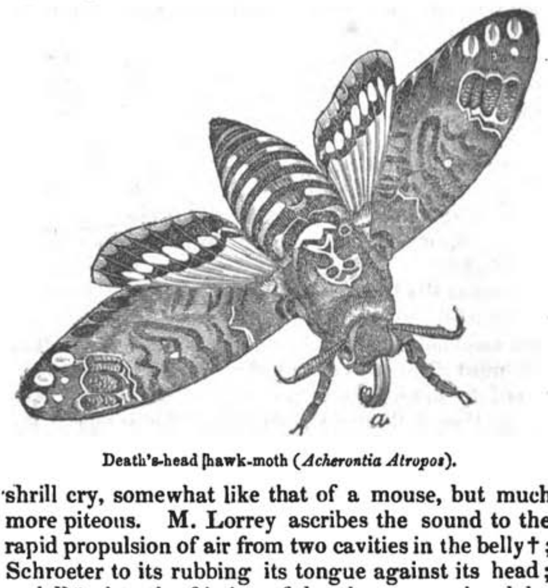
The drone of the dung-beetle (*Geotrupes stercorarius*), on the other hand, is, like the hum of the industrious bee, rather pleasant than disagreeable, from its being associated with the still twilight of a summer's evening; though Linnæus was certainly wrong in thinking it an indication of fine weather. It is probably occasioned by the friction of the wing-cases upon the base of the wings, throwing them into vibratory motion. Though most commonly remarked in this beetle, it is not peculiar to it, for we have observed it, though not quite so loud, in the flight of the musk-beetle (*Cerambyx odoratus*, De Geer) and in the green rose-chafer (*Cetonia aurata*), whose loud humming, as we once noticed in one flying around a wild rose-tree in Epping Forest, made us suppose it to be the violet carpenter-bee (*Xylocopa violacea*), which has not hitherto been found in Britain †.

Most of the larger animals have particular cries expressive of fear, distress, or danger; but we are not well acquainted with these in the insect world. The one most familiar, but not, that we are aware, mentioned by naturalists, is the peculiar buzzing of flies when they fall into the fangs of the spider. We say "peculiar," because it is altogether unlike any sound emitted by flies at any other time. As a fly does not emit this sound when it is accidentally betrayed to venture too far into a honey-pot, nor when it is caught by the hand, it must arise from some instinctive knowledge of the nature of its arch enemy, rather than from the mere circumstance of its being entrapped: yet we have heard flies emit this sound when caught in a spider's web that had

* See Insect Architecture, p. 405. † J. R.

been deserted by the proprietor, as well as when pounced upon by a hunting spider, which spins no web. We have not been able to satisfy ourselves whether or not this sound of distress is produced by the same organ as the common buz in flying*.

One of the most puzzling sounds to the curious in such inquiries, is that emitted by the death's-head moth (*Acherontia Atropos*), when it is caught and kept a prisoner. This is described to be a loud

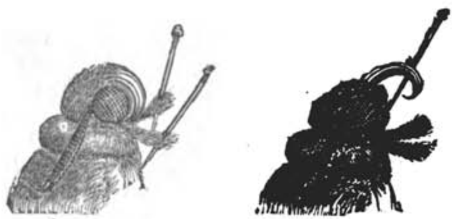


Death's-head hawk-moth (*Acherontia Atropos*).

shrill cry, somewhat like that of a mouse, but much more piteous. M. Lorrey ascribes the sound to the rapid propulsion of air from two cavities in the belly †; Schroeter to its rubbing its tongue against its head; and Rösel to the friction of the chest upon the abdomen. That the wings are not concerned in it, is proved by the cry being uttered when both they and

* J. R. † Latreille, Règne Animal, v. 590.

the body are held firmly down. Réaumur, after many experiments, concludes, that "in the more minute parts of Nature's works there is always something which we cannot explain." It appeared to him most probable that the cry came from the head, perhaps from the mouth, or rather from the tongue, and it might be by friction of the palpi against the tongue; for when he unfolded the spiral tongue with a pin, the cry ceased, but was renewed the instant it was coiled up again between the palpi. He then prevented the palpi from touching the tongue, which also stopt the sound, and when only one was permitted to touch it, the sound was much more feeble*.



Réaumur's experiments on the death's-head hawk-moth. *a*, the tongue unfolded with a pin; *b*, the palpi prevented from touching the tongue.

Huber, without mentioning the particulars, says he has ascertained that Réaumur was quite mistaken †. Engramelle informs us that M. de Johet plucked out the jaws (*maxillæ*) and cut off the palpi of one of these moths, and yet the noise was produced when the wings were agitated. Being thence led to examine the wings, he found two concave scales at their base, which he supposes may be the organs of sound; and when the scales were cut off, the insect, he says, became mute. M. de Johet thinks the sound is produced by the air being

* Mémoires, ii. 293. † On Bees, p. 313, Note.

suddenly propelled against these scales by the action of the wings. M. Lorrey again states that the sound arises from the air escaping rapidly through peculiar cavities communicating with the spiracles, and furnished with a fine tuft of hairs on the sides of the abdomen *. M. Passerini, curator of the Museum of Natural History at Florence, has lately investigated the subject more minutely. He traced the origin of the sound to the interior of the head, in which he discovered a cavity at the passage where muscles are placed for impelling and expelling the air. M. Dumeril has since discovered a sort of membrane stretched over this cavity like, as he says, to the head of a drum. M. Duponchel has also confirmed by experiment the opinions of Passerini and Dumeril, and confutes Lorrey, by stating that the noise is produced from the head when the body of the insect is removed †.

The death's-head moth is not the only insect whose sound alarms the superstitious. Insects, which are much more common, though from their minuteness not so often seen as heard, often strike the uneducated with terror as the messengers of death. We refer to the sound which most of our readers may have heard issuing from old timber or old books, resembling the ticking of a watch, and hence popularly called the *death-watch*. Some writers, who are desirous of being thought very accurate, are particular in distinguishing a certain insect as the genuine death-watch, while others are held to be spurious; yet there can be no doubt that the same sort of ticking is produced by several species. Latreille, indeed, seems to say that it is common to a whole genus (*Anobium*, FABR. ‡); and besides these,

* Stephens's Illustr. (Haust.) i. 116.

† Annales des Sciences Naturelles, Mars., 1828.

‡ Familles Naturelles, i. 484, ed. 1829.

of which Mr. Stephens enumerates ten species found in Britain, we know at least two species of a very different genus (*Atropos*, LEACH), also indigenous, which produce the so much dreaded sound.

Sir Thomas Browne considered the subject of the death-watch of great importance, and remarks that the man "who could eradicate this error from the minds of the people, would save from many a cold sweat the meticulous heads of nurses and grandmothers *," as such persons are firm in the belief, that—

The solemn death-watch clicks the hour of death.

Swift endeavoured to perform this useful task by means of ridicule. His description, suggested, it would appear, by the old song of "A cobbler there was, and he lived in a stall," runs thus :—

———"A wood worm
That lies in old wood, like a hare in her form,
With teeth or with claws, it will bite, it will scratch;
And chambermaids christen this worm a death-watch;
Because, like a watch, it always cries click.
Then woe be to those in the house that are sick!
For, sure as a gun, they will give up the ghost,
If the maggot cries click when it scratches the post.
But a kettle of scalding hot water injected,
Infallibly cures the timber affected:
The omen is broken, the danger is over,
The maggot will die, and the sick will recover †."

It may be well to give a few notices from naturalists who have observed the proceedings of those insects. "I possess," says Swammerdam, "a small beetle, which, having firmly and strongly fixed its foremost legs, and bent and put its head through the space between them, makes a continual noise in

* Vulgar Errors.

† Quoted in Kirby and Spence, Intr. ii. 386.

old pieces of wood, walls, and ceilings, which is sometimes so loud, that, upon hearing it, people have been persuaded that nocturnal hobgoblins, ghosts, or fairies wandered about them. Other species of beetles make a strange noise by rubbing their head against their breast, and others press their tail or belly close to their wing-cases, and by that means also make an uncommon creaking *."

Derham kept a male and a female (*Anobium tesselatum ?*) together in a box for about three weeks, and by imitating their call, he could make them click whenever he pleased. At the end of this time one of them died, and soon afterwards the other gnawed its way out and escaped. Mr. Stackhouse also kept a beetle of this kind in a box, and carefully observed the manner of its beating. According to him, it raises itself on its hind legs, and, with the body somewhat inclined, beats its head with great force and agility against the place on which it stands. One of them, on a sedge-bottomed chair, exerted so much force, that its strokes were impressed and visible in the exterior coat of the sedge, for a space equal to that of a silver penny.

M. Geoffroy supposes the noise to be caused by the insects striking the wood in order to make holes to lodge in†; but M. Olivier, having heard the sound come from the interior of the wood, thinks it must be produced by the grub rather than the perfect insect, because the beetle has not sufficiently strong mandibles, like the grub, for gnawing; and besides, it does not require to enter again after it goes out, since it does not lay its eggs in holes, but in cracks and crevices‡. M. Tigny again, though he does not impugn Olivier's accuracy, says, that the perfect insects *can* produce the sound, "for we

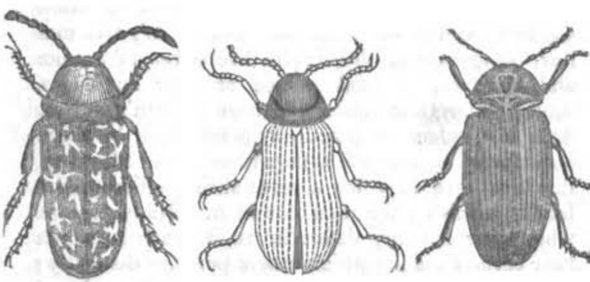
* Hill's Swammerdam, i. 125.

† Faune Parisienne. ‡ Coleopteres.

have several times surprised the Savoyard beetle (*Anobium tesselatum*, FABR.) beating with redoubled strokes with its head upon the ceiling*." He pretends not to decide whether it was to knock out a cavity for its eggs, or a call to its mate.

Latreille says, the male and the female (*Anobia*), at the period of pairing, strike many times successively and rapidly with their mandibles the wainscot where they are placed, and mutually answer each other's signal, and such is the cause of the ominous ticking†. He observed an instance of this in the striated timber beetle (*Anobium striatum*), which, upon striking with its mandibles on the outside of a pile of wood, was answered from within.

We have ourselves observed the clicking made by a beetle (*Anobium pertinax*), more common, perhaps,



Several species of death-watch beetles greatly magnified. *a, Anobium tesselatum. b, Anobium striatum, c, Anobium pertinax.*

than the preceding, in the holes of old wood, and have heard it more frequently in the night than the day. It moves its head up and down like a pendulum when it clicks, but we could not be certain whether

* Hist. Nat. des Insectes, iii. 123, ed. 1830.

† Règne Animal, iv. 484, ed. 1829.

we saw it strike the wood. In the case of the timber-louse (*Atropos pulsatorius*, STEPHENS), the insect certainly strikes the object; for in consequence of the softness of its body, it could not otherwise produce the clicking, which is much quicker, and not so loud as that of the beetles. We have even distinguished this sound to be much less perceptible when the insect was, as it often is, in a collection of dried plants than when on an old book or a drawer*.

These are only a few of the more remarkable sounds produced by insects; but it is highly probable, as we have already hinted, that these tiny creatures emit many sounds altogether imperceptible to us,—an opinion which is strikingly corroborated by the experiments of Wollaston. It is well known that persons affected with slight deafness hear sharp sounds much better than those which are grave and low, being able to distinguish the voices of women and children, in consequence of their acuteness, much better than the lower tones of men's voices. This fact, indeed, is practically acted upon by those accustomed to converse with persons hard of hearing, in which case they use a more shrill, rather than a louder tone of voice than common. Many persons who never felt any defect in their hearing cannot hear certain sounds which others perceive distinctly; and this partial deafness may be artificially produced by shutting the mouth and nose, and then exhausting the air in the Eustachian tube by expanding the chest in a forcible attempt to take breath. When this is done so that the exhaustion of the air behind the drum of the ear is as complete as possible, the external air is felt strongly and even painfully pressing on the drum, in which case the ear becomes insensible to low sounds, though shrill sounds are

* J. R.

as readily perceived as before. After the ear is brought into this state it will remain so for some time, without continuing the painful effort to take breath, for, by suddenly discontinuing the effort, the end of the tube will close like a valve, and prevent the air from getting into the drum. The act of swallowing, however, will open the closed tube, and restore the ear to its wonted feeling.

While the ear is exhausted of its internal air, if we attempt to listen to the sound of a carriage passing in the street, the rumbling noise cannot be heard, though the rattle of a chain or a loose screw remains as easily heard as before. At a concert the experiment has a singular effect. As none of the sharper sounds are lost, and the great mass of the louder sounds are suppressed, the shriller ones are consequently so much the more distinctly heard, even to the rattling of the keys of a bad instrument, or the scraping of cat-gut unskilfully touched. In the natural healthy state of the ear, there does not seem to be any strict limit to our power of perceiving grave sounds; but if, on the contrary, we turn our attention to the other extremity of the scale, and with a series of pipes, exceeding each other in sharpness, we examine the effects of them in succession, upon the ears of any considerable number of persons, we shall find a very distinct and striking difference between the hearing of different individuals, whose ears are in other respects perfect. The suddenness of the transition from perfect hearing to total want of perception, occasions a degree of surprise, which renders an experiment, with a series of small pipes, among several persons, rather amusing. Those who enjoy a temporary triumph, from hearing notes inaudible to others, are often compelled, in their turn, to acknowledge to how short a distance their superiority extends. Dr. Wollaston accordingly found that one of his friends was quite insensible to the sound of a small organ-pipe, which was far within the limits of his own hearing. He also remembers a female relation to have said that she never could hear the crink of the hedge-cricket. Two ladies of his acquaintance told him that their father could never hear the chirping of the house-sparrow, and this is the lowest limit to acute hearing which he met with, and he supposes it to be very uncommon; deafness, even to the sound of the house-cricket, is not usual, while it is by no means rare to find people who are insensible to the shrill squeak of the bat.

The range of human hearing comprised between the lowest notes of the organ, and the highest *known* sound of insects, includes more than nine octaves, the whole of which are distinctly perceptible by most ears. But "since there is nothing," Dr. Wollaston concludes, "in the constitution of the atmosphere to prevent vibrations much more frequent than any of which we are conscious, we may imagine that animals like the crickets (*Grylli*), whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist; and that there may be other insects, hearing nothing in common with us, but endowed with a power of exciting, and a sense that perceives, vibrations indeed of the same nature as those which constitute our ordinary sounds, but so remote, that the animals who perceive them may be said to possess another sense, agreeing with our own solely in the medium by which it is excited, and possibly wholly unaffected by the slower vibrations of which we are sensible *."

* Dr. Wollaston in Phil. Trans. for 1820, p. 314.

ORGAN OF HEARING IN INSECTS.

LEAVING insects for a moment out of consideration, we find a much greater difference in the form and structure of the ears, than of the eyes, of other animals. The eyes are always placed in nearly the same part of the head, and consist of a transparent portion more or less complicated, and a nervous expansion for receiving the visual image. This uniformity, however, does not hold in the case of ears, for though their situation is as constantly the same as the eyes, their form is exceedingly varied. The opening of the ear, for example, is admirably contrived. "In the owl that perches on a tree," to use the words of Grew, "and hearkens after the prey beneath her, it is produced farther out above than it is below, for the better reception of the least sound. But in a fox, that scouteth underneath the prey at roost, it is for the same reason produced farther out below. In the polecat, which hearkens straight forward, it is produced behind, for the taking of a forward sound. Whereas in a hare, which is very quick of hearing, and thinks of nothing but being pursued, it is supplied with a bony tube, which as a natural otocoustick (*ear-trumpet*) is so directed backward, as to receive the smallest and most distant sound that comes behind her*." The outer ears also of hounds, swine, and other animals designed to hear low sounds, are either pendulous or moveable, to compensate for their difficulty of moving the head; for were their ears not so constructed, hogs while eagerly digging for roots, and hounds when keenly pursuing their game by the scent, might fall into danger, which their hanging ears readily intimate by catching the lowest sounds that float along the ground.

* Cosmologia Sacra, i. 5.

In insects again, to come directly to our subject, the eyes, as we shall see in the next chapter, are varied infinitely more than in the larger animals, both in structure, number, and position, and this we think affords a fair presumption that the ears may exhibit a corresponding variety. But it will be objected, we foresee, that the ears of insects have never been discovered, or at least that no two observers are agreed about what they consider the organs of hearing in insects. We should answer that this is one of the arguments which tends to corroborate our position. The opinion that the antennæ are the organs in question, appears to correspond most nearly with our preceding remarks, and though rejected by many distinguished naturalists, it is maintained by others inferior to none in accuracy and acumen, among whom we may reckon Bonsdorf, Göze, and Christ, and our own deservedly celebrated entomologists, Kirby and Spence, though on one occasion they think the antennæ may be organs of smell.

The antennæ, then, according to these views, correspond to the ears of larger animals in number, in position, in standing out from the head; and what is no less important, unless we admit this opinion, no other organ seems to represent the ears, and hence it appears highly probable, that their primary function is hearing, whatever their secondary functions may be, as the primary function of the tongue is tasting, though it is in some cases used as an organ of touch. According to this view they may be used as tactors, or as hygrometers, if we may use the term, to discover the state of the weather, which some insects appear to be skilful in discovering, and which Lehmann terms Aëroscepsy*.

"I once was observing," says Kirby, "the motions of a weevil (*Apion*) under a pocket microscope: on

* De Antennis Insect. ii. 85.

seeing me, it receded. Upon my making a slight but distinct noise, its antennæ started: I repeated the noise several times, and invariably with the same effect. A beetle (*Harpalus*), which I was holding in my hand, answered the sound in the same manner repeatedly. I will now mention another effect that I observed, still more remarkable. A little moth was reposing upon my window; I made a quiet, not loud, but distinct noise: the antenna nearest to me immediately moved towards me. I repeated the noise at least a dozen times, and it was followed every time by the same motion of that organ; till at length the insect, being alarmed, became more agitated and violent in its motions. In this instance, it could not be touch; since the antenna was not applied to a surface, but directed towards the quarter from which the sound came, as if to listen." It is necessary, however, to remark, that there is a want of precision in these experiments, as no precautions are mentioned to have been taken to hide the cause of the noise from the eyes of the insect.

"It has been used as an argument," he continues, "that the antennæ are primarily tactors or instruments of touch, that a four-winged parasite fly (*Fœnus jaculator*, FABR.), before it inserts its ovipositor, plunges its antennæ into the hole forming the nidus of the bee, to the grub of which it commits its egg. But had those who used this argument measured the antennæ and the ovipositor of this ichneumon, they would have discovered that the latter is thrice the length of the former: and as these insects generally insert it, so that even part of the abdomen enters the hole, it is clear that the antennæ cannot touch the larva; its object therefore cannot be to explore by that sense. Others suppose that by these organs it scents out the destined nidus for its eggs; but Lehmann has satisfactorily proved that they are not olfactory organs. We can therefore only suppose, either that, by means of its antennæ, it hears a slight noise produced by the latent grub, perhaps by the action of its mandibles; or else that, by its motions, it generates a motion in the atmosphere of its habitation, which, striking upon the antennæ of the Fœnus, are by them communicated to its sensory. A similar disproportion is observable between the antennæ and the ovipositor of another parasite fly (*Pimpla manifestator*) *. Bees, when collecting honey and pollen, first insert the organs in question into the flowers which they visit; but, as I have more than once observed, they merely insert the tip of them. If anthers are bursting, or nectar is exuding, these processes probably are attended by a slight noise, or motion of the air within the blossom, which, as in the last case, affects without immediate contact the exploring organs †." It is also probable that this insertion is to ascertain the presence or absence of insect enemies, which may be lying in wait for mischief in the flowers.

It is important to remark, with regard to this inquiry, that no effect is likely to be produced upon insects by sounds unconnected with their habits ‡; for even the timid hare will scarcely bend its ear to the clang of a peal of bells, or the beat of a drum, while the bark of a lap-dog would put it to immediate flight; and though a flock of rooks, as we have frequently remarked, will feed unalarmed during a violent thunderstorm, the report of a fowling-piece, though ever so distant, or even of a boy's pop-gun, will instantly rouse them. The same holds with respect to insects; and accordingly the quick-eared grasshoppers, locusts, and crickets, will not pay any attention to the beating of a watch, the ringing of glasses, or any similar noise, while the object is kept out of their sight,—but the rustle of leaves, or the

* Figured in Insect Transformations, 57-8.

† Intr. iv. 242. ‡ Huber on Bees, p. 285.

seemingly noiseless tread of one of their own species, near them, puts them in a moment on the alert.—Having at present about a dozen of different species of this order alive, we have repeated these experiments in every possible form; but the most important, with respect to the antennæ, is that, when a leaf or a bit of paper is rustled under a table, the green grasshopper (*Acrida viridissima*) immediately bends one or both of its long antennæ in the direction of the sound, just as a rabbit would do its ears if similarly alarmed. The same effect is produced when a large beetle, in a box, is placed out of sight near it; and when placed behind, it bends the antennæ back over the body, and bustles to get out*. It is obvious to us, indeed, that it is partly, if not wholly, in consequence of the great length of their antennæ that these insects hear so acutely; and we think we have remarked that the species in which they are short have a less perfect sense of hearing. In the capricorn beetles (*Lamia*, *&c.*), which live on the wood and bark of trees, the antennæ are also very long, for the purpose, it may be, of warning the insect of the approach of snakes, lizards, or the voracious wood-pecker, whose loud tapping, however, it will not be difficult to recognise. The pretty moths, called by our London collectors the long-horned japan (*Adela*, LATREILLE), have their antennæ prodigiously long; and as they appear early in spring, even, as Latreille remarks, before the oak is in leaf, may not these organs be to give them quick intelligence of the approach of birds, who are then most eager in hunting after insects? Be this as it may, these little moths are exceedingly timid, and, though not of very rapid flight, will start off at the slightest rustle.

Both the Hubers have inferred that the antennæ in

* See page 77 for a figure.

a, Acanthocinus ædilis, MEGERLE. *b, Adela De Geerella*, male. *c, Adela De Geerella*, female.

bees and ants are instruments of language by the medium of touch and gesticulation. Let us examine the experiment made to ascertain the means by which intelligence of the loss of a queen is spread through the hive, which always takes place within an hour after the event.

"I divided," he says, "a hive into two portions by means of a grating, executing the operation with such expedition and delicacy, that the smallest agitation was imperceptible, nor was a single bee injured. The bars of the grating admitted the free circulation of air, but were too close for the reciprocal passage of the bees. I did not know which half contained the queen, but the tumult and buzzing in number one soon assured me she was in number two, where quietness and tranquillity prevailed. Still preserving the circulation of the air, I closed the entrance of both, that the bees, seeking for their queen, should not find her. In two hours they calmed, and order was restored; and we afterwards saw the commencement of three royal cells.

"The apertures in the division between the halves allowed the communication of the bees of number one with a queen produced from these, by means of smelling and hearing. They were separated by an interval not exceeding the third or fourth part of an inch, which they could not pass: yet the same bees became agitated; they constructed royal cells, and reared young queens, as if their queen had been quite lost. This observation proves that it was neither from sight, hearing, nor smell, that the bees were sensible of the presence of their queen, and that the aid of another sense was interposed. The division inserted between the halves of the hive having deprived them of nothing but contact with her, was it not very probable that her presence had to be learned by touching her with their antennæ? It is by means of these organs that bees gain the knowledge of their combs, their young, their companions, and also of their queen, all communicated by the sense of feeling.

"To be satisfied on this point, a queen was confined in a glass box, covered within with a grating, which allowed the passage of the antennæ, but was too small for the heads of the bees. We remarked from the first, that the distress commonly following the departure of a queen was not manifested on this occasion. All the bees knew that she was not lost, and when she was restored to them, they seemed to recognise her immediately. The communications of the bees with this queen were made by means of an infinite number of antennæ thrust through the grating, and turning in all directions, plainly indicating that they were occupied with her. She acknowledged the interest they took in her by always remaining fixed on the grating, and crossing her antennæ with those so evidently employed in ascertaining her presence *."

To us, this certainly proves the importance of the secondary use of the antennæ in touching; but the buz which spreads through the hive is evidently the means by which the loss of a queen is made known to those that have not had an opportunity of ascertaining it by other means.

The younger Huber has attributed to ants what he calls an antennal language. He tells us, that the means of mutual communication among ants consists "in striking with their head the corselet of their companions, in the contact of their mandibles; but the antennæ, and the organs of touch, and perhaps of some other sense, are the principal instruments connected with the language of ants. We have seen these insects frequently use them on the field of battle, to intimate approaching danger, and to ascertain their own party when mingled with the enemy. They are also employed in the interior of the ant-hill, to warn their companions of the presence of the sun; in their excursions, to indicate their route; and in their recruiting, to determine the time of their departure. The ant who experiences hunger, begins by striking with both its antennæ, with an extremely rapid movement, the antennæ of the ant from whom it wants its supply; it then draws closer, with its mouth open and its tongue extended, to receive the fluid. During this operation, the ant who is receiving aliment does not cease caressing its kind friend, by continuing to move its antennæ with great quickness; it also plays upon the lateral parts of the head of its benefactor with its fore feet, which, from the

* Huber on Bees, p. 280.

delicacy and rapidity of their movement, yield in no respect to the antennæ*."

To us there does not, however, seem to be anything in this which shows the antennæ to have any peculiar functions, any more than we should think it correct to theorize in the same way upon the bills of nestling birds, which are opened to receive food, or their wings, which are opened and vibrated rapidly while they receive it. The quick movements of the antennæ, indeed, which have in many insects been remarked as indicating eagerness to explore by touch, appear to us precisely like the similar motions remarkable in the ears of horses, and even of the dullest ass, when excited by anything that pleases them. Ants, bees, and other insects, perhaps employ sounds for communicating with one another inaudible to our ears. That bees, at least, are affected by noises which we can hear is proved from the singular effect produced upon them by sounds occasionally emitted by the queen, as well as by the death's-head moth (*Acherontia Atropos*).

The younger Huber also fancies that the aphides and gall insects, upon which the ants depend for a considerable portion of their food, understand the antennal language as well as the ants themselves. "By watching a single brown ant" (*Formica brunnea*), he says, "on a branch of a thistle, I saw it at first pass, without stopping, some aphides, which it did not disturb, but shortly after stationed itself near one of the smallest, and appeared to caress it by touching its tail alternately with its antennæ, with an extremely rapid movement, like the play of the fingers in a shake upon the piano-forte. I saw with much surprise the fluid (honey-dew) escape from the body of the aphis, and the ant take it into its mouth. Its antennæ were directed to a much larger aphis than the first, which, on being caressed after the same manner, discharged

* Huber on Ants, page 208.

the nourishing fluid in greater quantity, and this the ant immediately swallowed. In the same manner it proceeded to a third, a fourth, and a fifth, after which it returned to the nest. Those which remained on the thistle presented me with the same scene." Again, "I was very much astonished when I saw, for the first time, an ant approach a gall-insect, and perform with its antennæ, on its lower extremity, the same manœuvres as in the instance of the aphides. After having a few moments caressed this insect, I saw proceed from its back a large drop of fluid, which the ant immediately lapped up. I observed the same occurrence, with reference to other gall-insects on the same tree, during several seasons *."

We can produce an almost exact parallel to these observations in the case of several sea-birds (*Lestris*, ILLIGER). According to Temminck, "these rarely fish on their own account, but most commonly subsist on aliments which they oblige the sea-maws (*Lari*) to disgorge, throwing themselves with an astonishing velocity upon this, which falls from a height in the air, and thus they live at the expense of others, which they incessantly pursue †." From our own observation, however, we are quite convinced that it is the mute of the gull, and not the fish it disgorges, which the arctic gull (*Lestris parasiticus*, Boié), procures by following others, and this accords with both the scientific and the popular name of the bird in most languages. The French call it Stercoraire, the Italians Stercorario, the Scotch the dirty-allen, and the English the dung-bird or dung-hunter. Though we have seen it in numerous instances thus procuring its food by following its congeners in the air till they muted, we never imagined, as Huber does with respect to the ants and aphides, that they understood its language of solicitation, or that it had peculiar organs for that purpose. But most

* Huber on Ants, p. 220. † Manuel d'Ornith. ii. 790.

sorts of birds will mute if they are approached, and it appears the arctic-gull profits by the knowledge of this. We have at this moment a black-cap (*Sylvia atricapilla*) in a cage, who invariably mutes every time any one comes near him, and the red-breast (*S. rubecula*) may be observed to do the same when he is frightened away from his crumbs at the cottage door. That it is the same in the case of the ants and aphides any one may prove, by taking a pin or a camel-hair pencil, and gently touching the aphis, when it will eject the honey-dew as readily as by the caressing of the antennæ *.

In many insects it is obvious the antennæ cannot be employed as organs of touch, on account of their peculiar conformation. In the common flies (*Muscidæ*), for example, they are very short, and in some of the beetles cannot be bent to the plane upon which they walk. The great importance of the organ, however, to beetles and some water insects is proved by the care taken to protect it, and the manner in which it is employed. In the water-scorpion (*Belostoma*) there is a cavity in the head, containing a very deep kidney-shaped box between the eye and the throat, to receive and defend its singular antennæ, which, when they are reposing, is closed by the exterior harder joints, and from which it seems as if they turned out like a sentinel out of his box. In some water-beetles (*Gyrinus*, *Parnus*, &c.) they are withdrawn within a lateral cavity of the same part, and are defended from the water externally by the auricle at their base. When a beetle rouses itself from repose, the first thing it uniformly does is to expand its antennæ, which are usually kept in active motion till it stops again, for the purpose as it seems to us, not of feeling its way, because they seldom touch anything, but of listening to the approach of enemies or of prey.

* J.R.

Amongst the authors who have advocated the opinion of antennæ being the organ of hearing, Bonsdorff appears to have been amongst the first *; and his statements were followed up and extended by M. Christ † and Göze, the latter holding it a good argument that insects erect their antennæ as other animals do their ears ‡, but which Lehmann, full of his own notion of aëroscepsy, treats as a mere conjecture, devised because they could find no other parts like the ears of other animals §. Comparetti, an Italian naturalist, however, persuaded himself that he could demonstrate an organ of hearing in insects, consisting of certain little sacs (*Sacculi*), filled with fluid, in hollows under the bulbs of the eyes, and pellucid ducts convoluted and intermingled with white filaments of nerves, distinct from the vessels of the wind-pipes (*tracheæ*). Of these he has given minute descriptions as they appear in the field-cricket, the locust, the cicada, the white butterfly, the dragon-fly, the hornet, the common fly (*Musca domestica*), the ant, the bee, and in spiders ||.

Whether this be, in fact, part of the internal apparatus for hearing in insects, we cannot tell; but, at all events, from being situated near the base of the antennæ, it does not contradict the position we have maintained. The same is also confirmed in a remarkable manner by the known situation of the ears in crabs and lobsters, which agree with insects in possessing antennæ. At the base of the antennæ, accordingly, in crustaceous animals, are two moveable organs in the form of protuberant papillæ, but thicker and harder than the shell that covers the body. The centre of these is perforated with a round hole, over which, in the living animal, an

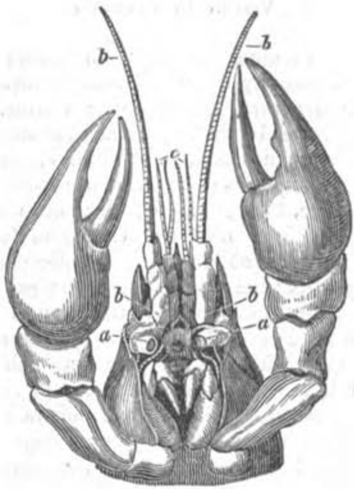
* De Usu Antennarum. † Der Hymenopterorum, p. 53.

‡ Natur. Meuschenl. und Voresch. v. 389.

§ De Sensibus Externis, p. 26.

|| De Aure interna comparata, pp. 287—304.

elastic membrane like the drum in the human ear is tensely stretched *. Fabricius † and Cavalini ‡, indeed, term this the drum (*tympanum*) : Scarpa calls it the window of the vestibule. But be this as it may, the nerves of hearing are expanded upon the interior, and are intimately connected with the antennæ.



Ear, &c. of the crab. *a a*, the ears, from the base of which the antennæ, *b b*, arise ; *c*, the palpii.

According to this view of the matter, the antennæ of crabs and lobsters, and by analogy in insects, may perform something of the same office as Laennec's instrument called the Stethoscope, which medical men use for assisting the ear to ascertain the sounds produced within the chest by breathing, speaking, the beating of the heart, and other organic movements. The stethoscope magnifies these sounds, and gives facility and precision of listening.

* Scarpa de Auditu, pp. 2, 3. † Nye Skrifter, ii. 376.
‡ Lehmann de Sensibus Externis, p. 26.

CHAPTER V.

VISION IN INSECTS.

THERE is no animal naturally blind, says Bidloo*. But the universality of the position is rendered doubtful by the structure, if not by the actions, of some insects observed by distinguished naturalists, whose testimony is unimpeachable. Latreille, for example, describes two species of ants, whose workers are, to all appearance, blind, though their males and females have eyes sufficiently obvious. One from South America (*Formica cæca*), in Olivier's collection, he had never seen alive; the other (*Ponera contracta*, LATR.) he found under stones near Paris, though not common. "I have never," he says, "been able to detect the eyes, even with the aid of a lens half a line in focus. I have seen a great number of individuals, both living and dead, and I have only once or twice imagined I could just see a very small depressed point in the place of the eye†." Again, he says, "if the eyes exist at all, they can be of little more use to these ants than those with which nature has furnished the mole; for, like it, they are destined to pass their days in obscure retreats, inaccessible to light, and are never seen running about like the others in open day, and if they do venture abroad from their dark galleries, it is only during the night‡."

We have ourselves verified all these observations upon this species, at Havre de Grace, where it is more common than at Paris. We found that their dislike

* De Oculis et Visu.

† Hist. Nat. des Fourmis, 196. ‡ Ibid.

to light was so great, that when we shut up a few of them, with their pupæ, under a glass, with only a sprinkling of earth, they contrived to pile up enough to cover themselves completely in; and even when we made the floor of their prison of a plate of glass, so that the light could be admitted below, they still contrived to manage their scanty materials so as to pave this glass floor, sprinkling it with minute grains. Two females, with a few workers that chanced to escape, were afterwards discovered on the floor, within a bramble leaf, which had coiled up in withering, and, in deficiency of other material to stop up the openings, they had gnawed portions of the leaf itself, and masoned them into little walls to exclude the light. But, so far from inferring from this that they are blind, we should be disposed to conclude that they have *eyes extremely sensible to light*, though, from their minuteness, they elude our search. It is to be recollected, indeed, that the insect is one of the smallest, being rather less than a sixth of an inch in length; but the circumstance is more remarkable from most ants having very large and prominent eyes*.

A more extraordinary opinion has been maintained respecting the blindness of spiders, inasmuch as their eyes are, in most species, so very conspicuous, and more brilliant than in any animal we at present recollect. Speaking of one of the hunting spiders (*Salticus scenicus* ?), Swammerdam says, "These seize their prey by a sudden leap, and therefore nature has provided them, as well as other spiders, with eight eyes, and a most acute sight. It is more difficult to judge of this sight in spiders that make webs, for, so far from taking any notice of a finger put close to their eyes, they neither express any concern at it, nor attempt to run away; whereas, let the most minute animal fall into their nets, they imme-

* J. R.

diately perceive and lay hold of it. This apparent insensibility on the one hand, and readiness of perception on the other, has made some philosophers think the web-spiders had no eyes, but received information concerning their prey only by the tremulous motion of their web. When these gentlemen further consider, that what look like eyes in spiders never appear, when viewed with the microscope, of a reticular form, as is the case in the scorpion, they more rouudly deny that they have any eyes. But it by no means follows, from the web-spider's never leaping upon its prey, or from its never running to it, unless when taken in its net, that it has no eyes; and this conclusion must appear yet weaker, on considering that eyes are as distinctly perceivable in this kind as in the jumping-spider (*Salticus scenicus?*), and withal are disposed in the same manner. As to the argument drawn from the parts which look like eyes in web-spiders not being formed in the netted manner as in other insects, it is equally unsatisfactory; for what difference is there between its eyes being placed singly in different parts of the surface of the body, as in the jumping-spider, and their being gathered into one net, as in other insects? Besides, the eyes of spiders thus scattered are much larger than those which form the netted eyes in other insects; so that, every thing duly considered, there is reason to affirm that spiders have a more perfect sight than the generality of other insects, except the dragon-fly (*Libellula*), which appears to have very large and very numerous complex eyes. Thus has nature displayed her wonders, even in those little animals, which at first sight appear to many beneath their notice *."

The best ascertained instance of the want of eyes in insects occurs in the white-ants (*Termites*), all the members of whose communities, except the males and

* Biblia Naturæ, i. 23.

females, are considered blind. Even the males of one species (*Termes fatalis*) are said by Dr. König *, who observed them at Tranquebar, to have only an obscure spot near the antennæ; and he could not perceive the gold-coloured point in the forehead, described by Fabricius †. The seinsects, it mus thowever be remarked, like Latreille's blind French ants, are impatient of light, and always, even in foraging, walk under cover.

If we turn to insects which are admitted by all to possess vision, we shall find that authors are by no means agreed respecting its nature and extent, as is most strikingly the case in the instance of bees. "How great," exclaims the elder Huber, "is their perfection of sight, as if to compensate the defects of their hearing ‡. The bee, from this cause, recognises its habitation amidst an apiary of numerous others resembling it, and returns in a straight line with great velocity: we must suppose that it is distinguished by marks escaping our notice. The bee departs, and flies straight to the most flowery field; and having ascertained its course, it is seen traversing it as directly as the flight of a cannon or musket ball. When it has made its collection, it rises aloft in the air to reconnoitre its hive, and returns with the rapidity of lightning §."

Wildman, on the other hand, tells us that he has observed them go up and down, seeking the door of the hive, and be obliged after alighting to rise again in order to find it. He conceived that they see better when flying than when alighted ‖; not, however, as Dr. Bevan remarks, because their vision is improved by the act of flying, but from objects being placed at a greater distance, and better adapted to the focus of

* Beschäftigungen der Berlin, iv. 1.
† Bestimmung des Geschlechts, i. 179.
‡ See page 73. § Huber on Bees, p. 221.
‖ Wildman on Bees.

their eyes*. The observations of Dr. Evans corroborate those of Wildman. "We frequently observe bees," he says, "flying straight homeward through the trackless air, as if in full view of the hive; then running their heads against it, and seeming to *feel* their way to the door, with their antennæ, as if totally blind †." The experiments of Sir C. S. Mackenzie support the same doctrine, for he remarked the imperfect vision of bees, and how much they are sometimes puzzled to find their way, if the hives were removed two or three yards from the place where they usually stood; and he found that, for the first day or so, they did not venture to fly to a distance, till they had visited and recognised neighbouring objects ‡.

The author of "The Pleasures of Memory," upon the authority of Prevost, adopts the notion of bees being near-sighted:

> "Hark! the bee winds her small but mellow horn,
> Blithe to salute the sunny smile of morn.
> O'er thymy downs she bends her busy course,
> And many a stream allures her to its source.
> 'Tis noon, 'tis night. That eye, so finely wrought
> Beyond the search of sense, the soar of thought,
> Now vainly asks the scenes she left behind;
> Its orb so full, its vision so confined!
> Who guides the patient pilgrim to her cell?
> Who bids her soul with conscious triumph swell?
> With conscious truth retrace the mazy clue
> Of varied scents that charm'd her as she flew?
> Hail! Memory, hail! thy universal reign
> Guards the least link of being's glorious chain."

But unfortunately for this poetical fancy, it does not accord with the facts; for independently of

* The Honey-Bee, p. 311.
† The Bees, a Poem.
‡ Bevan on the Honey-Bee, p. 314.

the practice of bees flying, as Huber has stated, straight to and from the hive, we have in numerous instances seen a bee search the same blossom two or three times in the course of a few minutes, in utter forgetfulness of having already plundered it of its honey *.

If Réaumur, however, be correct in his opinion, as we are inclined to think he is, these apparent discrepancies may be easily reconciled; for he attempts to show, that bees and most other insects are endowed with two sorts of eyes, one for distant, and another for near vision; instead of having the power as we have of adapting the eye to various distances, the nature of which adaptation is not well understood †. In order to understand this more precisely, it will be necessary to enter into a few details as to the number and structure of the eyes of insects.

It may at first appear not a little puzzling to conceive how a spider with eight eyes, a centipede with twenty, and a butterfly with thirty-five thousand facets in its two eyes, can perceive only one object; yet the difficulty is not of a very different kind from that of our own two eyes representing only a single object and not two,—a subject which has exercised the ingenuity of many a philosopher. Vandermonde ‡, for example, supposed that children at first see double, and correct the error by experience; an opinion adopted by Blumenbach: Dr. Reid referred it to an original and inexplicable law of human nature §, confessing thereby his inability to explain it; and some of the old philosophers satisfied themselves that it was because the nerve from each eye meets

* J. R.

† Des Cartes, Mariotte, Jurine, Dr. T. Young, Mr. C. Bell, Mr. Travers, &c. have given various opinions on this subject.

‡ Apud Haller, Physiol.

§ Inquiry into the Human Mind.

before reaching the brain. The latter would have perhaps been satisfactory, had it not been refuted by the simple experiment of pushing one of the eyes a little aside, when objects will be seen double, though this cannot alter the meeting of the nerves. Dr. Wells explains it by the coincidence of what he calls the visible direction *.

Whatever opinion be adopted, it is evident that most creatures can see an object by using one eye only, sometimes better than when both are employed. The celebrated painter, Leonardo da Vinci, upon this principle recommended his pupils always to look at distant objects with one eye only †, and we have frequently observed in birds, particularly those which feed on insects (*Sylviadæ*, *Merulidæ*, *&c.*), that on looking out for prey, they most commonly turn their head on one side, so as to bring only one eye to bear on the object. A thrush always does so when he examines a snail-shell that he means to attack, and a red-breast before he pounces upon a worm. It is no doubt for this very reason that the wryneck (*Yunx torquilla*) is enabled to move its head in the manner from which it derives its popular name; and many insects, such as the dragon-flies (*Libellulina*), can turn their heads nearly round about; though, from the great volume of their eyes, this might almost be considered superfluous.

Most spiders have eight, though some only six eyes, and these are so variously arranged, that their positions have been employed by systematic writers for distinguishing the genera and species; and as it may not only be useful for this purpose, but illustrative of the subject immediately before us, we shall here give figures of the position of the eyes of a number of spiders.

* Phil. Trans. for 1792 and 1811.

† Mem. d'Acad., Berlin, 1768, p. 80.

a 

a, Eyes of *Mygale avicularia*.

b 

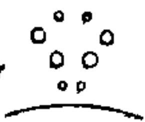
 c

b, Eyes of *Mygale cæmentaria*—and *c*, *Lycosa vorax*.

d 

 e

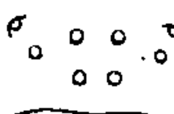
d, Eyes of *Dolomedes marginatus*—and *e*, *Ctenus dubius*.

f 

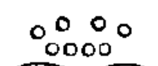
 g

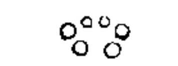
f, Eyes of *Sphasus indianus*—and *g*, *Attus parus*.

h 

 i

h, Eyes of *Eresus cinnaberinus*—and *i*, *Thomisus citreus*.

k 

 l

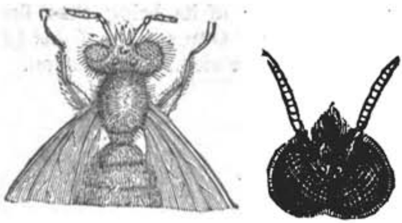
k, Eyes of *Clubiona accentuata*—and *l*, *Dysdera erythrina*.

m, Eyes of *Segestria perfida*—and *n*, *Tegenaria domestica.*

o, Eyes of *Epeira diadema*—and *p*, *Theridion coronatum.*

q, Eyes of *Latrodecta*, 13 *guttata*—and *r*, *Argyroneta aquatica.*

Three different sorts of eyes in insects have been described by some authors, while others mention only two, accounting the third sort only a peculiar coronet (*stemma*, Linn., Fabr.) for ornamenting the head. It is not a little singular, however, that such men as Linnæus and Fabricius should have come to this conclusion, with the works of Swammerdam and Réaumur before them. The supposed coronet consists most commonly of shining, transparent, smooth, round points, usually three in number, placed on the front or top of the head, for the most part in form of a triangle. Swammerdam, in speaking of what he calls "the three singular small eyes in a triangular form between and below the larger eyes," in the head of a male bee, says, "The first thing that I have observed distinctly with regard to these little eyes, is that they have a pellucid cornea, and secondly, that in their cavity there likewise appears a coloured little part, which may be called the uvea." He also traced nerves from the upper or cranial ganglion running towards each of those three eyes; and adds, "these are the reasons why I call them eyes, to which may be added, that the eyes of spiders and scorpions are



The three small eyes on the upper part of the head and between the antennæ and the two large facetted eyes of the bee. *a*, worker bee; *b*, male.

externally formed exactly in the same manner, and are smooth, glittering, and without divisions, and are as much dispersed as those that are disposed at random over the body. The wolf-spider (*Salticus scenicus?*) which catches its prey by leaping on it, has its eyes placed in the same manner *."

Independently, however, of the anatomical structure, of which from the minuteness of the parts there might be considerable doubt, the experiments of Réaumur appear to settle the point. "I have varnished those eyes," he says, "or what amounts to the same, I varnished the back part of the head in more than twenty bees, which I then set at liberty, three or four paces from the hive; but not one of them knew where to find it again, nor appeared to search for it. They flew at random towards the adjacent plants, but never to a distance, and though they seemed to have no difficulty in flying, I never saw them rise in the air as those do whose facetted eyes I had varnished over †." The latter observation seems to prove, that the coronet-eyes (*stemmata*, LINN.) are appropriated to upward vision; while we may suppose the facetted eyes (*oculi*) to be for horizontal vision, and for looking downwards. Kirby, indeed, has distinguished a whole genus (*Tetrops*)

* Biblia Naturæ, i. 214. † Mémoires, v. 289.

from the circumstance of its being thus furnished with two pair of eyes. One species of this (*Tetrops præusta*) is found in the vicinity of London.

a, Tetrops præusta; *b*, eyes of ditto very greatly magnified.

Fabricius, who is followed by Olivier, considers one pair of these eyes as nothing more than a spot; but accurate examination shows that the principal facetted eyes are actually divided by the crossing of the corner (*canthus*), which in other insects of this family (*Cerambycidæ*) only enters, and indents a portion of the eye without dividing it entirely*. What is not less singular, the males of more than one species of day-fly (*Ephemera*), besides the regular number of facetted and coronet eyes, have a pair of facetted eyes on the top of a short columnar projection.

In the little whirlwig (*Gyrinus natator*) that skims about so merrily on standing water, the upper portion of the eyes, fitted for seeing in the air, is placed on the upper part of the head, and the lower portion, fitted for seeing in water, in the lower part, a thin division separating the two†.

a, Gyrinus natator: *b*, eyes of ephemera very greatly magnified.

When a facetted eye, such as that of a butterfly, is

* Kirby and Spence, Intr. iii. 498, &c.
† See Insect Transformations, page 370.

examined a little closely, it will be found to have the appearance of a multiplying glass, the sides, or facettes, resembling a brilliant cut diamond. Puget adapted the eye of a flea (*Pulex irritans*) in such a position as to see objects through it by means of a microscope, and nothing could exceed the singularity of the exhibition. "A soldier, who was seen through it, appeared like an army of pigmies; for while it multiplied it also diminished the object: the arch of a bridge exhibited a spectacle more magnificent than human skill could perform; and the flame of a candle seemed the illumination of thousands of lamps*." Leeuwenhoeck, in the same manner, looked through the eye of a dragon-fly (*Libellula*), and viewed the steeple of a church which was 299 feet high, and 750 feet from the place where he stood. He could plainly see the steeple, though not apparently larger than the point of a fine needle. He also viewed a house in the same manner, and could discern the front, distinguish the doors and windows, and perceive whether they were open or shut†.

Swammerdam has given us so beautiful an account of the eye of the hive-bee (*Apis mellifica*), that our pages will be enriched by abstracting it. The outer coat (*cornea*) of a bee's eye is stiff, hard, flexible, and transparent, similar to a very thin plate of horn. It is not smooth, as in men and other animals, but divided by various and manifold divisions, which resemble globules or little spheres; and hence Dr. Hooke and others supposed that the insect's eye was a congeries of innumerable little eyes, each agreeing in structure with the eyes of the larger animals; but this Swammerdam was unable to verify. The divisions in the eye of the bee, indeed, are by no means globular, but rather six-sided, exactly like the closed cells of the comb, rising into a

* Goldsmith's Anim. Nat., iv. 320.

† Select Works by Hoole.

convex and globular surface, as if it were vaulted. The woven cells of a hornet's nest still more accurately resemble the facettes of a bee's eye, having six sides, and being very beautifully surmounted by an arched web. The eye of the bee, and most other perfect insects, considered in this light, is really like a little net. Some curious persons, to whom Swammerdam showed these six-sided facettes, were of opinion that, in the structure of the eyes, reasons might be found why bees make their comb-cells six-sided, because they exercise the sense of vision with six-sided eyes. "Behold," he exclaims, "how far we are led away by fictions, when, being ignorant of the foundations of things, we follow our vain fancy as a guide; for it would be as natural to say, we should build only round houses, because the pupil of our eyes is of that figure *."

Dr. Hooke computed, in the two eyes of a dragon-fly, 14,000 facettes, and Leeuwenhoeck counted 12,544 in (we may suppose) a different species; and each was, besides, so beautiful, so regular, and formed with so much art, as far to surpass the most exquisite specimens of human workmanship †.

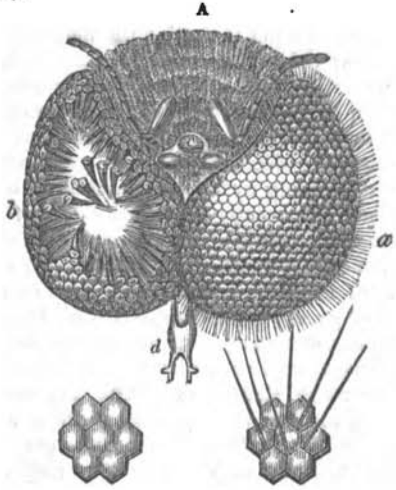
The eyes of the bee, Swammerdam further describes as very thickly covered with hair, serving, as he supposes, instead of eye-brows, or eye-lashes. In structure these hairs resemble bristles, being round, and tapering from the root to a fine point. They are very firmly fixed, piercing through the outer coat of the eye as hairs do through the human skin. Their number is very considerable, and, though less than the number of the facettes, they appear so closely set as to constitute a thick forest of bristles, like so many fir trees planted upon the eye. They are probably fixed, to guard the eye against anything falling on or striking against it; to keep off the dust, and, in case any of these annoyances should slip in, to assist the

* Biblia Nat. i. 211. † Micrographia.

bees to throw it off, or brush it away the more easily, by a friction which bees perform with their feathered legs. Similar hairs are found in the facetted eyes of many other insects*.

Behind the outer coat (*cornea*) of the bee's eye, there is an opaque substance, like what is called the paint (*uvea*) in the eyes of quadrupeds and man. In bees this is of a deep purple colour; in other insects it is green; in some blue; in some black; and, in others, it has a very beautiful mixture of various colours†.

A



B C

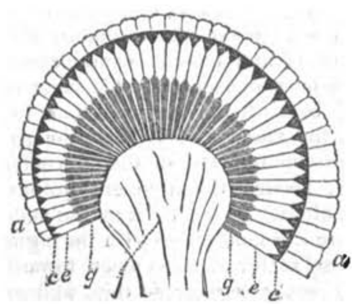
A, Eyes of the bee greatly magnified. *a*, an eye in its perfect state covered with the cornea; *b*, an eye from which the cornea and some of the hexagonal facettes have been removed to show its structure; *c*, the three stemmata or coronet eyes; *d*, the ganglion of nerves. B, a portion of the surface of the eye deprived of its cornea. C, ditto covered with the cornea, and showing the hairs which cover its surface; *c*, the three small eyes, shown also in page 127.

* Swammerdam, i. 211. † Ibid. i. 212.

Mr. Herschel seems inclined to make observations, with regard to the vision of insects, somewhat analogous to those of Dr. Wollaston in the instance of hearing. It may not be improper to give his own statement of his views. "Although," says he, "any kind of impulse, or motions, regulated by any law, may be transferred from a molecule in an elastic medium, yet in the undulating theory of light, it is supposed that only such primary impulses as recur according to regular periodical laws at equal intervals of time, and repeated many times in succession, can affect our organs with the sensation of light. To put in motion the molecules of the nerves of our retina with sufficient efficacy, it is necessary that the almost infinitely minute impulse of the adjacent ethereal molecules should be often and regularly repeated, so as to multiply, and, as it were, concentrate their effect. Thus, as a great pendulum may be set in swing by a very minute force often applied, at intervals exactly equal to its time of oscillation, or as one elastic solid body can be set in vibration by the vibration of another at a distance, propagated through the air, if in exact unison, even so may we conceive the gross fibres of the nerves of the retina to be thrown into motion by the continual repetition of the ethereal pulses; and such only will be thus agitated as from their size, shape or elasticity, are susceptible of vibrating in times exactly equal to those at which the impulses are repeated. Thus, it is easy to conceive how the limits of visible colour may be established; for if there be no nervous fibres in unison with vibrations, more or less frequent than certain limits, such vibrations, though they reach the retina, will produce no sensation. Thus, too, a single impulse, or an irregularly repeated one, produces no light; and thus, also, may the vibrations excited in the retina continue a sensible time after the exciting cause has ceased, prolonging the sensation of light (especially of a vivid one) for an instant in the eye. We may thus conceive the possibility of other animals, such as insects, incapable of being affected with any of our colours, and receiving their whole stock of luminous impressions from a class of vibrations altogether beyond our limits, as Dr. Wollaston has ingeniously imagined (we may almost say proved) to be the case with their perceptions of sound *."

This view of the matter is certainly beautiful and plausible, though, in the present state of our knowledge, we can only admit it as a theory.

The vision of insects has been recently investigated with great minuteness by Professor Müller, of Bonn †, an excellent account of whose researches has been given by Mr. Parsons, of which we shall avail ourselves. "The compound eye of the common or grey dragon fly" (*Libellula Vulgata*), says Mr. Parsons "when examined externally, may be divided into two parts; one superior and posterior, of an obscure red colour, and provided with facets



* Encycl. Metropol., *Art.* Light.
† Act. Cur. Bonn; and Meikel's Archiv. 1829.

N

at least twice as broad as those of the other part, which is anterior and below, and of a greyish tint. When a section of the eye is made, we see behind the cornea (*a*) a layer of black pigment (*c*); then a broad zone (*e*), orange-coloured posteriorly, and black in front; and a second zone (*g*), situated within the first, and appearing to be nearly wholly of a somewhat deep black hue. This latter immediately surrounds the white swelling or ganglion of the optic nerve (*j*). Each of these parts shall now be described more in detail.

"The cornea (*a*) is thickest at the posterior part of the eye; the facets there being about four times as thick as they are broad; in that part also it may be readily seen that each facet is separated from the adjoining ones by an opaque line, a kind of suture, which gives to the whole of this transparent layer a bluish tinge, and thus softens, when the eye is examined externally, the intense colour of the pigment beneath.

"The black pigment (*c*) forms a layer of a very dark colour; but its thickness is not so great as that of the cornea. Müller very justly regards it as identical with the pigment situated more deeply in the eye. At a first and cursory examination it might very readily be supposed that this layer is perfectly continuous beneath the cornea, so as to intercept completely the passage of light to the parts within it; but a careful removal of the internal structures of the eye, leaving this pigment untouched, will show that, although very thick at the sutures of the facets, where it is continuous with the pigment of the more internal textures, it becomes, towards the centre of each facet, exceedingly thin, and at the very centre no pigment can be seen; a minute perforation, as it were, in the layer being there observed. If a cornea, with its layer of pigment still attached to it, be put in water, and its internal surface be then examined at different angles, and with a powerful magnifier, a position will be soon found in which the light will be seen to traverse, without obstruction, the centre of each facet. This position, of course, varies very much, because the internal prolongations or septa, which the pigment forms in its course towards the centre of the eye, are necessarily cut and torn in exposing the internal surface of the cornea; and consequently they float and waver about in all directions. If the cornea is examined out of water, these septa lie flat upon its internal surface, and, masking in this manner the perforations, exhibit the appearance of one continuous layer.

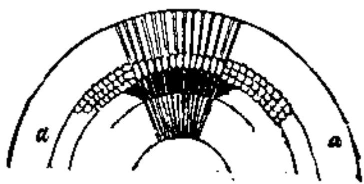
"The presence of this layer does not therefore intercept the passage of light, but merely diminishes its quantity. It is found in many, if not all, the diurnal insects, and is perforated with as many holes as there are facets on the cornea; but, as might indeed be expected, it is not met with in any of the nocturnal insects.

"The zone (*e*) which is observed in the section of the eye, within the layer just described, is seen, when examined with a powerful magnifier, to be very evidently composed of straight and transparent cylinders, smaller at the lower and anterior part of the eye, where the facets have the least dimensions, than at the upper and posterior part. They are equal in number to the facets of the cornea. The orange and black tints already mentioned are owing to the coloured pigment which extends between these crystalline cylinders, surrounding and insulating them throughout their whole length. Besides the general difference in size just mentioned, the cylinders are found to be much longer at the back than in the front of the eye; all are perpendicular to the surface of the cornea, and they converge regularly towards the centre of the eye. When examined individually, they are seen to be exactly rectilinear and parallel to each other, except, of course, the slight divergence consequent upon their radiated arrangement. They are cylindrical in the greater part of their length, and from ten to twenty times longer than they are broad. This great length of these diaphanous bodies is one of the peculiarities of the eyes of the Libellulæ: it is much less in most other insects, in which also they are conical. Their perfect transparency has caused them to be mistaken for bundles of tracheæ mixed with nervous filaments; but the absence of all lines, whether spiral or otherwise, in their structure, ought to have prevented this error. They refract light in the same manner as it is done by glass cylinders. When torn and emptied, they appear as membranous sheaths, which, in the perfect state, contain a viscid humour, requiring some pressure for its expulsion. The contained humour is coagulated by alcohol; is of greater density than water, in which it sinks; and the perfect cylinders themselves very evidently refract light when they are immersed in water. The extremity of each cylinder, towards the cornea, terminates in an obtuse point (*f*), which is inserted in the perforations of the superficial pigment already noticed. At their opposite extremity, these bodies become suddenly very slender, and are then continuous with the nervous filaments which constitute part of the deeper zone already mentioned.

"This zone (*g*), of a deeper black colour than the preceding, and of greater thickness at the front than at the back part of the eye, contains the nervous filaments, which, arising from the bulb or ganglion of the optic nerve, terminate in the transparent cylinders already described. Like these latter, the filaments converge from the circumference towards the centre, being linear, straight, and as nearly parallel as their radiated disposition will permit; but they are much smaller in diameter than the cylinders, and, notwithstanding their slenderness, appear, under the microscope, somewhat opaque and of a fibrous texture. Surrounded by a dark choroid secretion (*i*), these filaments, on account of their great tenuity, cause the pigment to appear much thicker and darker, when regarded *en masse*, than that portion of it represented as passing between the cylinders. These latter are almost in immediate contact with each other: the nervous filaments, on the contrary, are separated by spaces much exceeding in size their own diameter.

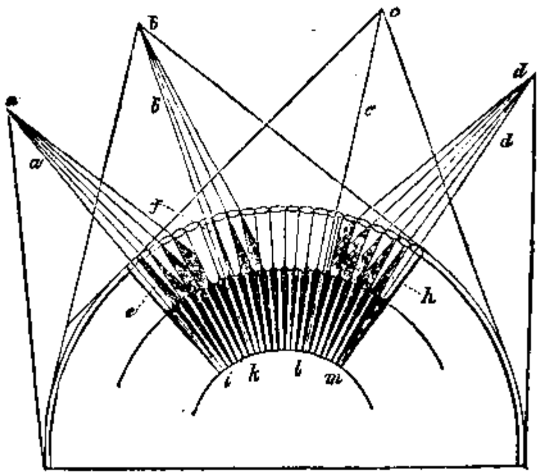
"In the centre of the eye is the optic ganglion (*j*), which, however pulpy and homogeneous it may appear at first sight, exhibits nevertheless a fibrous and radiated structure when submitted to moderate compression. Indeed, it may in some degree be regarded as the optic nerve passing into the filamentary arrangement observed a little farther from the centre.

"Such are the anatomical details exhibited in the eye of the grey *Libellula* and of other insects, with some modifications to be hereafter noticed. In examining each of these parts, we may, to a certain extent, refer them hypothetically to the structures forming the simple eye of the vertebrated animals. In fact, we find in these compound eyes a nervous filament attached to the extremity of a transparent body representing the vitreous humour and crystalline lens; a transparent cornea covering externally this apparatus; and a choroid membrane, represented here by a coloured pigment, which surrounds, as in the vertebrated animals, these minute organs of refraction and sensation. We may still further remark that the pigment, continuous in all parts, although varying in thickness, forms between the cornea and the transparent or crystalline cylinder, an iris (l), or at least a uvea, which allows the light to pass only through the centre of the apparatus. There is also a perforation, a true pupil, which appears black, as in man, when examined with a powerful magnifier. The whole of these pupils, whose axes correspond to that of the eye of the observer, form the black and mobile spot which has often been a source of embarrassment to those examining these parts.



"In the *Lucanus Cervus*, the cornea (a) is of extraordinary thickness, and its facets are accordingly so much elongated as to appear like prisms. The cones have their bases nearly in contact with the cornea, and at that part are apparently without pigment; towards their apices, where they are attached to the nervous filaments, they are surrounded with pigment of a violet colour. The nervous filaments, also, in the greater part of their course from the optic nerve, are without any investiture of coloured matter."

Numerous details of a similar minute kind are given of the eyes of many other insects, but what we have now quoted will show the nature of these researches. We cannot, however, omit one other extract, exhibiting M. Müller's idea of the principles of insect vision. "The following figure," we again use the words of Mr. Parsons, "represents the section of a compound eye, in order to show the course of



the light. If rays of different colours, given out from the points *a*, *b*, *c*, *d*, fall upon the eye, the cone *h* will be illuminated throughout its whole length by the ray *d'*, which traverses this cone in the direction of its long axis. The other cones situated in the vicinity of the line *m d* will not be illuminated as far as their internal extremity by the rays from *d*, which penetrate less and less deeply into the neighbouring cones, in proportion as they become more remote from the line *m d*. The nervous filament *m*, corresponding to the cone *h*, is consequently impressed with the ray *d'*; other rays from *d*, being absorbed by the pigment investing the neighbouring cones, will of course produce no effect on any nervous filament placed out of the line *m d*. The coloured ray *d'* is therefore perceived only by means of the filament *m*, on which latter alone it impinges. So also the ray *c'*, given out at the point *c*, will pass through the whole length of the cone *g*, and will affect only the corresponding nervous filament *l*; the ray *b'* traverses only the cone *f*, and is perceived only by means of the filament *k*; and the ray *a'*, emitted at the point *a*, is perceived only by means of the filament *i*, after having passed through the cone *e*.

"The variously coloured rays given out from the points *a*, *b*, *c*, *d*, will thus produce in the interior of the eye a determinate figure, corresponding to the luminous object without; and the same remarks will necessarily apply to any number of points situated between *a*, *b*, *c*, *d*.

"Each nervous filament conveys to the bulb of the optic nerve the impression of the ray which it has individually received; and, as all the nervous filaments, at first insulated by the pigment, are at length united together into one common and continuous bulb or nervous expansion, the impression received by each filament is united to those of all the others in the bulb of the optic nerve, and so a common and continuous image is produced. Rays coming from one point of a remote object will, it is true, illuminate throughout more than a single cone; and then, to each luminous point without, there will correspond in the interior of the eye, not exactly a single illuminated point, but rather a little circle of diffused or dispersed light; and, in consequence, an image of but little distinctness will be reproduced on the sentient surface or retina; the distinctness of the image of course increasing in proportion as the object approaches the eye.

"The image in the interior of the eye will be more distinct, precisely as the cones, in a given portion of the eye, are more numerous; the distinctness will also increase in proportion to the length of the cones; for the longer the cones are, the more completely will all rays entering them obliquely be prevented from reaching their internal extremity or apex. The dipterous and neuropterous insects, whose eyes contain thousands of facets and corresponding cones, are distinguished in general by their more powerful sight from other insects; and this is owing to the number of facets, &c., and not to the size of the eyes; for the size of the eyes merely influences the extent of their visual horizon.

"From this statement, it may be inferred that the vision of the compound eyes must be very imperfect and indistinct; but at the same time, no doubt, it is amply sufficient for the wants of insects, &c. The quantity of light which enters into the interior of the eye is also very small; but the optic nerve is probably so constituted as to perceive the faintest differences in the intensity of light and colours. Of the whole light emitted or reflected by exterior objects, we ourselves receive into the eye only that portion which the pupil is capable of admitting; and yet, when the pupil is at its minimum of dilatation, as at the time of our looking at very near or brightly illumined objects, or when we are in considerable darkness with the pupil dilated perhaps to its maximum, the smallest quantity of light will be sufficient to enable us to distinguish the general forms of bodies. A light of moderate intensity, with a mean degree of dilatation of the pupil, seems best suited to the degree of perceptibility of our sense of visinn; for, when the pupil is widely dilated, as by means of belladonna, objects at other times moderately bright then become dazzling. As soon as the general sensation of light exists, the local diversities of clear, dark, aod coloured parts in bodies will likewise be perceived, provided only those conditions are present which are required for the proper insulation of the differeot kinds of rays*."

* Loudon's Mag. of Nat. Hist., vol. iv. p. 124, &c.

SECTION II.

FOOD OF INSECTS.

It appears to have been first observed by Aristotle, that insects may be divided into such as are furnished with jaws for eating, and such as are provided with a tongue for lapping or sucking *,—a division which in modern times was placed in a more prominent light by Clairville †, and has been adopted by Stephens ‡ and other eminent living naturalists. In one point of view these two divisions are of considerable value, as they afford an obvious and broad basis upon which to build the minor divisions of a system; but like many other distinctions in natural history, it requires no little refinement of erudition to render the principle in all cases practically applicable. An intelligent reader, for example, who has not paid much attention to the study of insects, upon being told that all insects either masticate solids or suck fluids, may wish to verify the distinction upon the first he meets with: and if he chance to light upon a beetle or a gnat, he will find that the former has jaws and the latter a sucker; but if a bee should come in his way, he would be somewhat embarrassed, for, upon perceiving its large jaws, he would be disposed to arrange it among eating insects, did he not advert to the well-known fact of its lapping honey with its tongue—an organ no less conspicuous than its jaws.

* Hist. Animal. viii. 11.
† Entomologie Helvetique, Zuric, 1798.
‡ Systemat. Catal. &c.

Aristotle was shrewd enough to perceive this difficulty, when he says of such insects (*Hymenoptera*) that they have teeth, not for feeding but for fulfilling other instincts *, such as building cells of wax, and similar materials. In the systems, however, founded on Clairville's arrangement, bees and other insects of the same order are classed among eating insects. As it would not suit the design of our little work to throw in the way of the reader any difficulties of this kind which we can avoid, we shall follow a hint thrown out by Kirby and Spence †, and consider them under the three-fold division of eaters, lappers, and suckers, though plausible objections, we are well aware, may be made to this, as well as to most other arrangements.

* De Partib. Animal., iv. 5. † Intr. iii. 418.

Chapter VI.

EATING INSECTS.

The larger animals differ so much from one another in their feeding organs, that Linnæus selected the teeth as best adapted to distinguish his orders of quadrupeds,—a circumstance which appears to have led his celebrated Danish pupil, Fabricius, to fix upon the analogous organs in insects for the same purpose. But, confining our views only to insects which eat, we shall find that the structure and form of the organs in question are much more diversified than in the larger animals. From the latter, the jaws differ in not being placed vertically but horizontally. There are two pairs of jaws, one above the other, with an upper and under horizontal lip. The upper pair of jaws, or mandibles (*mandibulæ*), one on the right and another on the left, usually resemble a large tooth, more or less curved, and jointed into the sides of the head immediately below the upper lip (*labrum*). Their substance is hard, horny, and of considerable strength, and is usually more or less indented with projections resembling teeth, but which make a portion of the jaw itself, not being inserted in sockets like the teeth of other animals. The under pair of jaws (*maxillæ*) are inserted in the right and left of the inner cavity of the mouth; but their structure differs from the upper jaws, being jointed and furnished with appendages, perhaps for feeling (*palpi*). They are protected below by the under lip, and the projection upon which the latter is attached, called the chin (*mentum*) *.

* V. Audouin, Resumé d'Entomol. ii. 52.

The jaws, it has been well remarked, "are admirably adapted for their intended services: some sharp and armed with spines and branches for tearing flesh; others hooked for seizing, and at the same time hollow for suction; some calculated like shears for gnawing leaves; others more resembling grindstones, of a strength and solidity sufficient to reduce the hardest wood; and this singularity attends the major part of these insects, that they possess in fact two pairs of jaws, an upper and an under pair, both placed horizontally, not vertically,—the former apparently in most cases for the seizure and mastication of their prey; the latter, when hooked, for retaining and tearing, while the upper comminute it previously to its being swallowed *."

Among quadrupeds we can readily tell what food an individual naturally feeds on by inspecting the teeth. But amongst insects this principle is by no means so obviously applicable; for several of those which are furnished with the most formidable jaws, such as the stag-beetle (*Lucanus Cervus*), feed upon vegetable substances almost exclusively. We say *almost*, for it is not a little remarkable that a very great number of insects, whose natural food seems to be vegetable, will occasionally prey upon animals in the same way as soft-billed birds (*Sylviadæ, &c.*) will feed either on berries or insects as they can procure them, and as the common garden snail (*Helix aspersa*, MULLER), though it usually devours leaves, will sometimes make a meal of an earth-worm, as we have observed more than once †. In the case of insects, we may illustrate our remark by referring to the earwig (*Forficula auricularia*, LINN.), well known in every garden. There

* Kirby and Spence, Intr., i. 394.

† J. R. See also Sowerby on Helix nemoralis, in Zool. Journ. i. 285.

is nothing more certain, Goldsmith tells us, than that it lives among flowers and destroys them, and when fruit has been wounded by flies, the earwig generally comes in for a second feast, and sucks those juices which they first began to broach; yet the insect, he adds, is not so noxious as it would seem, since it is seldom found but where the mischief has been originally begun by others*. Bingley copies all this without any suspicion of its inaccuracy, and subjoins, that "in the night they may occasionally be seen in amazing numbers upon lettuces and other esculent vegetables, committing those depredations which are often ascribed to snails or slugs†." On the contrary, it agrees with our observation that the depredations frequently imputed to earwigs are more usually committed by slugs, particularly in the case of flowers. We had a considerable collection of the finest varieties of heart's-ease (*Viola tricolor*), which, just as they came into bloom, were rendered unsightly by holes and notches gnawed into the petals during the night, and we did not hesitate to accuse the earwigs of the damage, till we began to reflect that it was too early in the summer for them to appear in sufficient numbers, the broods not being yet hatched. Observation being always preferable to the most plausible conjecture, we soon satisfied ourselves of the fact by examining our flowers after dark by candle-light, when we did not find a single earwig, but a great number of minute slugs, little larger than a pin's-head, and recently hatched, no doubt, from eggs deposited the preceding autumn. The leaves of the plants were probably too tough and coarse for their infant organs, since they uniformly attacked the

* Animated Nature, iv. 241.

† Anim. Biog. iv. 43; 6th edit.

blossoms, and, when these were unexpanded, gnawed their way into the bud*.

There can be no doubt, however, that when the summer is more advanced, and the young broods of earwigs have left their mothers †, they commit similar depredations upon flowers to those of the young slugs in the spring. "The English women," says Mouffet, "hate them exceedingly, because of the flowers of clove gilliflowers that they eat and spoyl, and they lay snares for them thus: they set in the utmost void places ox-hoofs, hogs-hoofs, or old cast things that are hollow, upon a staff fastened into the ground, and these are easily stuffed with cloathes or straw; and when by night the earwigs creep into these to avoid the rain or hide themselves, in the morning these old cast things being suddenly taken away and shook forth, a great multitude of them fall, and are killed with treading upon them ‡." The bowls of tobacco-pipes, or the claws of lobsters stuck upon the top of the sticks supporting flowers, are the usual methods for entrapping earwigs in the vicinity of London; and we recollect being not a little puzzled to conjecture what was the meaning of sticking up some dozens of lobsters' claws over a flower-border; for, upon the notion that, like the broken tea-cups ranged on the mantel-piece of Goldsmith's village ale-house, they were meant

"For ornament, and not for use,"

we deemed the taste of the suburban Londoners not a little singular.

But though vegetable substances seem to be the staple food of earwigs, they not only upon occasion show carnivorous, but even cannibal, propensities, for we have more than once given a dead ear-

* J. R. † See Insect Transformations, p. 102.

‡ Theatre of Insects, by Maserne, p. 1023.

wig to one confined in a box, and found that it devoured it*; and a brood of young ones, reared by Baron de Geer, ate the dead body of their own mother, as well as the bodies of several of their brethren which chanced to die†. It has, therefore, been inferred with considerable plausibility that earwigs in some degree make up for their ravages by diminishing the number of other insects, though the night habits of the earwig renders it not a little difficult to ascertain this.

A similar propensity to carnivorous habits exists among locusts and crickets, whose staple food is derived from vegetable substances. The house-cricket (*Acheta domestica*, FABR.) seems in this way to be a vegetable-feeder, for it thrives best in the vicinity of a baker's oven, where there are plenty of bread crumbs. Mouffet marvels at its extreme lankness, inasmuch as there is not "found in the belly any superfluity at all, although it feed on the moisture of flesh and fat of broth, to which, either poured out or reserved, it runs to in the night; yea, although it feed on bread, yet is the belly always lank and void of superfluity‡." White of Selborne, again, says, "as one would suppose, from the burning atmosphere which they inhabit, they are a thirsty race, and show a great propensity for liquids, being frequently found dead in pans of water, milk, broth, or the like. Whatever is moist they are fond of, and, therefore, they often gnaw holes in wet woollen stockings and aprons that are hung to the fire. These crickets are not only very thirsty but very voracious; for they will eat the scummings of pots, yeast, bread, and kitchen offal, or sweepings of almost every description§." Latreille, on the other

* J. R. † De Geer, Mem. iii. 548.
‡ Theatre of Insects, p. 996.
§ Nat. Hist. of Selborne.

hand, says it only eats insects,—a palpable mistake, since it would often be impossible for them to find any in the places which they frequent, except in some instances where they may be established in the same hearth with a colony of the cock-roach (*Blatta Orientalis*, LINN.), when it is probable the two species prey reciprocally on each other.

A foreign insect, which Kirby supposes to be a cricket (*Acheta*), is described by Captain Green to have exceeded our common cricket in voracity. At Cuddapa, in the ceded districts to the northward of Mysore, these are said to abound in the night, being very injurious to papers, books, and leather, which they both discolour and devour. Such also is their boldness and avidity, that they attack the exposed parts of the human body during sleep, nibbling the ends of the fingers, particularly the skin under the nails, which is only discoverable by a slight soreness that succeeds *.

Although we have paid considerable attention to the habits of this order, both in the fields and when individuals were kept in a state of confinement, and have watched their movements for hours together, we never saw them, when at liberty, attack other insects, much less any of their own kindred. But having one day put several blue under-winged grasshoppers (*Locusta cærulescens*, &c.) alive into a collecting phial, for the purpose of feeding some insectivorous birds (*Sylvia hortensis*, &c.), we were not a little surprised to see them fall immediately upon one another, with the most cannibal voracity. In another instance we placed a male and female of the large green locust (*Acrida viridissima*) in the same phial, when the female forthwith munched a large piece out of the other's back, and upon rescuing him from her fangs, and giving him the advantage of

* Intr. i. 242.

position, he immediately made reprisals by eating a hole into her side. Yet we had for several weeks a great number of this species, both male and female, hopping about our study, without one attempting to prey on another. They manifested, however, not a little mutual fear on a near approach, and in such cases the male always uttered two or three notes of alarm, and started away *. An eminent entomologist of the present day having caught one of these insects, and holding it by one of its hind-legs, it made a sudden spring, and jerked off its leg: the limb was put with the insect in a phial, and by the following morning this portion of itself was half-devoured.

Those who have been erroneously taught at school to translate the Latin *cicada* and the Greek τεττιξ, by "grasshopper," will perceive from these details that it is a very mistaken notion to suppose these insects feed on dew †. It is to the treehopper, and not to the grasshopper, that these lines of Anacreon apply:

> Happy creature! what below
> Can live more happily than thou?
> Seated on thy leafy throne,
> (Summer weaves thy verdant crown,)
> Sipping o'er the pearly lawn
> The fragrant nectar of the dawn,
> Little tales thou lovest to sing,
> Tales of mirth—an infant king.

But we need wonder less at popular mistakes of this kind, when we find similar ones promulgated, respecting the insects in question, by so eminent a naturalist as Swammerdam. "I preserve," says he, "a three-fold stomach of a locust, which is very like the stomachs of animals that chew the cud, and particularly has that part of the stomach called

* J. R.

† Virgil, Bucol. v. 77; Plin. Hist. Nat. xi. 26.

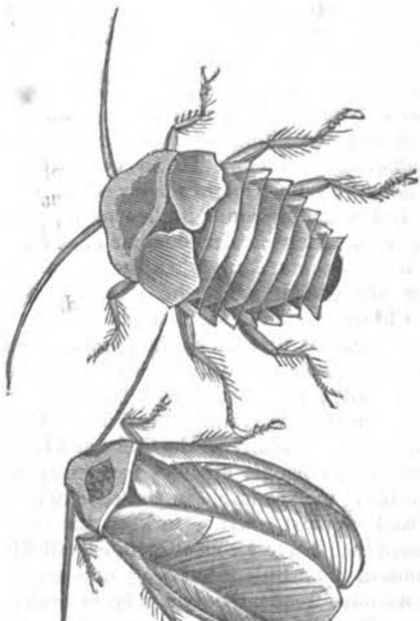
echinus very distinctly visible. I do not therefore doubt but locusts chew the cud, as well as the animals just mentioned: indeed, I persuade myself that I have seen this*." Ramdohr, on the other hand, demonstrates that this is altogether erroneous†, while we can readily point out the origin of the mistake, so far as it regards observation.

Like spiders, then, and many other insects‡, locusts and grasshoppers are very assiduous in cleaning their limbs; and we have seldom seen them long stationary without doing something of this kind, their mandibles being actively at work in mumbling their antennæ and other organs, and biting off every film or particle of dust adhering to them. To an ordinary observer this action of the jaws might readily suggest a resemblance to ruminating animals chewing the cud, particularly as the long slender antennæ of some species (*Acrida viridissima*, &c.), when thus operated upon, may be overlooked, while the attention is wholly directed to the motion of the mandibles. This it was, we have no doubt, that led Swammerdam to imagine he had actually seen a locust chewing the cud; though it is not a little singular that, with his habits of accurate and minute observation, he did not detect the genuine fact, particularly as the limbs and feet, which are large and obvious, are very frequently operated upon, it being indispensable in these, as in all insects which walk against gravity, to keep the suckers or cushions of their feet free from all extraneous defilement. It is, indeed, not a little interesting to a naturalist to see, as we have frequently done, a large heavy locust walking with ease up the glass pane of a window, and occasionally stopping to examine one or other of its feet to try whether it is fit for duty, and going

* Book of Nature, i. 94. † Anatomie der Insekten, 18.
‡ See Insect Arch. p. 368; and Ins. Transf. p. 357.

carefully over it both with its teeth and its tongue for this purpose; the whole resembling not a little the chewing of the cud*.

The family of the cockroaches (*Blattidæ*, STEPHENS) appear to be still more voracious than the preceding. A small species (*Blatta Lapponica*,



Giant cockroach (*Blatta gigantea*), reduced in size.

* J. R.

Linn.), occasionally met with about London, swarms numerously in the huts of the Laplanders, and will sometimes, in conjunction with a carrion-beetle (*Silpha Lapponica*, Linn.), devour in a single day their whole store of dried fish. In London, and many other parts of the country, cockroaches—originally, it would appear, introduced from abroad—have multiplied so prodigiously as to be a very great nuisance. We have seen them so numerous in kitchens and lower rooms in the metropolis as literally to cover the floor, and render it impossible for them to move, except over each other's bodies. This, indeed, only happens after dark, for these are strictly night insects, and the instant a candle is intruded upon their assembly, they rush towards their hiding places, and in a few seconds not one of the countless multitude is to be seen. In consequence of their numbers, independently of their carnivorous propensities, they are forced to eat every thing which comes in their way; and besides devouring every species of kitchen stuff, they gnaw clothes, leather, and books. They likewise pollute every thing they crawl over, with an unpleasant nauseous smell. These black-beetles, as they are commonly called, however, are harmless, when compared with a foreign species, the giant-cockroach (*Blatta gigantea*), which is not content with devouring the stores of the larder, but will attack human bodies, and will gnaw the extremities of the dead and the dying *.

Another family of the same order are no less savage than voracious, and, together with the numerous other instances which we have given of cannibal insects, afford no colour to the doctrine maintained by some, that man is the only animal who preys on his own species. According to Sir Walter Scott,

* Drury's Illustrations of Nat. Hist. iii. Pref.

Even the tiger fell, and sullen bear,
Their likeness and their lineage spare:
Man only mars kind nature's plan,
And turns the fierce pursuit on man*.

The praying mantis (*Mantis oratoria*, LINN.) is one of these cannibal insects. Sir J. E. Smith tells us, that a gentleman having put a male and a female into a glass vessel, the female began to gnaw off the head of her companion, and ended by devouring his whole body†. According to Mr. Barrow, the Chinese children have taken advantage of the ferocious habits of these insects to procure an amusement, only outdone in barbarity by the cock-fighting and bull-baiting of our own country, by placing two of the insects in a bamboo cage to make them fight‡.

It is remarkable that they show the same savage habits in the earliest stage of their existence. Their eggs are placed in an oblong bag of a thick, spongy, imbricated substance, and fastened lengthwise to the branch of a plant. Rösel, being desirous of observing the development of the insects, placed one of these egg-bags in a close glass, into which, when the young appeared, he put different sorts of plants. But vegetable food not suiting their taste, they preyed upon one another. This determined him to supply them with insect food, and he accordingly put several ants into the nurse-glass. Then, however, they betrayed

* *Rokeby*, iii. 1. The passage of the modern poet is a paraphrase of Juvenal:—

Sed jam serpentum major concordia. Parcit
Cognatis maculis similis fera. Quando leoni
Fortior eripuit vitam leo? quo nemore unquam
Exspiravit aper majoris dentibus apri?
Indica tigris agit rabida cum tigride pacem
Perpetuam: sævis inter se convenit ursis
Ast homini ferrum letale incude nefanda
Produxisse parum est, &c.

Lib. x. Sat. xv. ver. 159—166.

† Tour on the Continent. ‡ Travels in China.

as much cowardice, as they had previously showed barbarity; for the instant the ants were observed the mantes attempted to escape in every direction, evidently from instinctive fear of a natural enemy. Afterwards, he tried them with some of the common house-flies, and these they seized with eagerness, and tore to pieces. But, notwithstanding their apparent fondness for flies, they continued to destroy each other through savage wantonness. Rösel despairing at last, from their daily decrease, of rearing any to the winged state, separated them into small parcels, in different glasses; but here, as before, the strongest of each community destroyed the rest. Having, subsequently, received several pairs of the same insects, arrived at their full growth, Rösel, profiting by his former experience, separated them, placing a male and a female together, in different glasses: but they, even in this arrangement, exhibited the most ferocious enmity, which neither age nor sex had any effect in softening. No sooner did they observe each other than they threw up their heads, brandished their fore legs, and each waited an attack. They did not remain long in this posture; for the boldest, throwing open his wings with the velocity of lightning, rushed at the other, and tore it in pieces. Rösel compares the onset to a combat between two hussars; for they dexterously guard and cut with the edge of the fore claws, as the hussars do with their sabres, and sometimes, at a stroke, one of them cleaves the other through, and severs its head from its body, the conqueror always devouring his antagonist*. M. Pairet made similar experiments to those of Rösel, by putting a male and female mantis into a glass. The female instantly made an attack upon her companion, seizing him between the sharp points of her claws, with which she soon cut off his head. As

* Insecten Belustigung, iv. 96.

they are very tenacious of life, he continued to appear lively for a considerable time; but the female ended by devouring him *.

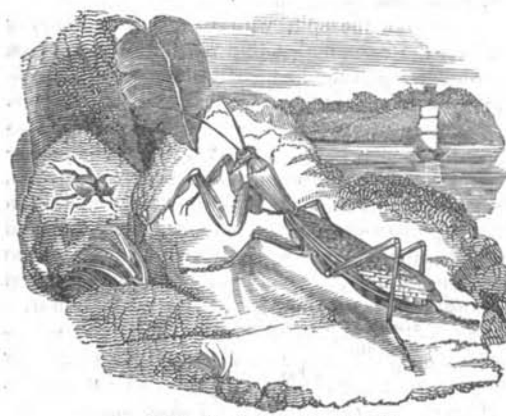
The singular form, and particularly the attitudes, of the insect in question, have given rise to several superstitions. "They are called *Mantes*, that is, fortune-tellers," says Mouffet, "either because by their coming (for they first of all appear) they do shew the spring to be at hand, so Anacreon, the poet, sang; or else they foretell death and famine, as Cælius, the scholiast of Theocritus, writes; or lastly, because it always holds up its fore feet like hands, praying, as it were, after the manner of their diviners, who, in that gesture, did pour out their supplications to their gods. So divine a creature is this esteemed, that if a childe aske the way to such a place, she will stretch out one of her feet, and shew him the right way, and seldome or never misse. As she resembleth those diviners in the elevation of her hands, so also in likeness of motion, for they do not sport themselves as others do, nor leap, nor play, but walking softly, she returns her modesty, and showes forth a kind of mature gravity †."

The attitude, however, which has obtained for the insect the name of praying mantis (*Prie Dieu*, in France), is nothing more than the posture in which it patiently lies in wait for its prey; for, having once set its eyes upon an insect, it rarely loses sight of it, though it may require some hours before it can make a capture. Should the insect be over head, and beyond its reach, it slowly erects its long neck, and elevates itself on its hind legs. If this bring it within reach, it throws open the last joint of its fore paws and snaps the insect between the spines, set in rows on the second joint. Should it prove unsuccessful,

* Encyclopedie Methodique, Insectes, in voce.

† Theatre of Insects, page 983.

it does not retract its paws, but holds them stretched out, and waits again till the insect is within its reach, when it springs up and seizes it. Should the insect go far from the spot, it flies or crawls after it slowly on the ground, like a cat; and, when the insect stops, it erects itself as before*.



Praying Mantis (*Mantis religiosa*).

The cannibal propensities of some of the preceding herbivorous insects may be illustrated by what occurs among larger animals, particularly the order of gnawing quadrupeds (*Glires*, LINN., *Rodentia*, CUV.). Among these, the mouse lives chiefly among grain, and the rabbit (*Lepus cuniculus*) upon greens; but when their natural food fails, or some apparently unnatural appetite is developed by disease, they will sometimes exhibit carnivorous habits. In this way we had once a large box of insects destroyed by mice, who ate, indiscriminately, the soft feathery wings of butterflies and the hard wing-cases (*elytra*) of

* Anim. Biog. iv. 49.

beetles. Having thus acquired a taste for insect food, we found it not a little difficult to prevent them from destroying our whole collection by eating through the wood-work of the drawers. Rabbits, however, are occasionally much more carnivorous. A poulterer, near Covent Garden, having some live rabbits in a hutch, upon the top of which he had placed some fowls ready for the spit, with their heads hanging down over the bars, and within reach of the rabbits, we remarked that they had gnawed away almost the whole head of one. The poulterer told us that this, which appeared so anomolous to us, was by no means of uncommon occurrence. What is still more remarkable, however, a friend of ours had a litter of rabbits, about two months old, which were not separated from their dam; when she unexpectedly produced a second litter. But the elder brood, as if determined not to be supplanted by their younger brethren, fell upon them, and, tearing off their limbs, devoured them with evident relish*. Even the mother rabbit will sometimes also eat some of her own offspring, particularly should these appear sickly; and the same unnatural appetite has beeu observed among cats and swine†.

It has never occurred to us to witness any of the dragon-flies (*Libellulina*, MAC LEAY) preying upon their own kindred, though they will often drive away intruders from their hawking stations; yet it is by no means improbable that they may, upon occasion, make a meal of a conquered relative. Their habits very much resemble those of the flycatchers (*Muscicapidæ*, VIGORS), among birds, as, like them, they frequently select a post, or a leafless branch, as a station from which they make frequent excursions upon the insect tribes on the wing around them.

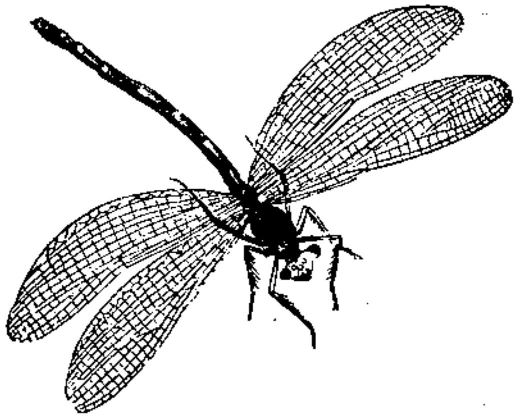
* J. R.

† Architecture of Birds, chap. xiv., Parasite Birds. Darwin, Zoonomia, xvi. 5. 1.

Like the swallow and the bat, also, the dragon-flies always catch their prey on the wing, but, like the fly-catcher and the butcher-birds (*Laniidæ*, VIGORS), they always return to their resting-place, to devour it at leisure. While the Rev. R. Sheppard was sitting by the side of a pond, to observe a large dragon-fly as it was hawking backwards and forwards in search of prey, a cabbage butterfly (*Pontia Brassicæ*) suddenly flew past. The dragon-fly instantly attacked and caught it in the air, then settled on a twig, close at hand, to eat it at leisure. It bit off the wings, and then, in less than a minute, devoured the body *. "I have been much amused," says Kirby, "by observing the proceedings of a species, not uncommon here. It keeps wheeling round and round, and backwards and forwards, over a considerable portion of the pool it frequents. If one of the species comes in its way, a battle ensues; if other species of the family presume to approach, it drives them away, and it is continually engaged in catching water-flies (*Phryganeæ*), and other insects, that fly over the water, pulling off their wings with great adroitness, and devouring in an instant the contents of the body †."

It is not a little remarkable that this voracious and blood-thirsty family are very conspicuous for gay and even gaudy colouring, from which the French have been led to give them the inappropriate name of damsels (*Demoiselles*), and the systematic writers such appellations as pretty-wing (*Calepteryx*), girl (*Puella*), bride (*Sponsa*), and virgin (*Virgo*). Kirby very correctly talks of their "dress" as "silky, brilliant, and variegated, and trimmed with the finest lace;" and Mouffet, with no less truth, says, they "set forth Nature's elegancy beyond the expression of

* Bingley, Anim. Biogr. iv. 117.
† Intr. i. 276.



Virgin dragon-fly (*Calepteryx Virgo*).

art." One (*Calepteryx Virgo?*), he adds, "is of a most curious colour; the body blue or sky-colour, the wings of a bright violet; the space between the shoulders is adorned with four golden gems, set, as it were, in a blackish collet." Another he describes as having "the eyes blue, the head green, the whole body mixed with green and blue, except the wings, which are most accurately wrought with silver-colour and black, in the middle shadowed with a dark purple*."

Voracious, however, as these insects undoubtedly are, they are far exceeded by the white ants (*Termites*) of warm climates. Forbes tells us that on surveying a room which had been locked up during an absence of a few weeks, he observed a number of advanced works † in various directions towards some prints and drawings in English frames, the glasses of which appeared more than usually dull, and the frames covered with dust. "On attempting,"

* Theatre of Insects, p. 943. † See Insect Architecture, p. 289.

he adds, "to wipe it off, I was astonished to find the glasses fixed to the wall, not suspended in frames as I had left them, but completely surrounded with incrustation, cemented by the white ants, who had actually eaten up the deal frames and backboards, and the greater part of the paper, and left the glasses upheld by the incrustation, or covered way, which they had formed during their depredation*."

They make their way with the utmost ease into trunks and boxes, even though made of mahogany, and destroy papers and everything they contain, constructing their galleries, and sometimes taking up their abode in them. One very serious consequence of this, as Humboldt informs us, is, that throughout all the warmer parts of equinoctial America, where these and other destructive insects abound, it is infinitely rare to find papers which go fifty or sixty years back†. Cloth, linen, and books are equally to their taste, and in one night they will devour all the boots and shoes left in their way.

Mr. Smeathman informs us, that "The tree termites, when they get within a box, often make a nest there, and, being once in possession, destroy it at their leisure. They did so to the pyramidal box which contained my compound microscope. It was of mahogany, and I had left it in the store of Governor Campbell, of Tobago, for a few months, while I made the tour of the Leeward Islands. On my return, I found these insects had done much damage in the store, and, among other things, had taken possession of the microscope, and eaten everything about it, except the glass, or metal, and the board on which the pedestal is fixed, with the drawers under it, and the things inclosed. Their cells were built all round the pedestal and the tube,

* Oriental Memoirs, i. 362.

† Pol. Ess. on New Spain, iv. 135.

and attached to it on every side. All the glasses, which were covered with the wooden substance of their nests, retained a cloud of a gummy uature upon them that was not easily got off, and the laquer or burnish with which the brass-work was covered was totally spoilt. Another party had taken a liking to the staves of a Madeira cask, and had let out almost a pipe of fine old wine. If the large species of Africa (*Termites bellicosi*) had been so long in the possession of such a store, they would not have left twenty pounds weight of wood remaining of the whole building, and all that it contained.

"These insects are not less expeditious in destroying the shelves, wainscoting, and other fixtures of a house, than the honse itself. They are for ever piercing and boring in all directions, and sometimes go out of the broadside of one post into that of another joining to it; but they prefer, and always destroy, the softer substances first, and are particularly fond of pine and fir boards, which they excavate and carry away with wonderful dispatch and astonishing cunning: for, except a shelf has something standing upon it, as a book, or anything else which may tempt them, they will not perforate the surface, but artfully preserve it quite whole, and eat away all the inside, except a few fibres, which barely keep the two sides connected together, so that a piece of an inch-board which appears solid to the eye, will not weigh much more than two sheets of paste-board of equal dimensions, after these animals had been a little while in possession of it. In short, the termites are so iusidious in their attacks, that we canuot be too much on our guard against them: they will sometimes begin and raise their works, especially in new houses, through the floor. If you destroy the works so begun, and make a fire upon the spot, the next night they will attempt to rise through another part; and if they happen to emerge under a chest or trunk, early in the night will pierce the bottom, and destroy or spoil everything in it before the morning.

"When the termites attack trees and branches in the open air, they sometimes vary their manner of doing it. If a stake in a hedge has not taken root and vegetated, it becomes their business to destroy it: if it has a good sound bark round it, they will enter at the bottom and eat all but the bark, which will remain, and exhibit the appearance of a solid stick (which some vagrant colony of ants, or other insects, often shelter in till the winds disperse it); but if they cannot trust the bark, they cover the whole stick with their mortar, and it then looks as if it had been dipped into thick mud that had been dried on. Under this covering they work, leaving no more of the stick and bark than is barely sufficient to support it, and frequently not the smallest particle; so that, upon a very small tap with your walking-stick, the whole stake, though apparently as thick as your arm, and five or six feet long, loses its form, and, disappearing like a shadow, falls in small fragments at your feet. They generally enter the body of a large tree, which has fallen through age or been thrown down by violence, on the side next the ground, and eat away at their leisure, within the bark, without giving themselves the trouble either to cover it on the outside or to replace the wood, which they have removed from within, being somehow sensible that there is no necessity for it. These excavated trees have deceived me two or three times in running; for, attempting to step two or three feet high, I might as well have attempted to step upon a cloud; and have come down with such unexpected violence, that, besides shaking my teeth and bones almost to dislocation, I have been precipitated, head foremost, among the neighbouring trees and bushes. Sometimes, though seldom, the animals are known to attack living trees; but not, I apprehend, before symptoms of mortification have appeared at the roots, since it is evident, as is before observed, that these insects are intended, in the order of nature, to hasten the dissolution of such trees and vegetables as have arrived at their greatest maturity and perfection, and which would, by a tedious decay, serve only to encumber the face of the earth. This purpose they answer so effectually, that nothing perishable escapes them, and it is almost impossible to leave any thing penetrable upon the ground a long time in safety; for the odds are, put it where you will abroad, they will find it out before the following morning, and its destruction follows very soon, of course. In consequence of this disposition, the woods never remain long encumbered with the fallen trunks of trees or their branches; and thus it is, as I have before observed, the total destruction of deserted towns is so effectually completed, that in two or three years a thick wood fills the space; and unless *iron-wood* posts have been made use of, not the least vestige of a house is to be discovered *."

Teak-wood (*Tectonia grandis*) is the only wood which they will not touch, probably on account of some essential oil in it disagreeable to their taste; for they will eat lignum vitæ, which is considerably harder †.

Kæmpfer gives a similar account of the white-ants in Japan. He observed, upon rising one morning, that a gallery, of the thickness of his finger, had been formed across his table; and found, upon further examination, that the insects had bored a passage up one foot of the table, run the gallery across it, and then pierced down another foot to the floor; all of which had been effected during the few hours that he had been asleep ‡.

* Smeathman, Phil. Trans. 1781, p. 183.
† Kirby and Spence, Intr. i. 243. ‡ Japan, ii. 127.

The account which Percival gives of the white-ants of Ceylon is precisely similar. "The white-ants," he says, "in the space of one night, will demolish and eat up all the boots, shoes, and bottoms of trunks, which come in their way, or are left on the ground. This is never done but by the carelessness of the black servants. In camp, the furniture of the tents is placed on inverted bottles, with their necks planted in the ground, which, on account of the slippery nature of the glass, cannot be climbed up by the ants. In the dwelling-houses, the trunks, chairs, and bed-posts, are for the same reason placed in tin vessels full of water. I have frequently seen the large beams of a house almost eaten through by these insects, and ready to tumble down on the heads of the inhabitants.

"This destructive insect, however, is not without the most singular utility, and is made by the Creator to serve the same benevolent purposes which are conspicuous in every part of his plan. In the immense forests which they inhabit, and which are never subject to the hand of cultivation, the constant accumulation of decayed timber would in time greatly impede, if not entirely choke vegetation, were not these animals employed by Providence continually to devour it *."

Insects, indeed, tiny and insignificant as they may appear, are, in such cases, the principal scavengers of nature; and wherever decaying vegetable or animal substances abound on land or in water, there myriads of insects are certain to be met with, greedily devouring what is most noxious in quality, and offensive to our senses. At the same time, the multiplication of their numbers, from this abundant supply of food, provides an almost exhaustless store of prey for those species of birds which feed upon insects.

We shall subjoin one other extract from Smeathman's interesting paper:—

* Percival's Ceylon, p. 308.

"The large species," he says, "are not only much more destructive, but more difficult to be guarded against, than those of trees (*Termites Arborum*), since they make their approaches chiefly under ground, descending below the foundations of houses and stores at several feet from the surface, and rising again either in the floors, or entering at the bottoms of the posts, of which the sides of the buildings are composed, which they bore quite through, following the course of the fibres to the top, or making lateral perforations and cavities here and there as they proceed.

"While some are engaged in gutting the posts, others ascend from them, entering a rafter or some other part of the roof. If they once find the thatch, which seems to be a favourite food, they soon bring up wet clay, and build their pipes or galleries through the roof in various directions, as long as it will support them; sometimes eating the palm-tree leaves and branches of which it is composed, and, perhaps, (for variety seems very pleasing to them,) the rattan, or other running plant which is used as a cord to tie the various parts of the roof together, and that to the posts which support it: thus, with the assistance of the rats, who, during the rainy season, are apt to shelter themselves there, and to burrow through it, they very soon ruin the house, by weakening the fastenings and exposing it to the wet. In the mean time the posts will be perforated, in every direction, as full of holes as that timber in the bottoms of ships which has been bored by the worms, the fibrous and knotty parts, which are the hardest, being left to the last.

"They sometimes, in carrying on this business, find (I will not presume to say how) that the post has some weight to support; and then, if it is a convenient track to the roof, or is itself a kind of wood agreeable to them, they bring their mortar, and fill all or most of the cavities, leaving the necessary roads through it, and as fast as they take away the wood, replace the vacancy with that material, which being worked together by them closer and more compactly than human strength or art could ram it, when the house is pulled to pieces, in order to examine if any of the posts are fit to be used again, those of the softer kinds are often found reduced almost to a shell, and all, or a greater part, transformed from wood to clay, as solid and as hard as many kinds of free-stone used for building in England. It is much the same when the *Termites bellicosi* get into a chest, or trunk, containing clothes or other things; if the weight above is great, or they are afraid of ants or other vermin, and have time, they carry their pipes through, and replace a great part with clay, running their galleries in various directions*."

"Not content," as the authors of the Introduction to Entomology express it, "with the dominions they have acquired, and the cities they have laid low on Terra Firma, encouraged by success, the white ants have also aimed at the sovereignty of the ocean, and once had the hardihood to attack even a British ship of the line (the Albion); and in spite of the efforts of her commander and his valiant crew, having boarded they got possession of her, and handled her so roughly, that when brought into port, being no longer fit for service, she was obliged to be broken up. She was indeed in such a condition from the attack of insects, supposed to be white ants, that had not the ship been firmly lashed together, it was thought she would have foundered in her voyage home†."

As the species, however, does not in the preceding case appear to have been correctly ascertained, it is

* Phil. Trans. for 1781, p. 179.
† Intr. i. 246.

not improbable that it may have been an insect (*Limnoria*, Leach) of another family, one species of which, according to the same authors, "in point of rapidity of execution seems to surpass all its European brethren, and in many cases may be productive of more serious injury than any of them, since it attacks the wood-work of piers and jetties constructed in salt water, and so effectually, as to threaten the rapid destruction of those in which it has established itself. In December, 1815, I was favoured by Charles Lutwidge, Esq. of Hull, with specimens of wood from the piers at Bridlington Quay, which wofully confirm the fears entertained of their total ruin by the hosts of these pigmy assailants, that have within a few years made good a lodgment in them, and which, though not so big as a grain of rice, ply their masticating organs with such assiduity, as to have already reduced great part of the wood-work into a state resembling honey-comb. One specimen was a portion of a three-inch fir plank nailed to the North Pier about three years since, which is now crumbled away to less than an inch in thickness: in fact deducting the space occupied by the cells, which cover both surfaces as closely as possible, barely half an inch of solid wood is left; and though its progress is slower in oak, that wood is equally liable to be attacked by it. If this insect were easily introduced to new stations, it might soon prove as destructive to our jetties as the Teredo navalis to those of Holland, and induce the necessity of substituting stone for wood universally, whatever the expense; but happily it seems endowed with very limited powers of migration; for though it has spread along both the North and South Piers of Bridlington harbour, it has not yet, as Mr. Lutwidge informs me, reached the Dolphin, nor an insulated jetty within the harbour.

"The inhabitants of Bridlington may believe that this insect was left there a few years ago by an American vessel, with what foundation I know not; but that it is an imported insect, and, like the Teredo navalis, not originally an European animal, seems very probable from the fact, that I can find no description of any species of oniscus at all resembling it, prior to that of Dr. Leach, who seems first to have given it a name, and it appears highly improbable that if it had been an European species it should not long since have attracted attention and been described. No other remedy against its attacks is known, than that of keeping the wood free from salt water for three or four days, in which case it dies; but this method, it is obvious, can be rarely applicable. In order to ascertain how far pure sea-water is essential to this insect, and consequently what danger exists of its being introduced into the wood-work of our docks and piers communicating with our salt-water rivers, as at Hull, Liverpool, Bristol, Ipswich, &c., where it might be far more injurious than even on the coast, I have, since December 15th, 1815, when Mr. Lutwidge was so kind as to furnish me with a piece of oak full of insects in a living state, poured a not very strong solution of common salt over the wood every other day, so as to keep the insects constantly wet. On examining it this day (February 5th, 1816), I found them alive; and what seems to prove them in as good health as in their natural habitat, numbers have established themselves in a piece of fir-wood which I nailed to the oak, and have in this short interval, and in winter too, bored many cells in it*."

* Intr. i. 238.

Chapter VII.

LAPPING INSECTS.

Those who have paid attention to a cat while lapping milk, may have remarked, that on darting out her tongue she bends the sides and point of it upwards, so as to form a sort of hollow scoop or spoon, sufficient to contain a considerable quantity of liquid. This is partly aided by the structure of the surface of the tongue itself, which is all over thickly studded with projecting denticulations * (if we may call them so), among which the particles of the liquid must be detained. This flexible and denticulated structure of the tongue gives to this family of animals a facility of lapping, which art would in vain attempt to imitate. Quadrupeds of other families, such as horses and oxen, drink not by lapping, but by sucking.

In insects again, with which we are more immediately concerned, somewhat similar varieties of structure and habits prevail. The first instance which occurs to our recollection, as forming a sort of link between eating and lapping insects, is in the ant family (*Formicidæ*, Leach). "When ants," says the younger Huber, "are disposed to drink, there comes out from between their lower jaws, which are much shorter than the upper, a minute, conical, fleshy, yellowish organ, which performs the office of a tongue, being pushed out and drawn in alternately: it appears to proceed from

* Figured in Menageries, vol. i. p. 179.

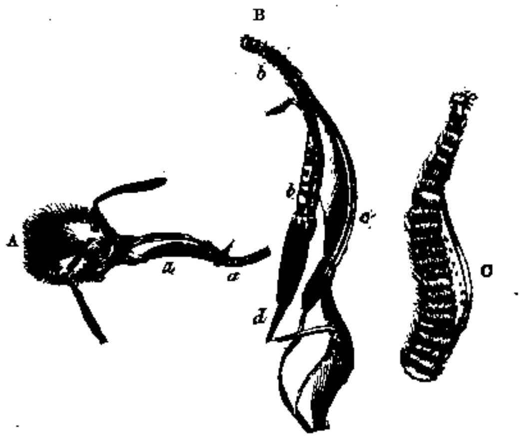
the lower lip, which itself has the power of moving forwards in conjunction with the lower jaws: and when the insect wishes to lap, all this apparatus moves forward; so that the tongue, which is very short, does not require to lengthen itself much to reach the liquid *.

It requires, however, very minute observation to see this, and it was only after many fruitless trials that we succeeded in verifying the fact. The method we found most convenient was to place one or more ants withinside an inverted wine-glass, upon the inner edge of which a drop of water had been put. By means of a pocket magnifying-glass, they can then be observed without disturbing them, for notwithstanding their anxiety to escape from confinement, they will greedily drink of whatever fluid may be presented to them, and, when satiated, will renew their efforts to get out †.

In the case of bees, such minute observation is not required, as their organs are large and conspicuous; and while they are collecting the nectar of flowers or sipping honey, which may be offered to them, we can readily perceive their long, glittering tongue darted out from its sheath, and busy in performing its office. But as this is an organ of no little interest, it may be well to describe it a little more in detail. It consists of no less than five distinct branches,—a central piece of four horny scales, which constitutes the tongue, tapering to a point, convex outwards, and concave on the side facing the trunk; the two outer ones sheathing the inner ones so as to appear but one single tube; by a joint in the middle they bend, or extend all at once, carrying with them the unjointed tongue, which is cylindrical, and about the size of a hair: seen through a magnifier, it appears to be composed

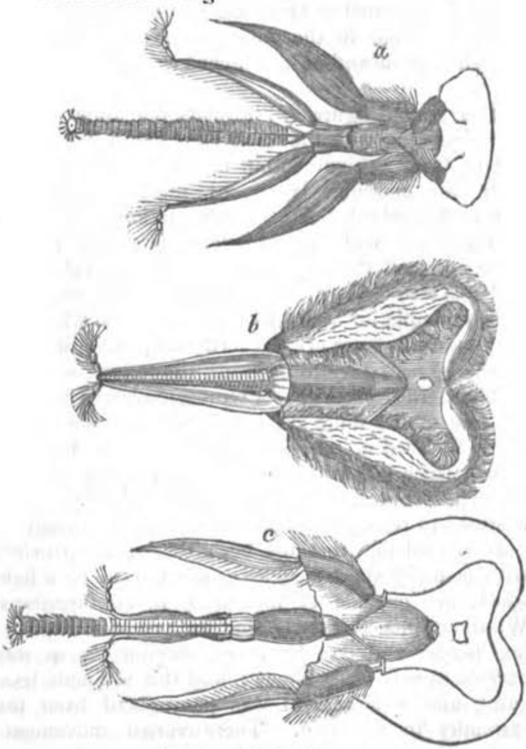
* Huber on Ants, p. 4; &c. † J. R.

of successive rings. If we hold a bee between the fingers, we can easily perceive a kind of brown, shining instrument, curved like a surgeon's needle, folded closely down from the mouth towards the throat, where it terminates in a point. At the pleasure of the bee this instrument can be projected forward either in a curved or straight form, so as to resemble the beak of a bird. The sheath, or



Tongue of the bee. A, *a a*, tongue. B, *b b*, tongue; *c*, sheath of the tongue; *d*, muscles for moving the tongue. C, tongue greatly magnified.

rather sheaths, for there are two, of the bee's tongue are considerably different from similar organs in other insects, one of these covering scarcely half its length, and the other not extending quite round the circumference. Each of the sheaths consists of two pieces, which may be called the demi-sheath. In order to see these different pieces distinctly, and the ingenuity of their arrangement, it is necessary to squeeze them gently at their origin, so as to make them protrude, when its apparently simple structure will disappear, and the five pieces come plainly into view. As a detailed description of this complicated apparatus could not well be made intelligible without magnified figures, we shall give such as appear to us most interesting.



Structure of the bee's tongue.

The first of these figures (*a*) represents the upper side of the whole apparatus, the sheaths being opened and spread out on either side, and the tongue stretched out to its greatest elongation. The latter is seen to terminate in a sort of button, fringed with a circle of hairs, as are the rings of the tongue (above forty in number) to its very base. These hairs are no doubt intended to brush off and secure the honey which is found in the cups of flowers, and a more efficient and beautiful instrument we could not conceive.

The second figure (*b*) exhibits the under side of the apparatus with the tongue lodged in the sheath, arising from a pivot within the head, and furnished with two muscular levers, by means of which it can be elongated. At the termination, the sheath is furnished with two small divaricating feelers, if we may call them so, consisting of several joints, and covered with a few scattered hairs, intended, it is probable, to assist its tactile powers, which we may naturally infer are put forth to ascertain whether it may be necessary to unsheath the tongue itself.

The third figure (*c*) is a representation of the under side of the same apparatus, but with the tongue partly inclosed in the inner sheath. At the base the pivot (which is pushed back in the first figure) may be seen advanced by means of the muscular levers, destined to regulate the movements of the tongue.

It is probable that the bee's tongue is furnished with as many short muscles as the tongue of a fish, which are capable of moving it in all directions. Wildmau, indeed, asserts that he has seen it growing bigger and less by turns, swelling as it was exerted in collecting honey; and this alternate lessening and enlargement was propagated from the extremity to the root. These varied movements and alterations of form and positiou are admirably fitted for its visiting every corner of the nectaries of flowers, many of them of such difficult access, that it has been said, by more than one respectable naturalist, that the bees eat their way into them by means of their jaws. We have only to look at the deeply curved nectaries of larkspur (*Delphinium*), or columbine (*Aquilegia*), to see, in a striking light, this beautiful contrivance of Providential wisdom in the tongue of the bee.

A, Larkspur (*Delphinium choilanthum*); B, Columbine (*Aquilegia bicolor*); showing the horn-shaped nectaries.

The bee can unfold, with great rapidity, its apparatus for lapping, and dart it into every part of a flower where it discovers the presence of honey; and can with equal ease sweep the convex and concave sides of a flower. When it has thus collected a sufficient quantity, it is first deposited in a sort of membranous bag capable of considerable inflation, previous to its being swallowed and consigned to the honey-stomach. But no sooner is its office performed, than it is as rapidly sheathed as it had been unfolded; for, in consequence of its length, it would be exposed to injury without this important provision. When at rest, therefore, it is doubled up by means of its joint, and lies in a very small compass, the first portion being brought within the lip, and a second part folded under the head and neck. It is altogether different then from the tubular sucking tongue of a fly, being imperforate and only fitted for lapping; while the insect is at the same time furnished with mandibles of similar structure to those of the eating insects described in the preceding chapter.

Having thus entered so minutely into the structure of the tongue of the bee, it will be unnecessary to describe in detail the similar organs of some other families, more particularly as these seem to be of inferior interest, at least so far as we have examined them. The wasps (*Vespidæ*), which so nearly resemble bees both in habits and in general appearance, are greatly different in the development of these organs, the tongue being small, while the mandibles, on the other hand, are large, and more like the insects which we have considered in the preceding chapter as exclusively eaters. They are accordingly better known for their depredations on fruit, than for feeding in the manner of bees; yet are they very fond of sweet things, since they will plunder bee-hives of their honey (though they will not take the trouble of collecting it from flowers), and they frequently devour great quantities of sugar. Kirby tells us, that a tradesman of his acquaintance calculated his loss of sugar in one year, by wasps alone, at twenty pounds sterling*. Wasps, besides, are insects of prey, and in France, Réaumur says, the butchers are glad to have wasps attend their stalls for the sake of their services in driving away the blow-flies; for a similar purpose the Americans sometimes suspend a hornet's nest in their parlour†.

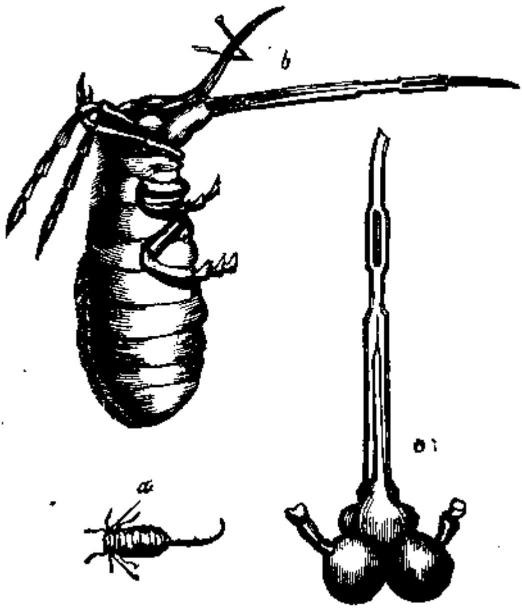
* Intr. i. 228. † St. John's Letters of an American Farmer.

Chapter VIII.

SUCKING INSECTS.

We have elsewhere remarked that, "the beak *(haustellum)* of an aphis is no more fitted for lapping honey-dew, than the bill of Æsop's crane was for eating out of a shallow plate*." The mere inspection of one of these insects with a pocket magnifier will be sufficient to demonstrate the position; but, for the sake of illustration, we shall give a few details, and for that purpose we shall select the brown aphis of the oak (*Aphis Quercus*, Linnæus), in which, from its being much larger than its congeners, the parts are more conspicuous. The sucker in this insect is much longer than the body, and, when unemployed, is carried between the legs close to the belly, extending behind the insect, like a tail slightly curved upward. The instrument consists of a transparent tube, terminating in a hole so minute, that Réaumur could not discover it with his most powerful microscopes, but easily proved its existence by pressing out from it a drop of fluid. By means of pressure, also, he could render more obvious two instruments of a brownish colour contained in the sucker, and which he conjectured to act like the piston of a pump; though from their minuteness this could not be correctly ascertained. We might suppose them to act as perforators, were it not that the point of the sucker itself seems sufficiently adapted to that purpose. The figures which we have here given will render our description easily understood.

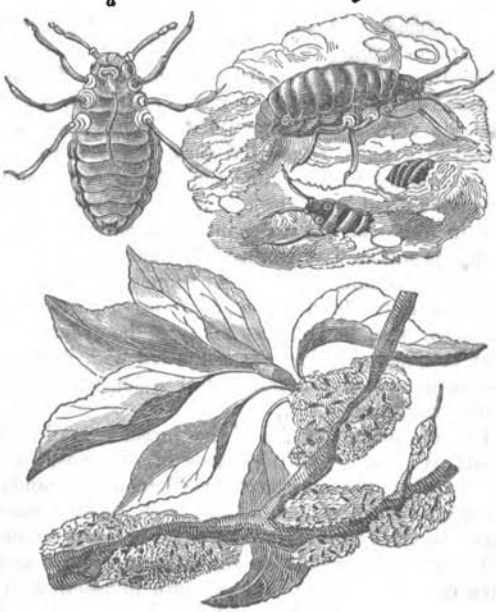
* Insect Transf. p. 18.



Aphis Quercus. *a*, real size, showing the sucker bent under it like a tail; *b*, magnified; *c*, sucker magnified.

With so efficient an instrument for wounding plants, we need not wonder that a race so countlessly numerous as the aphides effect most destructive ravages in the vegetable kingdom. The serious ravages of the dolphin, or collier (*Aphis Fabæ*), on the bean crop, and of the hop-fly (*A. Humuli*) in hop-grounds, are but too well known. Of late years another of these pests, called the American, or white, blight (*Aphis lanigera*, ILLIGER; *Eriosoma Mali*, LEACH), has been extensively destructive to our apple-trees. According to Mr. Knapp's information, it was first observed in the West of England, in 1819, in the nursery gardens of Messrs. Millar and Sweet, near Bristol, introduced, as was supposed, by some imported plant*. Salisbury, on the other hand, says, "I have from good authority heard that it was brought to this country from France in the reign of Louis XIV., when a colony of refugees settled at Paddington, and there it was first observed to begin its depredations on the apple-trees.

a b



c

Eriosoma mali. a, b, the insects magnified. c, an infected apple branch

* Journal of a Naturalist, p. 341; Note.

I am in some measure warranted in my belief, that the insect in question was introduced from France, as an old French gardener who worked in my garden stated that he was well acquainted with the bug, as he termed it, since his childhood, and that it had been the destruction of many fruits, not apples in particular, in the neighbourhood of Montpelier, where he had been brought up*." We have ourselves seen the insect in the orchards about Harfleur, in Normandy†; and M. Blot informs us that it is exceedingly destructive to the apple-trees in the department of Calvados‡.

Sir Joseph Banks traced the supposed first appearance of the insect to a nursery in Sloane-street, Chelsea; and, upon being informed that it was unknown in France, concluded that it was most probably imported from North America, with some apple-trees which had been brought over to that nursery. But, in whatever way it originated, it spread rapidly, though it was at first confined to the vicinity of the metropolis, where it destroyed thousands of trees§. Subsequently it found its way into other parts of the kingdom, and, in 1810, so many of the cyder apple-trees in Gloucestershire were infested with it, that it was apprehended the making of cider would have to be abandoned.

The particular history of the insect is well given by Mr. Knapp. "In the spring of the year," says he, "a slight hoariness is observed upon the branches of certain species of our orchard fruit. As the season advances, this hoariness increases; it becomes cottony, and, toward the middle or end of summer, the under sides of some of the branches are invested with a thick, downy substance, so long, as at times to be

* Hints on Orchards, p. 39. † J. R.
‡ Mem. Société Linn. de Caen pour 1824, p. 104.
§ Trans. Hort. Soc., ii. 162.

sensibly agitated by the air. Upon examining this substance, we find that it conceals a multitude of small wingless creatures, which are busily employed in preying upon the limb of the tree beneath. This they are well enabled to do, by means of a beak terminating in a fine bristle, which, being insinuated through the bark and the sappy part of the wood, enables the creature to extract, as with a syringe, the sweet, vital liquor that circulates in the plant. The sap-wood (*Alburnum*) being thus wounded, rises up in excrescences and nodes all over the branch, and deforms it; the limb, deprived of its nutriment, grows sickly; the leaves turn yellow, and the part perishes. Branch after branch is thus assailed, until they all become leafless, and the tree dies.

"Aphides attack the young and softer parts of plants; but this insect seems easily to wound the harder bark of the apple, and by no means makes choice of the most tender parts of the branch. They give a preference to certain sorts, but not always the most rich fruits; as cider apples aud wildings are greatly infested by them, and, from some unknown cause, other varieties seem to be exempted from their depredations. The Wheeler's-russet and Crofton-pippin I have never observed injured by them. This insect is viviparous, or produces its young alive*, forming a cradle for them by discharging from the extremities of its body a quantity of long, cottony matter, which, becoming interwoven and entangled, prevents the young from falling to the earth, and completely euvelops the parent and the offspring. In this cottony substance, we observe, as soon as the creature becomes animated in spring, aud as long as it remains in vigour, many round pellucid bodies, which, at first sight, look like eggs, only that they are larger than we might suppose to be ejected by the

* See Insect Transformations, p. 112.

animal. They consist of a sweet glutinous fluid, and are probably the discharges of the aphis, and the first food of its young. That it is thus consumed, I conjecture from its diminution, and its by no means increasing so fast as fæcal matter would do, from such perpetually feeding creatures. I have not, in any instance, observed the young to proceed from these globular bodies, though they are found of various ages at all times during the season. This lanuginous vestiture seems to serve likewise as a vehicle for dispersing the animal; for, though most of our species of aphides are furnished with wings, I have never seen any individual of this American blight so provided; but the winds, wafting about small tufts of this downy matter, convey the creature with it from tree to tree throughout the whole orchard. In the autumn, when this substance is generally long, the winds and rains of the season effectually disperse these insects, and we observe them endeavouring to secrete themselves in the crannies of any neighbouring substance. Should the savoy cabbage be near the trees whence they have been dislodged, the cavities of the under sides of its leaves are commonly favourite asylums for them. Multitudes perish by these rough removals, but numbers yet remain, and we may find them in the nodes and crevices, on the under sides of the branches, at any period of the year, the long cottony vestore being removed; but still they are enveloped in a fine, short, downy clothing, to be seen by a magnifier, proceeding apparently from every suture, or pore, of their bodies, and protecting them in their dormant state from the moisture and frosts of our climate. This aphis, in a natural state, usually awakens and commences its labours very early in the month of March; and the hoariness on its body may be observed increasing daily; but if an infected branch be cut in winter, and kept in a warm room, these aphides will awaken speedily, spin their cottony nests, and feed as they are accustomed to do in the genial season *."

With numerons facts of a similar kind on record, it was a singular oversight in Mr. Swainson, to state that sucking insects "can do no injury to the agriculturist †."

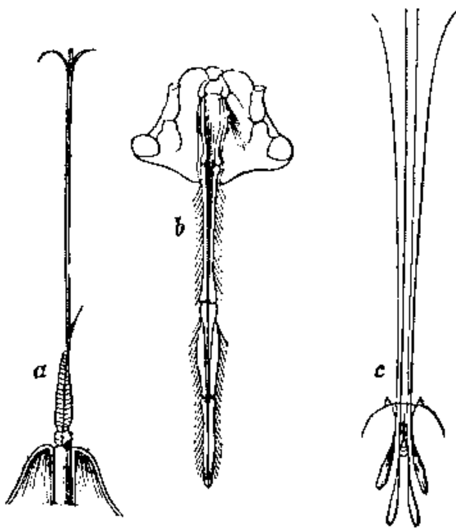
A numerous family of a different order of insects is but too well known, both in gardens and houses, under the general name of bugs (*Cimicidæ*, LEACH); most, if not all the species, being distinguished by an exceedingly disagreeable smell, particularly when pressed or bruised. Their sucking instrument has been so admirably dissected and delineated by M. Savigny, in his Theory of the Mouth of Six-legged (*hexapod*) Insects ‡, that we cannot do better than follow so excellent a guide. In the figure (*b*) is a view of the nnder side of the head of the black-horned bug (*Cimex nigricornis*, FABR.), exhibiting the sucker in its sheath, directed backwards, which is its natural position during repose. The sheath is composed of fonr pieces, which, according to Savigny's Theory, represent an under lip much prolonged. The edges bend dowuwards, and form a canal for receiving the four bristles, which he supposes to correspond with the two mandibles and the two lower jaws. In the figure (*a*) the sheathed upper lip, and the four bristles placed together and drawn out of their sheath, are presented from above; and in the third figure (*c*) the four bristles (representing the upper and lower pair of jaws) are developed so as to exhibit them separately. It is probable that the two middle ones act as piercers, while the other two, being curved at the

* Journal of a Naturalist, 341.

† Loudon's Encycl. of Agricult. page 1113, 2d edition.

‡ Mem. Anim. sans Vertèbres, i. 36.

extremity (though not at all times naturally so), assist in the process of suction.



Suckers of the black-horned bug (*Cimex nigricornis*).

The plant-bugs are all furnished with wings and membranous wing-cases, and many of them are of considerable size, and decked in showy colours; differing in all these points from their congener, the bed-bug (*Cimex lectularius*), which is small, without wings, and of a dull uniform brown. The name is derived from the same root as *bug*-bear, and hence the passage in the Psalms, "thou shalt not be afraid of *the terror* by night*," is rendered in Matthew's Bible "thou shalt not nede to be afraide of any *bugs* by

* Psalms, xci. 5.

night." In earlier times, indeed, this insect was looked upon with no little fear, no doubt because it was not so abundant as at present. "In the year 1503," says Mouffet, "Dr. Penny was called in great haste to a little village, called Mortlake, near the Thames, to visit two noblemen, who were much frightened by the appearance of bug-bites, and were in fear of I know not what contagion; but when the matter was known, and the insects caught, he laughed them out of all fear *." This fact, of course, disproves the statement of Southall, that bugs were not known in England before 1670. Linnæus was of opinion, however, that it is not originally a native of Europe, but has been imported from America. Be this as it may, it seems to thrive but too well in our climate, though it multiplies less in Britain than in the warmer regions of the continent, where it is also said to grow to a larger size, and to bite more keenly. We never observed this insect in Ireland †.

But even in our own island these obtrusive insects often banish sleep. "The night is usually the season when the wretched have rest from their labour; but this seems the only season when the bug issues from its retreats to make its depredations. By day it lurks, like a robber, in the most secret parts of the bed; takes the advantage of every chink and cranny, to make a secure lodgment; and contrives its habitation with so much art that it is no easy matter to discover its retreat. It seems to avoid the light with great cunning; and even if candles be kept burning, this formidable insect will not issue from its hiding-place. But when darkness promises security, it then issues from every corner of the bed, drops from the tester, crawls from behind the arras, and travels, with great assiduity, to the unhappy patient who vainly wishes for rest and refreshment. It is generally vain to destroy

* Theatr. Insect, 270. † J. R.

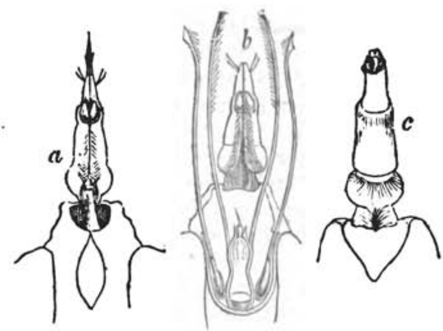
one only, as there are hundreds more to revenge their companion's fate; so that the person who thus is subject to be bitten (some individuals are exempt) remains the whole night like a sentinel upon duty, rather watching the approach of fresh invaders than inviting the pleasing approaches of sleep *." Mouffet assures us, that against those enemies of our rest in the night our merciful God hath furnished us with remedies, which we may fetch out of old and new writers, either to drive them away or kill them †. The following is given as the best poison for bugs, by Mr. Brande of the Royal Institution:—Reduce an ounce of corrosive sublimate (*Perchloride of mercury*), and one ounce of white arsenic, to a fine powder; mix with it one ounce of muriate of ammonia in powder, two ounces each of oil of turpentine and yellow wax, and eight ounces of olive oil: put all these into a pipkin, placed in a pan of boiling water, and when the wax is melted, stir the whole, till cold, in a mortar ‡.

Though most people, however, dislike this insect, others regard it not only with apathy but with protecting care; at least, one gentleman would never suffer them to be disturbed, or his bedsteads removed, till in the end they swarmed to an incredible degree, crawling up even the walls of his drawing-room; and after his death, millions were found in his bed and chamber furniture §. In the Banian hospital, at Surat, the overseers are said frequently to hire beggars from the streets, at a stipulated sum, to pass the night among bugs and other vermin, on the express condition of suffering them to enjoy their feast without molestation ‖.

The bed-bug is not the only one of its congeners which preys upon man. St. Pierre mentions a bug,

* Goldsmith, Anim. Nature, iv. 198. † Theatr. Insect.
‡ Materia Medica, Index.
§ Nicholson's Journ. xvii. 40. ‖ Forbes, Oriental Mem. i.

found in the Mauritius, the bite of which is more venomous than the sting of a scorpion, being succeeded by a swelling as big as the egg of a pigeon, which continues for four or five days *. Ray tells us that his friend Willughby had suffered severe temporary pain, in the same way, from a water-bug (*Notonecta glauca*, LINN.) †. The instrument employed by some of the water-bugs appears, from Savigny's dissections, to be still more formidable than the preceding.



Magnified figures of the sucker of a water-bug (*Nepa neptunia*). *a*, the sucker in its sheath; *b*, the several parts developed, so as to exhibit them separately; *c*, the sucker unsheathed.

From another pertinacious insect, the flea (*Pulex irritans*, LINN.), being without wings, some of our readers may suppose it to be nearly allied to the bed-bug; though the former does not even belong to the same order, but to a new one (*Aphaniptera*, KIRBY), established on the principle that the wings are obsolescent or inconspicuous. As we have elsewhere mentioned several extraordinary feats of strength recorded of fleas by various authors ‡, we shall here

* Voyage to the Isle of France. † Hist. Insect. 58.
‡ Insect Transformations, p. 180.

give our own testimony to a similar fact, which we have just witnessed. At the fair of Charlton, in Kent, 1830, we saw a man exhibit three fleas, harnessed to a carriage in form of an omnibus, at least fifty times their own bulk, which they pulled along with great ease; another pair drew a chariot; and a single flea a brass cannon! The exhibitor showed the whole first through a magnifying glass, and then to the naked eye; so that we were satisfied there was no deception. From the fleas being of large size, they were evidently all females *.

It is rarely, however, that we meet with fleas in the way of amusement; unless we are of the singular humour of the old lady mentioned by Kirby and Spence, who had a liking to them, because, said she, "I think they are the prettiest little merry things in the world; I never saw a dull flea in all my life †." When Ray and Willughby were travelling, they found "at Venice and Augsburg fleas for sale, and at a small price too, decorated with steel or silver collars ronnd their necks, of which Willughby purchased one. When they are kept in a box amongst wool or cloth, in a warm place, and fed once a day, they will live a long time. When they begin to suck they erect themselves almost perpendicularly, thrusting their sucker, which originates in the middle of the forehead, into the skin. The itching is not felt immediately, but a little afterwards. As soon as they are full of blood, they begin to void a portion of it, and thus, if permitted, they will continue for many hours sucking and voiding. After the first itching no uneasiness is subsequently felt. Willughby's flea lived for three months by sucking in this manner the blood of his hand; it was at length killed by the cold of winter ‡."

From this narrative, we should say that it was not

* J. R.

† Intr. i. 102.

‡ Ray, Hist. Insect., p. 8.

without good reason that two eminent naturalists have arranged fleas in a group, called, by way of emiuence, suckers (*Suctoria*, De Geer; *Sucœurs*, Latreille).

According to Mouffet's account of the sucker of the flea, "the point of his nib is something hard, that he may make it enter the better; and it must necessarily be hollow, that he may suck out the blood and carry it in*." Modern authors, particularly Straus and Kirby, show that Rösel was mistaken in supposing this sucker to consist of two pieces, as it is really made up of seven. First, there are a pair of triangular instruments, somewhat resembling the beak of a bird, inserted on each side of the mouth, nnder the parts which are generally regarded as the antennæ. Next, a pair of long sharp piercers (*Scalpella*, Kirby), which emerge from the head below the preceding instruments: and a pair of feelers (*palpi*), cousisting of four joints, are attached to these near their base. In fine, there is a long, slender tongue, like a bristle, in the middle of these several pieces.

Suckers of the flea, greatly magnified. *a*, side view; *b*, under side; *c*, upper side.

According to Mouffet, also, "the lesser, leaner, and younger they are, the sharper they bite, the fat ones being more inclined to tickle and play; and then are not the least plague, especially when in greater numbers, since they molest men that are

* Theatre of Insects, p. 1102.

sleeping, and trouble wearied and sick persons; from whom they escape by skipping; for as soon as they find they are arraigned to die, and feel the finger coming, on a sudden they are gone, and leap here and there, and so escape the danger; but so soon as day breaks, they forsake the bed. They then creep into the rough blankets, or hide themselves in rushes and dust, lying in ambush for pigeons, hens, and other birds, also for men and dogs, moles and mice, and vex such as passe by. Our hunters report that foxes are full of them, and they tell a pretty story how they get quit of them. The fox, say they, gathers some handfuls of wooll from thorns and briars, and wrapping it up, he holds it fast in his mouth, then goes by degrees into a cold river, and dipping himself close by little and little, when he finds that all the fleas are crept so high as his head for fear of drowning, and so for shelter crept into the wool, he barks and spits out the wool ful of fleas, and so very froliquely being delivered from their molestation, he swims to land *."

This is an excellent trick certainly for a flea-bitten fox on a summer's day; but a little more doubtful even than the story told of Christina, Queen of Sweden, who is reported to have fired at the fleas with a piece of artillery, still exhibited in the royal arsenal at Stockholm †. Her Majesty ought to have made an expedition to Tiberias, where, as an Arab Sheikh informed Dr. Clarke, "the king of the fleas held his court ‡." Nor are fleas confined to the old continent, for Lewis and Clarke § found them exceedingly harassing on the banks of the Missouri, where it is said the native Indians are sometimes compelled to shift their quarters, to escape their annoyance. They are not ac-

* Theatre of Insects, p. 1102.

† Linnæus, Lachesis Lapon., ii. 32; Note *.

‡ Travels, vol. ii.

§ Travels.

quainted, it would therefore seem, with the device of the shepherds in Hungary, who grease their clothes with hog's lard to deter the fleas,—nor with the old English preventive:—

> "While wormwood hath seed, get a handful or twaine
> To save against March to make flea refraine:
> Where chamber is swept and wormwood is strown,
> No flea for his life dare abide to be known *."

Linnæus was in error in stating that the domestic cat (*Felis maniculatus*, TEMMINCK?) is not infested with fleas; for in kittens in particular they abound as numerously as upon dogs †.

Fleas, it may be worth remarking, are not all of one species, those which infest animals and birds differing in many particulars from the common bed flea (*Pulex irritans*), and as many as twelve distinct sorts have been found in Britain alone ‡. The most annoying species, however, is fortunately not indigenous, being a native of the tropical latitudes, and variously named in the West Indies, chigoe, jigger, nigua, tungua, and pique (*Pulex penetrans*, LINN.)

Chigoe (*Pulex penetrans*).

According to Stedman, this "is a kind of small sand-flea, which gets in between the skin and the flesh without being felt, and generally under the nails of the toes; where, while it feeds, it keeps growing till it

* Tusser, Points of Goode Husbandry. † J. R.
‡ Insect Transformations, p. 393.

becomes of the size of a pea, causing no further pain than a disagreeable itching. In process of time its operation appears in the form of a small bladder, in which are deposited thousands of eggs, or nits, and which, if it breaks, produce so many young chigoes, which in course of time create running ulcers, often of very dangerous consequence to the patient; so much so indeed, that I knew a soldier, the soles of whose feet were obliged to be cut away before he could recover: and some men have lost their limbs by amputation, nay, even their lives, by having neglected, in time, to root out these abominable vermin. The moment, therefore, that a redness and itching more than usual are perceived, it is time to extract the chigoe that occasions them. This is done with a sharp-pointed needle, taking care not to occasion unnecessary pain, and to prevent the chigoe from breaking in the wound. Tobacco ashes are put into the orifice, by which in a little time the sore is perfectly healed *." Old Ligon tells us that in this way he had ten chigoes taken out of his feet in a morning "by the most unfortunate Yarico †," whose tragical story is so well known from the popular drama. Walton mentions that a Capuchin friar, in order to study the history of the chigoe, permitted a colony of them to establish themselves in his feet: but before he could accomplish his object, his foot mortified and had to be amputated ‡. No wonder that Cardan calls the insect "a very shrewd plague §."

Another troublesome sort of insects, less dangerous perhaps, though equally pertinacious, and more widely diffused than the chigoe, is the family of gnats (*Culicidæ*). Even these, however, sometimes produce formidable consequences; for M. Réaumur

* Stedman's Surinam; and Swartz, Swedish Trans., ix. 40.
† History of Barbadoes, p. 65. ‡ Walton's Hispaniola.
§ Subtilis. lib. ix.

says, "I have seen in marshy districts on the sea coast, individuals whose arms and legs were rendered shocking with the reiterated bites of gnats, and some of them so bad, that it was doubtful whether they could be cured without amputating the limb*." He adds, that if we will exert a little patient attention, we shall be compelled to admire the very instrument with which the insect wounds us. The elder Pliny becomes more than usually eloquent upon the structure of this insect. "In these so little bodies," he says,—"nay, points or specks, rather than bodies indeed,—how can one comprehend the reason, the power, and the inexplicable perfection that Nature hath therein shewed? How hath she bestowed all the five senses in a gnat? and yet some there be lesse creatures than they. But where, I say, hath she made the seat of the eyes to see before it? Where hath she set and disposed the taste? Where hath she placed and inserted the organ of smelling? and above all, where hath she disposed that dreadful and terrible noise that it maketh—that wonderful great sound, as I may call it, in proportion to so little a body? Can there be devised a thing more finely and cunningly wrought than the wings set to her body? Mark, what long shanked legs above ordinary, she hath given unto them. See, how she hath set that hungry hollow concavitie instead of a belly: and hath made the same so greedie and thirstie after blood, and man's especially. Come to the weapon that it hath to pricke, pierce, and enter through the skinne; how artificially hath she pointed and sharpened it! and being so little as it is, for the fineness thereof can hardly be seen, yet as if it were of bignesse and capacity answerable, framed it, she hath, most cunningly for a two-fold use, to wit, most sharpe pointed to pricke and enter, and withall, hol-

* Mém. iv. 573.

low like a pipe to sucke in and convey the blood through it*."

It is not a little singular that notwithstanding the early attention which was thus given to the sucker of the gnat, authors are by no means agreed as to its structure; and even a recent author of talent, M. Robineau Desvoidy †, has rather added to former errors than contributed to expunge them. The most accurate details and figures are those of Réaumur and Roffredi, which we shall chiefly follow. To the naked eye, the sucker of the gnat appears like a needle finer than a hair, solid and pointed; but the microscope shows that what appeared so simple, is really compound and complicated. It consists, according to Leeuwenhoeck of *four* pieces; Swammerdam found *six*, including the lip; but Réaumur says there are only *five*. It may be that their observations were made upon different species, or upon individuals which had sustained accidental mutilation. Swammerdam, indeed, mentions that he often observed in dead gnats the suckers broken off from their case ‡. This case or sheath is divided in its whole length, enclosing an apparatus of five piercers or lancets (*Scalpella*), with which it cuts into the skin. "After a gnat," says Réaumur, "had done me the honour of settling on my hand, I perceived that it put forth a very fine point from its sucker, with the end of which it felt four or five spots of my skin, apparently with the design of discovering where it could obtain the most blood with the least trouble §." This fine point, Swammerdam imagined to be simple and indivisible, and says, "the point is so sharp that I could never observe the least breadth in it with the best microscopes I could procure, though if you put the edges of the sharpest razors, or the points of the

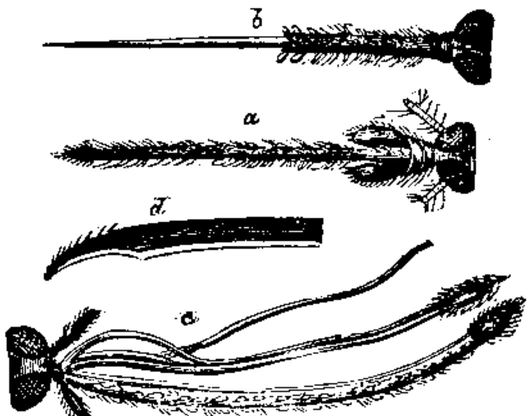
* Holland's Plinie, xi. 2.

† Mém. Soc. d'Hist. Nat. de Paris, iii. 390.

‡ Biblia Nat. i. 157.

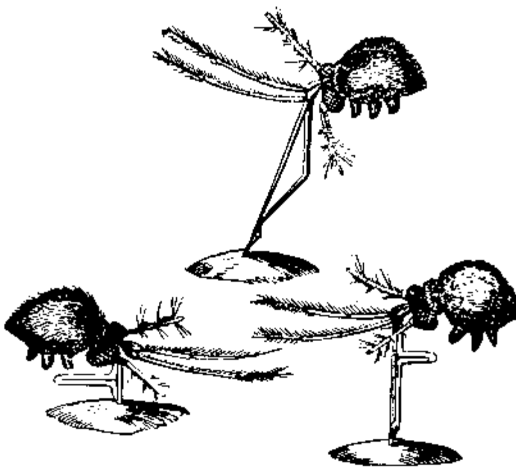
§ Mém. iv. 583.

finest needles or lancets before the microscope, you will easily see that they have visible breadth, and appear blunt, ragged, and dull." But Réaumur is not a little surprised at this, for Leeuwenhoeck and himself found this fine point composed of several needles, some of them barbed with teeth, as may be verified by pressing the instrument between the fingers. The magnified figures will give a clearer idea of the organ than the most minute description.



Magnified figures of the sucker of the gnat: *a*, the sucker in its sheath *b*, half of the sheath broken off to show the sucker; *c*, the sucker developed to show its several parts; *d*, the barbed point of one blade of the sucker.

The sheath is composed of a flexible substance, and is employed, it would appear, for supporting and keeping steady the piercers during the process of penetrating into the skin. Besides this, Swammerdam says, " I should think that the acute and hollow extremity of the sheath is certainly introduced into the wound, and by means thereof the gnat afterwards sucks the blood, which running or ascending by suction between these parts, is at length conveyed into the stomach of the insect. Hence, there appears almost the same use of this sheath, as there is of the silver pipes (*canulæ*) used by surgeons, through which they pass their lancets into parts deep seated, in order to prevent their wounding any other part than that which they intend to cut *." Our readers will be better able to judge of the accuracy of these views, by inspecting the figures below of the different positions of the sheath in penetrating the skin.



Modes of operation of the gnat's sucker.

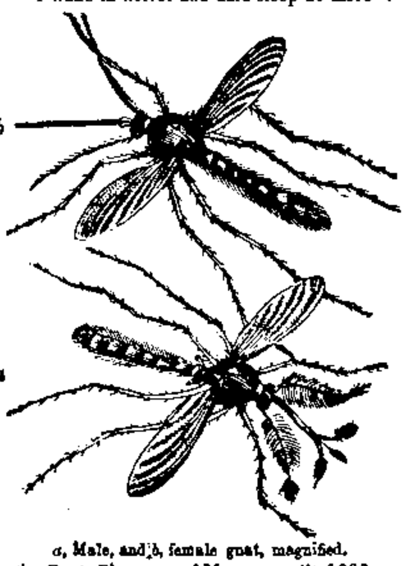
The mere wound, however, would not probably cause much uneasiness, were it not for the insertion at the same time of a sort of poisonous fluid, for the purpose, as Réaumur imagined, of thinning the blood, and rendering it thereby more easy to suck. If this conjecture be correct, we can thence understand why the pain and itching are not felt so acutely at first as some time afterwards. Rogers has given a

* Biblia Nat. i. 157.

lively sketch of the sanguinary proceedings of the gnat, when he had fallen asleep by a woodside, and was poetically dreaming of fairy-land:

" 'Tis thine to range in busy quest of prey
  Thy feathery antlers quivering with delight,
Brush from my lids the hues of heaven away,
  And all is solitude, and all is nigh!
Ah, now thy barbed shaft, relentless fly
  Unsheaths its terrors in the sultry air!
No guardian sylph, in golden panoply,
  Lifts the broad shield and points the sparkling spear.
Now near and nearer rush the whirring wings,
  Thy dragon scales still wet with human gore,
Hark, thy shrill horn its fearful larum rings,
  I wake in horror and dare sleep no more*."

b



a

a, Male, and *b*, female gnat, magnified.

* To the Gnat, Pleasures of Memory, edit. 1806, p. 176.

The poet has here fallen into one little error which a naturalist will perceive as readily as he himself would have detected a bad rhyme or a false quantity. It is only the male gnat which is adorned with "feathery antlers" (*antennæ*); and what is a very remarkable fact, this male gnat never sucks blood, the female alone, whose "antlers" are not "feathery," (see the distinction in the preceding two figures), being of a sanguinary disposition. Upon what then, it may be asked, do the males subsist? Kirby answers, "from the impossibility that one of a million of the innumerable swarms of gnats which abound in swampy places should ever taste blood, it seems clear that they are usually contented with vegetable aliment*." Swammerdam also says, "I am firmly persuaded that when the gnat has no opportunity of drawing blood out of animals, it sucks, with the help of its sheath, the juices of flowers, plants, or fruits, being content with feeding on the latter when the former is wanting†." But these distinguished naturalists should have recollected, that it is by no means indispensable for gnats to feed at all, the diminished capacity of their stomach and bowels‡ requiring little or no aliment during the very few days they are destined to live for the purpose of pairing and continuing their race.

Be this as it may, their pertinacity and numbers frequently render them a most formidable pest. Humboldt tells us, "that between the little harbour of Higuerote and the mouth of the Rio Unare, the wretched inhabitants are accustomed to stretch themselves on the ground, and pass the night buried in the sand three or four inches deep, exposing only the head, which they cover with a handkerchief§.

* Intr. i. 384. † Biblia Nat. i. 157.

‡ See Insect Transformations, p. 201.

§ Personal Narrative.

Stedman also mentions, as a proof of the dreadful state to which he and his soldiers were reduced by them, that they were forced to sleep with their heads thrust into holes made in the earth with their bayonets, and their legs wrapped round with their hammocks *. "The gnats in America," says Mouffet, "do so plash and cut, that they will pierce through very thick clothing; so that it is excellent sport to behold how ridiculously the barbarous people, when they are bitten, will skip and frisk, and slap with their hands their thighs, buttocks, shoulders, arms, and sides, even as a carter doth his horses †." Weld tells us that "these insects were so powerful and bloodthirsty that they actually pierced through General Washington's boots ‡." This does not appear very credible, though Mouffet says, "In Italy, near the Po, great store and very great ones are to be seen, terrible for biting, and venomous, *piercing through a thrice-doubled stocking, and boots likewise*, sometimes leaving behind them impoysoned, hard, blue tumours, sometimes painful bladders, sometimes itching pimples, such as Hippocrates hath observed in his Epidemics, in the body of one Cyrus, a fuller, being frantic §." When we consider these circumstances, we cannot justly discredit that they attacked so fiercely the army of Julian the Apostate as to drive him back; or that Sapor, king of Persia, as reported, should have been compelled to raise the siege of Nisibis by a plague of gnats, which, attacking his elephants and beasts of burden, so caused the route of his army ||.

At Oxford, during the summer of 1766, gnats were sometimes seen towards evening in such myriads as literally to darken the rays of the sun. Mr. Swinton mentions, that one evening, about half an

* Surinam, ii. 93. † Theatre of Insects, p. 955.
‡ Travels, p. 205. § Ut supra, p. 953.
|| Theodorit. Hist. Eccles. ii. 30.

hour before sun-set, he was in the garden of Wadham College, when he saw six columns of them ascending from the boughs of an apple-tree, some in a perpendicular, and others in an oblique direction, to the height of fifty or sixty feet. Their bite was attended with violent inflammation, and when one was killed after it had bit, the blood contained in it would cover three or four inches of wall *. About thirty years before this, vast columns of gnats were seen to rise in the air from Salisbury Cathedral, resembling, at a distance, columns of smoke, which made the people imagine the edifice was on fire†. At Sagau, in Silesia, in July, 1812, a similar occurrence gave rise in like manner to an alarm that the church was on fire‡. The poet Spenser says, the Irish "goe all naked except a mantle, which is a fit house for an outlaw—a meet bed for a rebel—and an apt cloak for a thiefe. It coucheth him strongly against the gnats, which, in that country, doe more to annoy the naked rebels, and doe more sharply wound them, than all their enemies' swords and speares, which can seldom come nigh them §." Elsewhere he gives another picture of the Irish gnats :—

——" When a swarme of gnats at eventide
Out of the fennes of Allan doe arise,
Their murmuring smal trumpets sownden wide,
Whiles in the air their clustering army flies,
That as a cloud does seem to dim the skies ;
Ne man nor beast may rest or take repast,
For their sharp wounds and noyous injuries,
Till the fierce northern wind with blustering blast
Doth blow them quite away and in the ocean cast ||."

It is worthy of remark that a numerous family

* Phil. Trans. 1767, pp. 111—118.

† Bingley, Anim. Biog. iv. 205.

‡ Germar, Mag. der Entomol. i. 137.

§ Spenser's View of Ireland. || Faerie Queene.

(*Culicidæ*) are confounded under the common names of gnat and musquito, as if there were only one or two species; whereas Mr. Stephens has enumerated twenty-two species of the genera *Culex* and *Anopheles*, found in Britain alone*; and hence it is probable, the foreign mosquitoes are also of several species, though to common observers they do not appear to differ from the common gnat (*Culex pipiens*).

Sucker of the cleg (*Hæmatopota pluvialis*): *a*, cleg, natural size; *b*, part of the head magnified; *c*, magnified still more, showing the facetted eye, the short antennæ, and the sucker unsheathed; *d*, the lancets, &c. of the sucker, separated to show their structure.

* Catalogue, ii. p. 232, 233; and Zool. Journ. i. 452, iii. 500.

The considerable difference of form must prevent the most indifferent observer from confounding gnats with the gad-flies (*Tabanidæ*). Their instrument of annoyance is also very different from that of the gnat, being much larger, more formidable, and not less skilfully adapted to its office. The figures will exhibit the difference at a glance.

Réaumur took advantage of his carriage being stopped in a narrow pass by some oxen, which were surrounded by gad-flies, to study the operation of one which alighted on his hand, by means of a magnifying-glass of considerable power. It gave him considerable pain, pierced a deep hole in his skin larger than the prick of a pin, and he afterwards found in the body of the insect seven or eight large drops of blood *. Lambert, in speaking of some fly of this order, says, " they are so very small as to be hardly perceptible in their attacks; and your forehead will be streaming with blood before you are sensible of being amongst them." Again he says, " I have sat down to write, and have been obliged to throw away my pen in consequence of their irritating bite, which has obliged me every moment to raise my hand to my eyes, nose, mouth, and ears, in constant succession †." It is very probable that our author here means a fly of a different family (*Stomoxydæ*, Meigen) from the preceding. One of these is so like the common house-fly (*Musca domestica*), as to be readily mistaken for it, though the house-fly has no organs fitted for penetrating the skin. Kirby says, " this little pest (*Stomoxys calcitrans*, Fabr.), I speak feelingly, incessantly interrupts our studies and comfort in showery weather, making us even stamp like the cattle by its attacks on our legs; and if we drive it away ever so often, it will return again and again to

* Mém. iv. 230. † Trav. through Canada, i. 126, 127.

the charge, and even contrives to make a comfortable meal through our silk or cotton stockings, by means of its horny, sharp-pointed weapon *." But this little phlebotomist is a solitary, not a social insect, like the house-fly, and seldom visits our apartments except when driven thither by bad weather †.

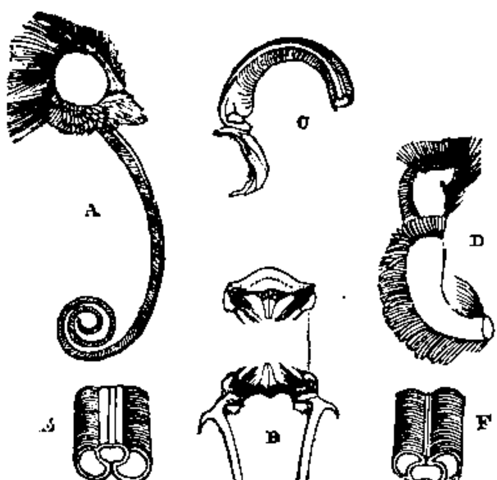
We have more than once alluded to the extraordinary change which takes place in the stomach and intestines of insects, when they pass from the infant to the perfect state; and have now to remark, that a similar change takes place in the organs of the mouth. In caterpillars, for example, the mouth is furnished with strong cutting mandibles, for feeding upon hard substances; while the moth or the butterfly, into which these are transformed, has only a tubular sucker, for absorbing the honey of flowers. But this change in the feeding organs, though so strikingly obvious, M. Savigny is not disposed to admit, proceeding upon the principle recently adopted in the French school, from hints found in Aristotle, Willis, and De Geer, which finds analogies and similarities in the members of animals the most remote from each other in structure and functions. The shell of the lobster, for example, is thus fancied to correspond to the bones of quadrupeds, not only in general, but in all its various pieces ‡; and the breast-fins of the whale are imagined to be analogies of the hands in man; the change being traced in successive gradations, from the ape, through the otter, seal, walrus, manati, and dugong, to the whale §. It may be well to hear what Savigny himself says on the subject immediately before us.

* Intr. i. 49—112. † J. R.

‡ Aristotle, Hist. Anim. iv.; Willis, De Anima Brutorum, p. 11; De Geer, Mem. ii, 2; Geoff. St. Hilaire, Mem. de l'Institute Franç.

§ Harwood, Brande's Journ.

Speaking of the suckers of butterflies, he remarks, that "the semblance is taken for the reality; for butterflies, in the same manner as their caterpillars, and as beetles, bees, and all eating insects (*broyeurs*), have two lips, one upper and one under; two mandibles; and two jaws (*machoires.*) This fact, though opposed to received opinions, is not the less certain. These parts, indeed, occupy their ordinary place. It is true they are so much shrunk and so much modified in their form and in their relative proportions, that it is not astonishing they have been misconconceived by excellent observers. How different soever these parts may appear from ordinary man-



Sucker, &c. of *Sphinx celerio*; greatly magnified.

A, Profile of the head, with the sucker unrolled. B, Upper lip and mandibles. C, Jaw and part of the sucker. D, Labial palpi. E, Portion of the sucker (A), showing the three tubes of which it is composed; viewed from above. F, The same parts, viewed from beneath.

dibles, it is impossible to refuse the name. Should an objection be raised from their substance, I have already said that they are horny, and although hollow within, they are more solid than the mandibles of certain beetles. Should their configuration be objected to, the conical form which they affect, is that of all mandibles; they have one point and one base distinct; and as they are fringed on their internal margin with numerous hairs, the mandibles of many bees and beetles are similarly fringed. Should we object to their mobility; it is answered, that though they are sometimes as it were glued (*soudées*), they are also sometimes articulated and distinctly moveable. Is their miuuteness objected to? The day-flies (*Ephemeridæ*) and water-flies (*Phryganidæ*) have mandibles smaller and more imperfect still, and yet nobody doubts that the latter ought to be placed among insects with jaws *."

From this extract our readers may learn the general principles of this doctrine, which is carried into minute details, derived from the very extensive and profound knowledge of the anthor. Althongh we may incline to believe these opinions more fanciful than just, and while we object to the hypothetical names given by M. Savigny, we readily acknowledge the very extraordinary accuracy of the dissections and figures which be has supplied in illustration.

* Mémoires sur les Anim. sans Vertèbres, i. 5.

SECTION III.

SOCIAL AND DOMESTIC HABITS OF INSECTS.

Chapter IX.

PAIRING OF INSECTS.

The diversity of character and habit exhibited by various animals, with regard to sociality, seems to have been originally impressed upon them by Providence, in conformity to their several wants, and the purposes they were designed to fulfil in the scale of creation. Those, for example, which have been intended to subsist by rapine are, for the most part, disposed to live solitary; and accordingly, the lion, the eagle, and the dragon-fly, pursue their prey alone, two individuals being rarely seen in the same circle. To this, however, there are some exceptions:—the most remarkable which occur to us take place among wolves, who often hunt in troops, as well as wild-dogs and jackalls; swallows, who congregate to hawk for flies; and spiders, of various species, whose nets are often spread contiguous to one another, sometimes even in contact. The latter appears the more singular, that spiders, though of the same species, have no hesitation in devouring one another when they can make a capture; but we have remarked, that those who weave snares, will not touch anything which they have not themselves entrapped;

and in an instance we have just been examining, of a garden spider (*Epeira diadema*) which had taken advantage of the suspensory cable line of a long-bodied spider (*Tetragnatha extensa*), to save itself the trouble of making an exterior frame-work for its net, it was not likely, considering their extreme vigilance, that either would fall into the other's toils*.

On the other hand, animals which feed on vegetables, or inanimate substances, usually incline to be gregarious, if not decidedly social; because, for one reason, the material of their food is, for the most part, in sufficient abundance to allow of this, and, in the instance of carrion, it is necessarily confined to a limited space. Accordingly, "Where the carcass is, there will the vultures be gathered together," though otherwise, the vulture is not perhaps more socially disposed than the eagle, or than the burying-beetles (*Necrophora*), which lend their assistance in destroying dead carcasses, and removing the nuisance they would produce. This congregating for the purpose of feeding seems, in some instances, to be either a cause, or a consequence, of social feelings and habits, which continue to influence the individuals when apart; and hence it is that a cow, or a sheep, will thrive better when amongst its fellows, than when kept in a cottage-paddock alnne. Eveu two or three are not coutent by themselves; and we have seen in such cases every effort made to leap hedges, and cross ditches and canals, by small groups of cows, desirous of associating with their kindred,—the parties on the opposite sides of the intervening obstacle appearing to be equally solicitous to surmouut it. Such endeavours have always reminded us of the Frenchman in the back settlements in Louisiana, who, if we may credit the Abbé du Pratz, annually travelled to

* J. R.

New Orleans, a distance of 300 miles, for no other purpose than to find people to talk with. In other cases, however, the habit of feeding or of travelling gregariously, does not produce a permanent influence; for the sky-lark (*Alauda arvensis*), and numerous other birds which congregate in winter, separate at the approach of the breeding season; while rooks, that breed in society, separate as soon as the young can provide for themselves. The latter, however, is perhaps peculiar to the rook; for sea-birds, which usually nestle together in great numbers, also continue to congregate all the year.

It would appear, then, from these illustrations, that animals generally congregate principally on account of the nature of their food; but it is also obvious, that even the most unsocial must lay aside some portion of their solitary habits during the breeding season, otherwise their race would soon become extinct. The proceedings of insects, in this respect, are so exceedingly different from all other orders of animals, that they will require to be exhibited in some detail. We have headed this chapter by the word "pairing" as the only unobjectionable term we could find; yet if the idea formed of this, from the habits of most birds, be transferred to insects, it will require great modification to render it applicable; for we question whether any species of insect can be said to pair in the manner of linnets, sparrows, and other birds, upon the principle of mutual assistance in rearing their progeny. Even in the instance of birds, the male always shows less solicitude in building the nest and feeding the young, than the female, his chief office appearing to be the feeding of the female while she sits upon the eggs, or the taking of her place while she procures food for herself.

Amongst insects, however, we are not aware of any assistance ever rendered by the male in any of those circumstances; and in the case of sitting upon the eggs, the only instances in which it occurs being among spiders, who have their nets ready spread contiguous to their nest, or carry it about with them, assistance seems to be little necessary. In the case o ;nest-building, on the other hand, where laborious operations have to be performed, we might have expected that the male would lend his assistance, such as in the structures of the mason-bee, or the carpenter-wasps *; but, so far as we are at present aware, the female performs the whole of the labour. The only circumstance we remember, which bears any resemblance to such mutual aid, occurs among a species of solitary bees (*Halictus*) which constructs galleries in sand-banks, but which, according to Walckenaër, work only during the night, while, during the day, either the male or the female always remains at the entrance, prepared to repel the intrusions of enemies †. It does not appear, however, that the male renders any assistance in digging out the gallery which he thus helps to defend.

In the instance of carnivorous insects, so far from rendering each other mutual assistance, it is no unusual occurrence for the one sex to attack and devour the other; and the female, being always the larger and more powerful, usually overcomes her partner. We know too little of the manners of fish, to assert that similar habits prevail amongst them; yet it seems by no means improbable that a hungry pike (*Esox lucius*) would make little ceremony of devouring his mate; for it devours its own species as readily as any other ‡, some of considerable size having been found in the stomachs of those that have been caught. We have ourselves frequently caught mackerel, and

* See Insect Architecture, chapters ii. and iii.

† See Insect Transformations, p. 53, 4.

‡ Donovan, Brit. Fishes, 109.

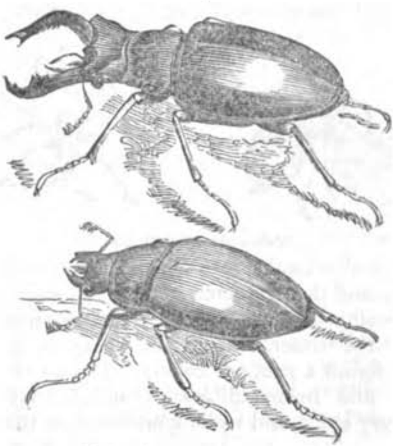
other sea-fish, with baits cut from the bodies of their comrades previously taken. The male of spiders not unfrequently falls a victim to his mate. Baron de Geer saw one that was seized by the object of his attentions, enveloped by her in a web, and then devoured,—a sight which, he says, filled him with horror and indignation*. This may, in part, account for the small number of male spiders we find, compared to the females, the latter being, we should think, from fifty or a hundred to one. Were the females not very prolific, therefore, and also exceedingly solicitous to preserve their eggs, the race would probably soon become extinct. Our readers, who are desirous of verifying these observations, may be told, that the external mark by which the male spider is distinguished from the female, consists in a sort of bulging, or knob, at the extremities of the feelers (*palpi*), which is wanting in the female.

Male spider, with the *palpi* magnified.

It may be useful to mention here a few other peculiarities of sexual distinctions. The greater size of the female alone is, for the most part, sufficient, when a male can be had for comparison; otherwise, the two sexes may be taken, even by very skilful naturalists, for different species. It is necessary to ob-

* Mémoires, vii. 180.

serve, however, that there are a few remarkable exceptions to this general rule, in the same way as, amongst birds of prey (*Raptores*, VIGORS), the greater size of the female is an exception to the general rule of the male of birds and quadrupeds being the largest. According to this latter rule, then, and of course an exception amongst insects, we may mention the dragon-flies (*Libellulina*), whose females are often a little smaller, and never larger, than the males, as is also the case with the water-spider (*Argyroneta aquatica*, WALCK.). But the most remarkable instance of this occurs in the stag-beetle (*Lucanus cervus*), so common in Kent and some other districts, though rare, or unknown, in the greater part of the empire. The size, however, is not the only distinction; for the female possesses little more than



Male and female stag-beetle.

the rudiments of the very remarkable horn-like mandibles with which the male is furnished. This organ in the male is no less formidable than it appears, as the unwary school-boy often experiences; for it can be used as a pair of pincers, so powerfully, as to inflict considerable pain. An instance, no less remarkable, though, from the size of the insect, less commonly observed, occurs in the horned wasp (*Synagris cornuta*), the male being furnished on the upper side of the base of its straight slender mandibles with a pair of crooked, decurved, and tortuous, sharp horns, longer than the head itself*. A distinction less conspicuous, but worthy of being noted, occurs in the sexes of the various species of humble-bee (*Bombus*). It may have been observed by some of our readers, in the early spring months, particularly in the afternoon of a fine day, that some very large humble-bees (*Bombus terrestris*, *B. lapidaria*, &c.), are busily prying into the holes and cre-

Male and female *Bombus*.

vices of hedge-banks, into which they enter for a few minutes, and then start off, as if dissatisfied, to some fresh locality. These are the females, which have survived the winter, and are in search of a suitable spot to found a summer colony. If one of these be caught, and its mandibles examined, they will be found very stout, and wide, constricted in the middle, and furrowed on the outer surface. In the small males, again, which may be taken in thousands, upon flowers, when the season is more advanced, the point

* Christ, Hymenoptera, xviii. 2.

of the mandibles will be found very slender, bulged out at the base, and destitute of furrows. In making experiments and observations on this interesting family, it will be useful to keep this distinction in mind, as the neglect of it must often lead to erroneous inferences with respect to their economy.

In another interesting bee (*Anthophora retusa*), one of the masons, the distinction of the sexes is so great that some naturalists of high name have described them as different species. The male is all black, except the hind thighs, which have an orange stripe; while the female is grey, and has the middle pair of feet fringed with long hairs *. This would be one of the best species for ascertaining the interest which the male takes in constructing the nest,—whether it be required to be mined into a sand-bank, or the mortar of walls, as it frequently is,—or whether it has to be built from the foundation with clay and other materials, as we have more than once seen it,—or whether both operations be required to complete the structure. When first disclosed in the early spring, we have remarked that the old nests are as much frequented by the black males as by the grey females, but we have never had the good fortune to witness either of them at work. We have also remarked that the males are much more numerous than the females †.

Many other insects have the sexes marked by different colours; though this will not hold as a general rule, for the greater number are not so distinguished. As in the instance of the bee just mentioned, the different colours of male and female butterflies misled Linnæus into the opinion that they were not only of different species, but of different families, and in many instances his two divisions of Trojans and

* See Insect Architecture, p. 84, for figure of female.

† J. R.

Grecians, into which he divides his knights (*Equites*) are merely different sexes,—as if we should rank in a different family the bright-coloured male of the brimstone butterfly (*Goneptyrex Rhamni*), from the dull greenish-white female. In a pretty moth, the spotted muslin (*Diaphora mendica*, STEPHENS), rare in some parts of Britain, the one sex is white and the other brownish, while both are similarly spotted and of a translucent lustre. A butterfly, known in every part of the island, takes its name of orange-tip (*Pontia Cardamines*) from the male only; for the female wants the beautiful streak of orange on the outer angles of the fore-wings, and might also be taken for a variety of one of our rarest insects, the Bath white butterfly (*P. daplicide*). The male of another fine butterfly (*Polygommatus Argus*) has the upper surface of the fore-wings of a beautiful dark blue, while the female has the same of a deep purplish-brown.

Among the dragon-flies, the large flat-bodied one (*Libellula depressa*)—one of the most common,—the male is of a leaden-blue, and the female yellow; but as the blue colour may be washed off, it is probable that weather-beaten males may sometimes be mistaken for females*. In an allied family (*Agrionidæ*, LEACH), there appears to have arisen no little confusion in consequence of the difference of the colour. In the finest native insect of this family (*Calepteryx Virgo*), the body of the male is of a rich, splendent, silky blue; in the female the colour is deep green, and little inferior in richness.

What is of more importance to be remarked with regard to the subject before us, is that in several species the males are furnished with wings, while the females are generally condemned to creep on the earth. This

* See Schelver, Entomologische, p. 224; and Réaumur, vol. vi. p. 423.

is well exemplified in the moths called vapourers (*Orgyia antiqua* * and *O. Gonostigma*), the female having only the rudiments of wings, while those of the male are large and ample. This comports with the different habits of the male and the female, the latter remaining (even when furnished with wings) in a great measure stationary, while the former roves restlessly about, ranging through every field, along every lane and hedge, and prying into every corner in search of a mate, whose care it seems to be to conceal herself as scrupulously as possible. In the instance of the orange-tip butterfly mentioned above, while every meadow is swarming with males, we seldom see more than one or two females in a whole season, and those which are observed are seldom on the wing. In some of the smaller ichneumons, among which the same distinction takes place, we may at first sight mistake the female for a large ant with an exserted sting,—a mistake that we have ourselves committed in the case of a male hunting-spider (*Salticus formicarius*, LATREILLE), which in size, form, and colour, narrowly resembled the wood-ant (*Formica rufa*); and we would certainly have passed it by as such, had we not found it on the rocky shore of the sea near Hâvre de Grace, and at a distance from any probable haunt of the pismire†.

But though female insects almost universally conceal themselves in the manner we have recorded, the male by his restless and active search is almost certain to discover their retreat. It is highly probable, as before mentioned, that their discovery is made through the medium of the sense of smell. Be the organ what it may, however, there can be no doubt of the fact that the males of many, if not of all insects, can discover the females at considerable

* See figures in Insect Transformations, p. 95.

† J R.

distances, even when placed in concealment. Upon this is founded the practice of *sembling*, as it is called by the London collectors, among whom, as we learn from Barbut and Harris, it has been long in use, for entrapping the males of the fox-moth (*Lasiocampa Rubi*), the grass-egger (*L. Trifolii*), and others. "It is a frequent practice," says Haworth, "with the London aurelians, when they breed a female of the lappit-moth (*Gasteropacha quercifolia*), and some other day-flying species, to take her in a box with a gauze lid into the vicinity of the woods, where, if the weather be favourable, she never fails to attract a numerous train of males, whose only business appears to be an incessant, rapid, and undulating flight in search of the females. One of these is no sooner descried, than they become so much enamoured of their fair kinswoman, as absolutely to lose all fear for their own personal safety, which, at other times, is effectually secured by the reiterated evolotions of their strong and rapid wings. So fearless, indeed, have I beheld them on these occasions, as to climb up and down the sides of the cage which contained the dear object of their eager pursuit, in exactly the same manner as honey bees which have lost themselves climb up and down the glasses of a window."

In other instances this does not succeed. In the spring of 1830 we bred a female of the lime-hawk moth (*Smerinthus Tiliæ*, Latreille), and placed her on a small lime-tree, planted in a garden-pot, and left her at full liberty, trusting to the known stationary habits of female insects for not losing her. In this we were not deceived, for though the tree contained only a single stem about three feet high, she never left it, remaining upon the same leaf sometimes for several days without stirring, and when she did move, it was only to perambulate the plant, agitating her wings the while (as she did while stationary) with a sort of tremulous quivering not very perceptible unless closely inspected. It might be that there were no males in the vicinity, though the insect is by no means rare around Lee; at all events, she remained without a mate for about three weeks, as the eggs which she at length laid proved to be infertile, and she died soon after. In the instance of a much rarer insect, the clear under-wing (*Ægeria asiliformis*, STEPHENS), having discovered a brood in the trunk of a poplar tree, we were desirous of securing all that issued from it, and having caught a female, we placed her in a box covered with gauze at the root of the tree,—the notion of surrounding the tree itself with gauze not having occurred to us at the moment. As this moth is one of the day-fliers, we expected to make sure of all the males in the neighbourhood; but, to our no small disappointment, not one approached the box, though we afterwards inclosed in it another female. This was the more remarkable, that, from the protrusion of the pupa cases from the tree, there was evidently not only one or two, but a considerable number evolved after the box had been placed there. In 1828, having discovered a beautiful male crane-fly (*Ctenophora pectinicornis*, MEIGEN), apparently just disclosed from the pupa, we carefully examined the old willow stump upon which it rested, expecting to find more of the same brood. Next day we accordingly observed a female, and imagining it to be one of the rare species (*Ct. ornata* or *Ct. flaveolata*), we placed her in a gauze-covered box; but no male approached for five days, when a large hunting-spider found means to introduce himself into the box, and make a meal of her *.

There is one extraordinary fact connected with this subject, which is worthy of being prominently stated, namely,—that after insects pair, and the females de-

* J. R.

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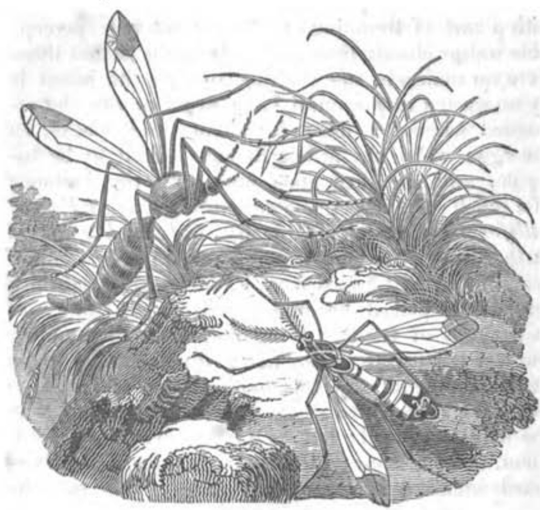


a, Ctenophora flaveolata. b, Ctenophora ornata.

posit their eggs, they very soon die, seldom living a few days, sometimes only a few hours, afterwards; but should pairing be prevented, their lives, and particularly that of the female, may be protracted to an indefinite period. Collectors, indeed, find that it is with the utmost difficulty a female can be deprived of her life before laying; and we have no doubt that the marvellous stories reported of the revival of flies and other insects, after long immersion in spirits, or after being crushed by shutting a book, originated in this circumstance, as well as the prolonged life of some insects, which is given on good authority. Rösel, for example, informs us that he kept a rose-chafer (*Cetonia aurata*) upwards of three years, feeding it with fruit and moist bread*; and Audebert is said to

* Inseckten Belustig. iii. 379.

have kept a spider for several years*. This, however, will not authorise us to credit Goldsmith's story of a spider, not confined, living for three years, particularly as it does not appear that he had any means of identifying the individual; and much less to believe that a flea, even when confined and well fed, would live six, or a mantis ten years,—such circumstance being so very anomalous as to be quite incredible.

It would not be correct, however, to say that the day-flies (*Ephemeridæ*) live only one day, and in some species only a few hours; for, in the form of grubs, some of those short-lived flies continue for two years; and though the goat-moth (*Cossus ligniperda*) and the stag-beetle (*Lucanus cervus*) live in their perfect state only a few weeks, their larvæ live for three years; that of the cock-chafer (*Melolontha vulgaris*) lives four years, as a destroyer of the roots of grass and other herbage †; while the beetle only lives to pair, and deposit its eggs. The same holds true of the queen-bee; but she does not, like the beetles and the moths, lay her eggs at once, but sometimes continues, if we may credit the elder Huber, for two successive years to deposit her eggs. The following experiment which he made to ascertain the fact of the first swarms being always, as Réaumur had conjectured, led by an old queen, is interesting as to this point:—

"One of my glass hives," he says, "consisting of three parallel combs, in frames opening like the leaves of a book, was well peopled, and abundantly provided with honey and wax, and with brood of various ages. From this hive I removed the queen, on the 5th of May, and next day transferred into it all the bees from another hive, with a fertile queen, at least a year old. They entered easily, without fighting, and were well received by the old inhabitants, who, upon having

* Nouv. Dict. d'Hist. Nat. ii. 285.

† See Insect Transformations, p. 227.

been deprived of their queen, had begun twelve royal cells. They likewise gave the queen a good reception, presenting her with honey, and surrounding her in regular circles. In the evening, however, there occurred a little agitation, though this was confined to the surface of the comb, where the queen had been placed, and which she had not quitted: on the other side all was perfectly quiet. By the morning of the 7th the bees had destroyed the twelve royal cells, but in all other respects good order continued to prevail in the hive; and the queen commenced to lay the eggs of males and of workers respectively in the large and small cells.

"About the 12th, I found the bees occupied in constructing twenty-two royal cells, of the species described by Réaumur, namely,—with the bases not in the plane of the comb, but appended perpendicularly by foot-stalks of different lengths, like stalactites, on the edge of the passage made by the bees through their combs. They bore, indeed, a considerable resemblance to the cup of an acorn, the longest being only about two lines and a half in depth from the bottom to the orifice. On the 13th, the queen seemed to be already more slender than when introduced into the hive; but she still continued to deposit some eggs both in common cells and in those of males. I also surprised her this day, laying in a royal cell: she first dislodged the worker there employed, by pushing it away with her head, and then supported herself by the adjoining cells, while depositing the egg. On the 15th, the size of the queen was still farther reduced, and the workers continued their attention to the royal cells, which were all unequally advanced, some to the height of three or four lines, while others were already an inch long; thus proving that the queen had not deposited eggs in the whole at the same time.

"At a moment when it was least expected, the hive swarmed on the 19th. We were warned of this by a noise in the air, and hastened to put the bees into a hive prepared on purpose. The object of the experiment, notwithstanding this unexpected occurrence, was completely fulfilled; for, on examination of all the bees, I was convinced they had been conducted by the old queen, whom I had introduced on the 6th of the month, and who had been marked, by depriving her of one of her antennæ; and what was more, there was no other queen besides this one in the colony; but in the hive she had left I found several royal cells, close at the top, but open at the side, and quite empty; eleven more were sealed, and some others newly begun. No queen remained in the hive.

"My attention was now directed to the new swarm, which I watched during the winter and the following spring, and in April I had the satisfaction of seeing another swarm depart, with the *same queen* at its head who had conducted the former one the preceding May. This experiment, then, is positive and conclusive; and I have repeated it several times, with equal success. It therefore appears to be incontestable, that the old queen always conducts the first swarm, but never quits the hive before depositing eggs in the royal cells, from which other queens will be disclosed, after her departure, to succeed to her abandoned kingdom. These royal cells are prepared by the bees only while the queen is laying male eggs, which is attended by the remarkable fact, that after this laying terminates, her belly being considerably diminished, she can easily fly, whereas it is previously so heavy that she can hardly drag it along. It becomes necessary, therefore, that she should lay, in order to be in a state for undertaking her journey, as this may sometimes be of considerable length *." We are hence authorised to infer that the deposition of eggs, from once pairing, takes the queen-bee above a year.

* Huber on Bees, p. 149.

In the glow-worm (*Lampyris noctiluca*), again, we have ascertained, by numerous observations, that the laying takes place soon after pairing, and is completed within a day or two; but as the circumstances attending the pairing of these insects have given rise to an opinion very generally diffused, it may be proper to examine its validity. We refer to the beautiful light from which the creature derives its name, and which is believed to be peculiar to the female, for the purpose of guiding the darkling flight of the male. "This phosphorescent light," says Dumeril, "appears to be intended by nature as the lamp of love—the pharos—the telegraph of the night, which scintillates and marks, in the silence of darkness, the spot appointed for the lovers' rendezvous *." "The female glow-worm," say Kirby and Spence, "hangs out her lamp of love, and the male, led by it, wings his way to her †." "The torch which the wingless female, doomed to crawl upon the grass, lights up at the approach of night, is a beacon which unerringly guides the vagrant male to 'her love-illumined form,' however obscure the place of her abode ‡."

Upon this statement Mr. Knapp has engrafted the following ingenious and pretty theory respecting the structure of the male glow-worm. "Most creatures," says he, "have their eyes so placed as to be enabled to see about them; or, as Hook says of the house-fly, to be 'circumspect animals;' but this male glow-worm has a contrivance by which any upward or side vision is prevented. Viewed when at rest, no portion of his eyes is visible, but the head is margined with a horny band, or plate, being a character of one of the genera of the order *coleoptera*, under which the eyes are situated. This prevents all upward vision; the blinds, or winkers, are so fixed at the sides of his eyes as greatly to impede the view of all lateral objects. The chief

* Dict. des Sciences Naturelles, xxv. 216. † Intr. iv. 514.
‡ Ibid. ii. 428.

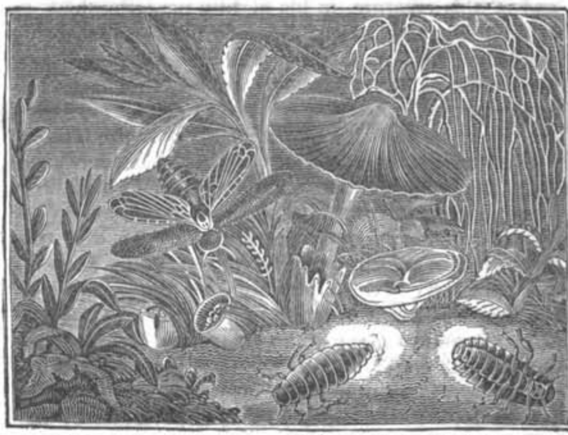
end of this creature, in his nightly peregrinations, is to seek his mate, always beneath him on the earth; and hence this apparatus appears designed to facilitate his search, confining his view entirely to what is before or below him. The first serves to direct his flight, the other presents the object of his pursuit; and as we commonly, and with advantage, place our hand over the brow, to obstruct the rays of light falling from above, which enables us to see clearer an object on the ground, so must the projecting hood of this creature converge the visual rays to a point beneath. This is a very curious provision for the purposes of the insect, if my conception of its design be reasonable. Possibly the same ideas may have been brought forward by others; but as I have not seen them, I am not guilty of any undue appropriation, and no injury can be done to the cause I wish to promote, by detailing again such beautiful and admirable contrivances *."

We are no less anxious to promote the cause advocated by the ingenious author than he can be; but in the instance in question he seems to have overlooked the circumstance, that the structure of the female glow-worm is precisely similar to that of the male, the head being not only covered with a broad plate which overshadows the eyes, but being retractile like that of the snail, a structure which, in her case, cannot be required for the purpose assigned by him to the male. A peculiarity which strikes us more remarkably, is the extraordinary magnitude of the eyes of the male, these being more than double, while the body is not above half the size of that of the female †.

It is a question indeed by no means decided, whether the light of the glow-worm is intended for the purpose popularly and poetically believed. We have

* Journal of a Naturalist, 293, 1st edit.

† J. R.



Male and female glow-worms. Male winged, female wingless.

Head of male glow-worm.

recently verified in several instances the facts first stated by Baron de Geer, " that this insect shines in its infant state, in that of larva, and even after it has taken the form of a nymph. Now, as in the first of these states it cannot propagate, and still less in the second, with what design is the light displayed? It must serve some purpose yet unknown. The authors who have spoken of the male glow-worms say positively that they shine in the dark as well as females *." We have in two instances observed this luminosity of the male, which however is much more feeble than that of the female. Ray first discovered this

* De Geer, Mémoires, iv. 44.

fact* in the common glow-worm, and Geoffroy and Müller give their testimony to its accuracy; while Illiger records it as occurring still more remarkably in two foreign species (*Lampyris splendidula*, and *L. hemiptera*). Kirby and Spence make an attempt to rebut the inferences drawn from these facts, by remarking that the circumstance of the male having the same luminous property, no more proves that the superior brilliancy of the female is not intended for conducting him to her, than the existence of nipples, and sometimes of milk in man, proves that the breast of woman is not meant for the support of her offspring †. But we do not see how the light in the male glow-worm can be thus compared with such decidedly sexual organs, though in the larva it may certainly be explained upon the principle of gradual development. Mr. Main thinks that the design of the light in the female is proved by the propensity of the males to fly towards light, and states that they have been seen in such numbers, as sometimes to cover a table round a lighted candle in an open room. But he surely forgets that gnats and moths do the same, although their females are not luminous.

In order to put this to a more certain test than a lighted candle, in July, 1830, we placed a number of female glow-worms in full light in an open shallow box, and after sun-set left it for about an hour on the sea-bank, near Hâvre de Grace where the insect abounds: but though there was here a concentrated blaze no males made their appearance; no, not though we afterwards carried the box about in all directions till near midnight, about which time White of Selborne observed the light to be extinguished, a circumstance also remarked by Shakspeare, who ascribes it to the male:

* Historia Insect. 81. † Intr. ii. 429.

> The glow-worm shows the matin to be near,
> And 'gins to pale *his* ineffectual fire.

It amounts also to a strong negative proof, that among the considerable numbers of females which we have collected when shining, we only once found a male; and Mr. Knapp says, "he has ever been a scarce creature with me, meeting perhaps with one or two in a year." The same author mentions another circumstance, which he thinks does not accord with the sexual theory of the light. Observation had taught him that the light is not emitted after the middle of July, at least so clearly and steadily, (we found them at Rudesheim on the Rhine in full light at the end of August) *; but he "repeatedly noticed, deep in the herbage, a faint evanescent light proceeding from these creatures even as late as August and September. This was particularly manifested September 28th, 1826. The evening was warm and dewy, and I observed on the house bank multitudes of these small evanescent sparks in the grass. The light displayed was very different from that which they exhibit in the warm summer months. Instead of the permanent green glow, that illumined all the blades of the surrounding herbage, it was a pale transient spot, visible for a moment or two, and then so speedily hidden that we were obliged, in order to capture the creature, to employ the light of a candle. The number of them, and their actions, creeping away from our sight, contrary to that half lifeless dullness observed in summer, suggested the idea that the whole body had availed themselves of this warm, moist evening to migrate to their winter station. A single spark was to be seen on some evenings after this, but no such large moving parties were discovered again. If we conclude that the summer light of the glow-worm is displayed as a signal taper

* See Insect Transformations, p. 39.

the appearance of this autumnal light can have no such object in view, nor can we rationally assign any use of it to the creature itself, unless, indeed, it serves as a point of union in these supposed migrations, like the leading call in the flight of night-moving birds *."

We suspect, however, that these ingenious conjectures are altogether founded on mistake. It is not correct to say with our author, that the glow-worms "retire during the winter to shine out again when revived by the summer's warmth †;" for, as we have seen above, both the males and females uniformly die a few days after pairing; and we have no doubt that those which he observed at the end of September were the grubs hatched in the preceding summer, and which differ little in appearance from the perfect female. We found several such grubs in September, at Hâvre de Grace. Mr. Knapp's mention of birds reminds us of other conjectures respecting the design of the glow-worm's light, which, according to Kirby and Spence, "may defend them from the attack of some enemies," in the same way as they think the golden wasps (*Chrysididæ*, LEACH) "are adorned with the most brilliant colours, which by their radiance, especially in the sunny situations frequented by those insects, may dazzle the eyes of their enemies, and enable them to effect unhurt the purpose for which they were created ‡." But in a subsequent page they remark, that "female glow-worms have the faculty of extinguishing or concealing their light, a very necessary provision to guard them from the attacks of the nightingale, and other nocturnal birds §." Mr. John Murray, on the other hand, thinks the only use of the light is either as a

* Journal of a Naturalist, p. 294. † Ibid. p. 293.

‡ See Insect Transformations, pp. 34 and 141.

§ Intr. ii. 411.

guide to its food, or as a sign to nightingales where to find their prey *. It would have been well however, before theorizing, to ascertain that the nightingale feeds at all during the night, which we much doubt, and that it feeds upon glow-worms, which we also doubt. We are, at all events, certain that the glow-worm never extinguishes its light when it is alarmed or even seized, and hence one portion of the theories must be given up.

In a still more splendid luminous insect, the fire-fly (*Elater noctilucus*) of tropical countries, we are

Fire-fly (*Elator noctilucus*).

not informed whether the light is in any way connected with pairing, though it is not improbable it may be for some other unknown purpose. The insect itself is one of the click-beetles (*Elateridæ*, Leach), several others of which are also luminous. Southey has given a spirited and accurate description of this fire-fly :—

* Experimental Researches.

"soon did night display
More wonders than it veil'd: innumerous tribes
From the wood-cover swarm'd, and darkness made
Their beauties visible: one while they streamed
A bright blue radiance upon flowers that closed
Their gorgeous colours from the eye of day;
Now motionless and dark, eluded search,
Self-shrouded; and anon, starring the sky,
Rose like a shower of fire." *Madoc.*

We are told by Mouffet, that when Sir Thomas Cavendish and Sir Robert Dudley landed in the West Indies, and saw in the evening an infinite number of moving lights in the woods, which, though nothing more than fire-flies, were taken by them for Spaniards advancing upon them by torch-light, they immediately fled to their ships *.

Lantern-fly (*Fulgora lanternaria*).

We are not aware that any native insect is luminous besides the glow-worm and the electric centipede

* Theatr. Insect. 112.

(*Scolopendra electrica*), which is by no means uncommon, though its light is seldom seen, in consequence of its living in holes or under ground, from which it is seldom roused during the night. We have, however, more than once seen it in out-houses, or crawling along a pathway, upon which it sometimes leaves a track of phosphoric matter that may be lifted. On two different occasions we collected some of this, but it disappeared, probably by evaporation, before we could subject it to chemical analysis *.

Electric centipede (*Scolopendra electrica*).

It does not seem to be yet satisfactorily ascertained to what cause is to be ascribed the beautiful phenomenon of the sparkling light so frequently seen at night in the waters of the sea, though the most prevalent opinion is, that it arises from marine insects, or crustaceous or molluscous animalcules, among which the shining crab (*Cancer fulgens*, &c.) has been particularized, apparently more from conjecture than observation. It is very improbable indeed that any species of crab would be so abundant,

* J. R.

particularly since they do not swim so well "as to bestar with their phosphorescent splendour the vast surface of the ocean, and transform it into a sea of flame,"—a spectacle, continues Humboldt, "which stamped upon my memory an ineffaceable impression, and always excited fresh astonishment, although it was renewed every night for months together. It may be seen in every zone; but those who have not witnessed it within the tropics, and above all upon the main ocean, can form but a very imperfect conception of the grandeur of the phenomenon, particularly if the spectator places himself in the shrouds of a ship of the line, during a fresh breeze, when she ploughs through the crests of the waves, and at every roll her side is raised out of the water enveloped in ruddy flames, which stream like lightning from the keel, and flash towards the surface of the sea. At other times, the dolphins, while sporting in the waters, trace out sparkling furrows in the midst of the waves*."

Leaving out of our consideration as inadmissible, the opinion of Le Gentil† and Forster‡, that the light in question arises from electricity excited by the friction of the water upon the sides of the advancing ship,—the ascertained facts appear to be the following. There are several luminous molluscæ which have the faculty of emitting at pleasure a feeble phosphorescent light, generally of a bluish colour. Three of these have been particularized, (*Nereis noctiluca; Medusa pelagica, β* §; and *Monophora noctiluca*,) the latter discovered by M. Bory de St. Vincent in Baudin's expedition‖. Besides these, a

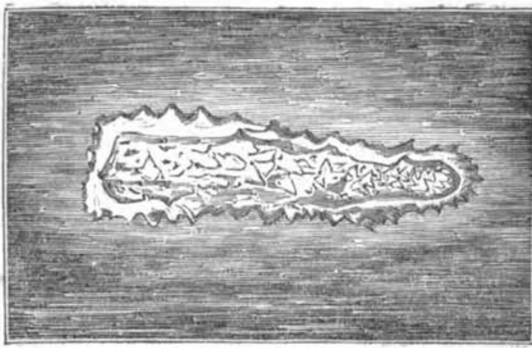
* Humboldt, Tableau de la Nature, vol. ii. p. 9, and Note.

† Voyage aux Indes, i. 685—98.

‡ Remarks made in a Voyage round the World, p. 57.

§ Forskål, Fauna Ægyptiaco-Arabica, p. 109.

‖ Voy. aux Iles d'Afrique, i. 104.



Monophora noctiluca.

number of microscopic animalcules of species still undetermined, which Forster found swimming in innumerable multitudes in the sea near the Cape of Good Hope, have been confidently asserted to be the cause of the phenomenon. But though these may be partly or sometimes the cause, yet, in the greater number of instances, no animalcules whatever can be discovered in the luminous water, even by the aid of the best glasses. Such was the decision come to by Humboldt from numerous observations in the tropical seas, and his authority is one of the highest which can be adduced *. We had recently an opportunity of repeating these observations at Hâvre de Grace, and could not discover the slightest trace of animalcules, although the water which we examined was so strongly luminous, that it shone upon the skin of some night-bathers like scattered clouds of lambent flame, appearing more as a property of the water itself than anything extraneous diffused through it; but we particularly remarked that no light appeared in quiescent water, it being only seen when the

* Humboldt, Tableau de la Nature, ii. 90.

surface was broken by the ripple of the tide, or when a wave dashed upon the pebbles on the beach*.

Humboldt, however, is of opinion, that though the phenomenon is only at times caused by animated lamp-bearers, it may probably arise in general from the decomposed fibrillæ of dead mollusca which abound beyond all calculation in the bosom of the waters. He proved this by passing some of the luminous water through cloth, when some of the fibrillæ were separated, and appeared in the form of luminous points. We should, on the other hand, have been inclined to infer that these points were caused by the luminous water moistening the fibres of the cloth: and our author himself afterwards seems to abandon the notion of fibrillæ for that of a gelatinous fluid produced by the decomposition of the dead bodies, and imparting to sea-water the nauseous taste, which is as much disliked by us as it is relished by the fishes. Water may thus be rendered luminous by throwing into it a quantity of herring brine, and hence it appears that salt is indispensable; for, as M. Bory de St. Vincent justly remarks, the waters of our lakes and marshes are never luminous, though these abound with polypi, both living and dead. There seem also to be certain states of the air favourable or unfavourable to the development of the light; for one night it will appear with great brilliance, while on the following, though the circumstances seem all equal, it will be gone. It seems to be more frequent, as Hnmboldt remarked, "when the sky was thick and cloudy, and upon the approach of a storm." We have remarked it as frequently following as preceding a storm; but it seems to be independent of heat or cold; for on the banks of Newfoundland it is observed to shine with great brilliance during the most rigorous frosts.

* J. R.

Chapter X.

SINGULARITIES IN PAIRING.

It may be perceived from some of the preceding details, that insects differ very considerably from the larger animals in their modes of pairing; but there are several species in which the peculiarities are much more remarkable. In the case of moths we have seen the extraordinary phenomenon of life itself being extended several weeks beyond its natural period when a mate could not be met with; and in butterflies it is probably extended to several months; in the case of those females (*Vanessa Io*, *V. Urticæ*, *Gonepteryx Rhamni*, &c.) which are hatched late in the autumn and live till they meet with a mate in the ensuing spring; while, had they been hatched a month or two earlier, and had left a progeny to supply their place, they would have infallibly died.

PAIRING OF APHIDES.

The earlier naturalists observing that aphides were always found where ants abound, concluded, without further investigation, that the ants shed upon the leaves of plants a sort of plastic humour, from which the aphides were generated *, on the same principles as they erroneously imagined flies to be produced from dead carcasses †. But miraculous as this would have been had it been the case, it is perhaps surpassed by the actual facts which have been ascertained by subsequent observations con-

* Gödart, ii. Exp. 22.

† See Insect Transformations, chap. i.

ducted in the most rigid scientific manner—Nature, as is well remarked by Bonnet, having sown them upon all sorts of plants and trees, to provide food for other species of insects, as we sow grain for our own subsistence*. In a word, it appears that the old opinion maintained by Leeuwenhöeck, Cestoni, and Bourguet, which maintains aphides to be generated without pairing, is partially true. Réaumur, in consequence of repeated accidents, was unsuccessful in his observations; but Bonnet, by extraordinary patience and care, succeeded beyond what could have been anticipated. We think his experiments cannot fail to prove interesting.

Upon a leafy branch of spindle-tree (*Euonymus*), plunged in a phial of water, and set in a garden-pot, he placed an aphis which be had seen born the instant before of a mother without wings; and having previously examined the leaves and stem with the most minute care lest there might be any other aphides upon them, he covered the whole with a glass vessel, the edges of which being plunged into the mould, he felt as confident that he had the control of the conduct of his prisoner as Acrisius did as to the actions of Danaë when he shut her up in a brazen tower. This was done on the 20th of May at five in the evening; and he continued to watch with a magnifying glass the imprisoned insect every day from hour to hour, beginning about five in the morning, and leaving off about nine or ten at night, noting its every movement in his journal. It changed its skin four times, in the same manner as caterpillars, and during the last moult it caused our ingenious experimenter not a little uneasiness, from its appearing as if it were preyed upon by internal parasites †, as in that case he would have

* Insectologie, Œuvres, i. 10.

† See Insect Transformations, page 57, &c.

lost much time of painful watching. His fears however proved to be vain, for it accomplished its moult without accident, and at seven o'clock in the evening on the first of June, it gave birth to a young one, and up to the 22nd of June inclusive it produced altogether ninety-five, all alive. The size of the mother became at this period much diminished, and precisely like those imagined by Geoffroy to be males. M. Bonnet's subsequent observations were interrupted by her escape; though the point was ascertained, as far at least as one experiment went, that the mother of ninety-five aphides had never paired *.

The result of these observations having been transmitted to Réaumur and read by him at a sitting of the Académie des Sciences at Paris, produced an extraordinary sensation among those who were interested in such pursuits; and as it was desirable that a deviation so very singular from the common laws of nature should not rest upon individual testimony, however respectable, the experiments and observations were repeated and varied in every possible way at the request of the Academy by a number of the most distinguished naturalists then living, namely, M. Bazin of Strasbourg, MM. Lyonnet and Trembley at the Hague, by M. Bonnet himself at Geneva, and in fine by M. Réaumur, who says he would have justly merited reproach if he had neglected to see with his own eyes experiments undertaken at his express request †.

M. Bazin was fortunate in selecting the species which feeds on the poppy (*Aphis papaveris*, FABR.) as the young arrive at maturity in seven or eight days, and they are besides not apt to ramble far from the spot where they are born. A young aphis of this

* Bonnet, Œuvres, i. 30.

† Mémoires, vi. 541.

species accordingly, of which M. Bazin witnessed the birth on the 29th of July, was secluded upon a poppy leaf, and by the 7th of August it had brought forth seven young ones. In similar trials with others of the same species, as well as with that of the rose (*Aphis Rosæ*), the same results followed.

M. Trembley proceeded somewhat differently, selecting two nearly of the same age from the species which feeds on the elder (*Aphis Sambuci*), and treating them in the same way, placing each upon a shoot of elder enclosed in a glass tube open at both ends, one of which he plunged into water, and covered the other with cotton. Although he did not begin his observations till the 28th September, the first produced young on the 25th, and the second on the 28th November, and continued at irregular intervals according to the temperature of the air.

Trembley's breeding apparatus.

The species selected by M. Lyonnet were those of the rose and of the willow (*Aphis Salicis*), with which the results were the same as the preceding.

M. Réaumur in his experiments introduced the stem of the plant through an aperture in a piece of moist parchment which covered a glass containing water, and over the whole he placed a larger glass, both being then placed on a bed of cotton. The species he selected were those of the elder, of the peach (*Aphis Pruni ?*), and of the currant (*A. Ribis*); but they did not seem to agree with such close confinement and moist air so well as those of the poppy tried by M. Bazin, for all of them died in a few days. He then had recourse to a gauze cover, the meshes of which were sufficiently small to prevent the escape of the insects, or the entrance of their congeners, while it furnished them with fresh air. With the latter apparatus, he succeeded in verifying the observations of M. Bazin upon the aphis of the poppy*.

Réaumur's breeding apparatus.

We have been thus particular in giving an abstract of the experiments and observations of these distinguished naturalists, for the purpose of removing all doubt respecting a fact so singular and extraordinary. But this anomaly, singular as it is, may be in some measure paralleled among another class of animals (*Mollusca*), it being well known that the earth-worms (*Lumbrici*) and snails (*Limaces*) are hermaphrodite, that is, each individual is

* Mémoires, vi. 544.

both male and female, and capable of producing eggs; snails and earth-worms, however, could not produce eggs, if secluded at the moment of birth as the aphides were in the preceding experiments, pairing being as indispensable with them as with the distinct males and females of other animals.

The fact discovered by M. Bonnet, which had been so strangely misrepresented by Leeuwenhöeck, Cestoni, and Bourguet, led him to push the investigation still farther, and his perseverance was rewarded by the discovery of other facts still more wonderful, and less to have been expected. He commenced with the aphis of the elder (*A. Sambuci*), secluding not only an individual at the moment of its birth, but one of its progeny, and so on successively, till he saw the fifth generation produced without any intermediate pairing; and the young of the latter brood, he had reason to believe, might have been eqnally fertile, had it not been in the winter, when he could not procure them a fresh elder-branch for nourishment. In a subsequent experiment with the large species which feeds on the bark of the oak (*Eriosoma Quercus*, STEPHENS) Bonnet pushed his observations as far as the ninth generation, which were produced in three months, the males being throughout rigorously excluded from the nurse-boxes in which the females were isolated*. Lyonnet made similar experiments with the aphides of the willow, but without recording the number of generations produced, his object being to ascertain whether they ever paired at all like other insects, or whether, as M. Trembley had imagined, they paired before birth. Both Lyonnet and Bonnet distinctly ascertained that Trembley's notion did not accord with fact, for after a time the fecundity of the females becomes exhausted, and pairing is then as indispensable to render

* Bonnet, Œuvres, i. 89.

them fertile, as to any other animal. It is very singular, however, that the female after pairing is not viviparous, that is, does not produce living young, but eggs; or, as M. Bonnet was inclined to think, a species of pupæ like eggs*: whereas the insects which are thence disclosed produce living young without pairing; and more wonderful still, all these broods are uniformly females, no males being produced till the pairing season, which is towards the close of summer or autumn.

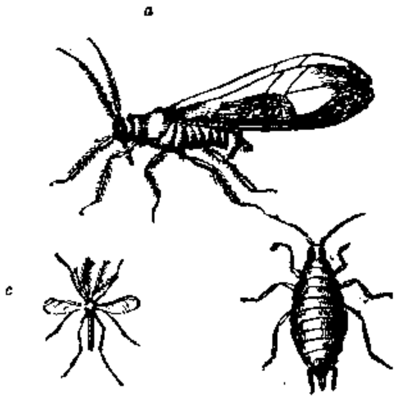
Amongst all these singularities relating to aphides, there is another which merits further investigation than it has yet received, namely, that some individuals are furnished with wings, while others are not. Analogy led to the supposition that the wingless ones are females, and the winged ones males, as occurs among the glow-worms (*Lampyridæ*), the cochineal insects (*Coccidæ*), and some moths. Observation, however, disproved this, it having been ascertained by Lyonnet and De Geer, that there are females as well as males, both winged and not winged†.

No other family of insects, so far as we are aware, exhibits anything similar to the aphides in these anomalies, and we must therefore guard our young readers against the following error in a popular work on natural history. "However similar," says Goldsmith, "insects of the gnat-kind are in their appearance, yet they differ widely from each other in the manner in which they are brought forth, for some are oviparous, and produced from eggs,—some are viviparous, and come forth in their most perfect form; some are of neither sex, yet still produce young *without any pairing whatsoever.* This is one of the strangest discoveries in natural history.

* See Insect Transformations, page 113.

† De Geer, Mém. iii. 21.

A gnat separated from the rest of its kind, and inclosed in a glass vessel, with air sufficient to keep it alive, shall produce young, which also, when separated from each other, shall be the parents of a numerous progeny. Thus, down to five or six generations, do these extraordinary animals propagate in the manner of vegetables *." It must have been some dreamy recollection of what he had read in Réaumur or Bonnet, whose works he elsewhere quotes, that led Goldsmith into so palpable an error.



a, Aphis of the elm; b, aphis of the willow, greatly magnified; c, common gnat, (*Culex pipiens*), natural size.

PAIRING OF ANTS.

The multitudinous population which attracts the attention of the common observer in an ant-hill is not composed, in the usual meaning of the terms, either of males or females, they being all incapable of propagation. Their chief employment is, however, the female duty of nursing the rising generation of

* Animated Nature, iv. 310.

the colony, providing them with food, constructing chambers for their reception *, and taking care to shelter them from cold and wet. On minutely examining their conformation, accordingly, these nurse-ants or workers, as they are usually termed, have been discovered to be, like the workers in a bee-hive, females imperfectly developed, and, therefore, incapable of laying eggs. This office is appropriated to a distinct class of the colony, which would not at first be recognized by the common observer as belonging to ants at all, inasmuch as they are not only thrice the bulk of the nurse-ants, but provided with four very ample wings, and are besides, in some species, very different in colour. The female, for example, of the yellow ant (*Formica flava*) is of a blackish-bronze colour, and might, if deprived of her wings, be taken for a worker of the jet-ant (*F. fuliginosa*), become grizzled with age. Although much remains still to be investigated with regard to these singular insects, and particularly as to their pairing, enough has been discovered by Gould, De Geer, and the younger Huber, to awaken interest and excite wonder.

Towards midsummer, on to the close of autumn, if a populous ant-hill of any species be examined, there will be seen mixed with the wingless workers a number of larger insects, with whitish, glistening wings, but not taking any part in the labours of the colony. Amongst these winged insects, also, further examination will show that some are much larger than others, though agreeing nearly with them in colour. These larger ones are the females; those of less size, the males. A very little attention will show, however, that these are neither kings nor queens in the State, at least so far as freedom of action is concerned, for they are not

* See Insect Architecture, chap. xiv.

allowed to move without a guard of workers to prevent their leaving the boundaries, and if one straggles away unawares, it is for the most part dragged back by the vigilant sentinels, three or four of whom may, in such cases, be seen hauling along a single deserter by the wings and limbs. We have never seen the delinquent offer the slightest resistance, nor make any endeavour to escape, but always, on the contrary, exhibiting as much eagerness as the guard to regain the nearest gateway of the city. When a colony, indeed, is exposed by removing the stone or other covering which shelters them, the winged inhabitants are always eager to conceal themselves in the lower chambers, and in a few minutes none of them are to be seen; but even in such a case the extreme jealousy of the workers is not contented with any display of agility, and they always subject them more or less to the dragging system. We may mention that this is not one of those rare phenomena which accident only brings under the eye of the naturalist, as it may be always witnessed whenever males and females are present in an ant-hill; and out of some hundreds which we have visited within a few days (*Formica flava*, *F. fusca*, *&c.*), we saw what we have described in more than two-thirds of the number*. We state this more particularly, as it does not appear to be altogether in accordance with the observations of Gould and the younger Huber.

"Let us retire," says the latter, "to a meadow on a fine summer's day, at a time when they first make use of their wings, and take a survey of their habitation, on the surface of which we shall observe, walking to and fro, many of its winged inhabitants. These are the males and females of the field-ant: they climb all the plants which surround their resi-

* J. R.

dence, and are every where accompanied by a multitude of workers, who follow their steps with ceaseless solicitude. Some, however, attempt to retain and reconduct them to the ant-hill; but the greater part content themselves with simply escorting them. They offer them nourishment for the last time, and render them the last token of their care and affection."

Again he says, "disorder and agitation are now manifest in the ant-hill; the bustle increases every moment. The winged insects climb with alacrity the adjacent plants, followed by a numerous train of workers, who are continually running from one male to another, touching them with their antennæ, and offering them food. The males, at length, quit the paternal roof, and take flight as from one general impulse, in which they are quickly followed by the females. The winged tribe soon disappear. The workers retrace, for some instants, the steps of these highly favoured beings, to whom they have shown such extreme care and attention, and whom they are never destined to see more."—"When the weather is favourable (not below 67° Fahr.), the labourers, who seem to be aware of it, form several apertures in the ant-hill, to give ready passage to the crowd that are about to quit it. The males and females may be then seen coming to take air at the entrance. The hour of departure arrives: they all take flight. The workers alone re-enter the nest and close the entrances *."

According to our observations, on the other hand, the workers, so far from ever facilitating the exit, much less the departure of the winged ones, more particularly the females, guard them most assiduously in order to prevent it; and are only forced to acquiesce in it when the winged ones become too

* Huber on Ants, p. 99.

numerous either to be guarded or fed. There seems, indeed, to be a uniform disposition in the winged ones to desert their native colony; and as they never return after pairing, it would soon become depopulated in the absence of females. In such a case, indeed, the workers would give up their industry, and would soon wander away and perish. But when they succeed in retaining a few females amongst them, they renew their labours with fresh ardour.

One circumstance is of importance to be considered. The actual pairing does not seem to take place within the ant-hill, and we have observed scouts posted all around, ready to discover and carry back to the colony as many fertile females as they could meet with. Nay, we are quite certain that whole colonies have been thus dispersed, and when they did not find fertile females near their encampment, they have gone farther and farther till they found them, and when it was deemed too far, never returned, but commenced a number of new establishments, according to their convenience. This, as it appears to us, accounts, in the only rational way, for the existence of so many colonies of the same species, frequently found near each other in particular localities. We have witnessed two instances in which populous colouies were in this manner completely broken up, and their original city abandoned by the workers, who had dispersed in pursuit of the fertile females which had escaped. One was the ash-coloured ant (*Formica fusca*), the other the red ant (*Myrmica rubra*); and an instance of the latter has just occurred to us in which a numerous establishment was, in the same way, reduced, within a few days, to two or three dozen; and these would probably have beeu dispersed in the same way, had they not been successful in capturing and retaining a few females, which we observed to be guarded with great care *.

The males, it is probable, soon after pairing, die, as do the males of bees and other insects; for, as the workers never bring any of them back, nor take any notice of them after leaving the ant-hill, they must perish, being entirely defenceless, and destitute both of a sting and of mandibles to provide for their subsistence. They accordingly disappear in a very short time, many of them falling a prey to spiders; and we have not only seen the webs of some of the geometers (*Tetragnatha extensa*, &c.) literally studded with their bodies, but have observed several of the hunters (*Lycosa saccata*, &c.) pouncing upon those which were enfeebled by hunger, when endeavouring to hide themselves among the grass †.

The subsequent proceedings of the females are very different, and of curious interest. It was supposed by the ancients, that all ants at a certain age acquired wings; but it was reserved for recent naturalists to ascertain that it is only the males and females that are ever winged, and that the latter lose these soon after pairing, as they have no longer any use for them. The younger Huber, in particular, by means of his artificial formicaries, traced the development of the wings in the female from the first commencement, till he saw them stripped off and laid aside like cast clothes.

"One day," says he, "with the view of ascertaining the precise condition of the females, I visited certain ant-hills, which I knew to be filled with winged ants, and whose departure could not be very distant. Scarcely had I reached the spot when I saw several, both females and males, pass over my head; while at the ant-hill, I observed several take flight, the males always preceding, and the labourers,

* J. R. † J. R.

as far as they could, accompanying them."—"I took eight pairs of these and placed them in a box, to observe them on my return; but a violent rain, which came on at this moment, offered me a sight as singular as unexpected. As soon as the shower had passed, I saw the earth strewed with females without wings; they were, most likely, the identical females I had seen traversing the air. They were of the same species (*Formica brunnea*) as the first.

"On my return home, I placed my eight prisoners, with some moistened earth, in a garden vase, covered with a glass receiver. It was nine o'clock in the evening; at ten, the females had lost their wings, which I observed scattered here and there, and were hiding themselves under the earth. On the following day I procured three other females, and this time I observed them with the greatest attention from the moment of pairing until nine in the evening,—a period of five hours; but during this time nothing was done to denote the approaching loss of their wings, which remained still firmly affixed. They appeared to be in excellent condition; and when I saw them pass their feet across their mouths, then over the antennæ, and again brush them upon one another, I expected to see their wings fall off, and could not conceive what retarded this, since the others had lost them so readily. I had no idea that the mere difference of the bottom of a sand-box, where there was no earth, would have had any influence in preventing this; but, in order that it might not affect them, I took some earth, strewed it lightly over the table, and covered it with a bell-glass. I still possessed three fecundated winged females, one of which I introduced under the recipient. I induced her to go there freely, by presenting her a fragment of straw, on which I conveyed her to her new habitation, without touching her. Scarcely did she perceive the earth which covered the bottom of her abode than she extended her wings, with some effort, bringing them before her head, crossing them in every direction, throwing them from side to side, and producing so many singular contortions, that all her four wings fell off at the same moment in my presence. After this change she reposed, brushed her corslet with her feet, then traversed the ground, evidently appearing to seek a place of shelter. She did not seem to be in the least aware that she was confined within a narrow enclosure. She partook of the honey I gave her, and at last found a hiding-place under some loose earth, that formed a little natural grotto.

"If I was surprised at seeing this female strip herself of her wings voluntarily, I was even more so, on finding that she did not appear to suffer from it, and that, after an act which would seem to us anything but natural, she delivered herself peaceably to her appetite, and sought a retreat, as if nothing out of the ordinary course had happened. This singular fact merited confirmation. I introduced a second female under the bell-glass about two hours afterwards, and with the same precautions, adding to the dry earth a little water. When she perceived that she stood upon moistened earth, she advanced a few paces, felt the ground with her antennæ, and took up a position in order to dispossess herself of her wings. Resting on her belly, she opened her wings in a disorderly manner, extended them in every direction, passed her legs behind them, and pressed them closely toward the ground. When she had succeeded in disembarrassing herself of them, I observed her walking about tranquilly in her enclosure, and begin constructing a grotto of earth.

"I still possessed another, which I reserved for the following morning, and, being confined to the dry sand, she had not lost her wings, though it was about sixteen hours later than the two former ones. She appeared in excellent condition, and had not apparently suffered by the delay. Scarcely had she touched the ground, than she hastened to get rid of her wings in the same manner as the others had done. In fine, I repeated the like experiments on several females, of different species, and always obtained the same result*."

Had this extraordinary fact rested on the single authority of Huber, we might have been disposed to think he had permitted his fancy to aid his observation. But several of the circumstances, as we have already noticed, had been observed by Linnæus, De Geer, and particularly by Gould, with whose accurate account of English ants Huber does not seem to be acquainted. Gould terms the winged females, ant-flies, and goes on to state,—"If you strip a large ant-fly of its wings, when a week old or more, which is very easily done, for they will come off by the most gentle touch imaginable, and then place it in a microscope with a queen (meaning a wingless female), you will perceive no manner of difference as to their frame; the like indented places or little hollows in the breast, where the wings commonly lie, will be found in each; whence there is great reason to believe, the queen was originally adorned with such gaiety, and appeared in the character of a fly. It is also observable, as a strong confirmation of this sentiment, that abundance of the large ant-flies, just before or after leaving the colonies, *actually drop their wings*, and, except a small difference in complexion, which has not attained its true gloss, are not to be distinguished from the queens. You may, in the latter end of July and great part of August, often meet with unwinged ants travelling about as it were at random. If you

* Huber on Ants, page 117.

place a number of large ant-flies in a box, the wings of many of them will, after some time, gradually fall off like autumnal leaves. This circumstance is peculiar to the large sort; for if you confine the small ones (meaning the winged males) ever so long, their wings will continue fixed, and cannot be separated without some difficulty."

Again, Mr. Gould remarks, that "the casting of their wings is an instance peculiar to the large ant-flies. These are, to other insects, their highest decorations, and the want of them lessens their beauty, and shortens their life. On the reverse, a large ant-fly gains by the loss, and is afterwards promoted to a throne, and drops these external ornaments as emblems of too much levity for a sovereign *."

We have, in several instances, verified these facts respecting the female ants losing their wings, and by confining them under glasses, have twice observed the process †; but after the details already given, it would be superfluous to record these experiments here.

When the females are thus disencumbered of their wings, they prepare for the new duties of their situation, by constructing suitable chambers in the first piece of moist earth which they find fit for the purpose. Those which we have placed in confinement performed similar labours, under various circumstances; for we found that a single female would work at the excavation as well as when several were put together, and also when they had several workers to assist them they did not appear to relax in assiduity ‡. These observations accord, in most particulars, with the experiments of Gould and Huber. The former, on opening mole-hills, found clusters of six or seven

* Account of English Ants, 12mo. London, 1747.

† J. R. ‡ J. R.

large female ants near the surface, but in no regular apartment. He deposited one of these clusters in a box, with some earth, under which they concealed themselves, still keeping together, but did not excavate any chamber. "Some time after," he adds, "three or four of these females laid a few eggs, but did not seem to take any great notice of them. For curiosity, I placed in the box a cell of workers, of the same species; and it was surprising to observe what fondness was expressed. The common ents immediately surrounded the females, took care of the eggs, and in a short period made an apartment in the earth fit to receive them. It may also be observed that there were no common ants (workers) in the hills where I found the above clusters. In all probability they were originally large ant-flies, which, having been expelled their colonies, and not falling victims to their adversaries, associated together in this manner, and survived the winter.*" The concluding conjecture shows that Gould mistook the efforts of the sentinel-ants to detain the females for forcible means of expulsion; so different does the same circumstances often appear when observed through the medium of preconceived notions.

Huber, in the same way as we have repeatedly done, enclosed several impregnated females in vessels filled with moist earth, in which they constructed apartments; laid eggs, of which they took great care; and, though they could not vary the temperature of their habitation, reared some of their larvæ till they were of tolerable size, but which perished from Huber's own neglect. "I afterwards," he continues, "placed some other females in a similar apparatus, and delivered to them some pupæ of workers, to ascertain if their instinct would teach them to open the covering in which they were enclosed. Although

* Gould's Account of English Ants.

these females had never paired, and were provided with wings, they laboured so well that I found on the following morning three workers among them. Some days after, I saw them occupied in delivering other labourers from their last envelope: they acted in the same way as ordinary ants, and did not appear to be at all embarrassed in the part which they now performed for the first time. It is, therefore, evident that females, in case of necessity, are enabled, unassisted, to educate their family. I have endeavoured to assure myself of this fact by proofs still more positive. After long researches, I discovered the retreat of these females, and the infant colonies which they had established, situated at a little depth in the earth, a small number of workers only being seen by the side of the mother, and some larvæ which they nourished. I have seen two examples of these newly-established colonies *." But, with all deference to M. Huber, we are clearly of opinion that these new establishments were composed of *old* workers, who, in their scouting expeditions, had discovered and seized upon fertile females, a circumstance of which we have witnessed numerous instances †.

The age to which these females live does not seem to have been ascertained; but it does not probably last above a few weeks after laying,—at least, if we may judge by analogies drawn from other insects. We are certain of one thing, that, on opening the nests of the wood-ant (*F. rufa*) and of the yellow-ant (*F. flava*), during the winter, we have never been able to detect a female; but whether some of the late-hatched females, as is the case with wasps and humble-bees, pair in winter and lay eggs in spring, or whether they lay their eggs in autumn, from which the summer females are subsequently hatched, we are still in the dark; though it is a point that might,

* Huber, *ut sup.* † J. R.

with some perseverance in making experiments, be probably ascertained *.

PAIRING OF BEES.

Few subjects have been more puzzling to scientific naturalists than the pairing of the hive-bee (*Apis mellifica*), as it differs in many particulars from what we have just related of ants, and which also is nearly similar to the pairing of wasps and humble-bees; for, among all these, a considerable number of females as well as males is produced towards the close of autumn. But in a honey-bee's hive only one female can exist at the same time; for, though several are always hatched, these either migrate successively, in order to establish new colonies, or are destroyed by the rivalry of the reigning queen, most commonly before they quit their cells, while they are of course incapable of defending themselves. The males, on the other hand, which are proverbially known by the name of *drones*, amount to six or eight hundred; and, as Kirby and Spence remark, to be born and die seems to be nearly the sum total of their history. Providence, however, has certainly some wise design in the creation of what appears at first sight so superfluous a number; probably to furnish a supply of food to the swallows and carnivorous insects, which, at the time the drones take flight, are eagerly on the hunt for prey, both to satisfy their own wants and the voracious cravings of their young. Be this as it may, the fact of these comparative numbers of the male and female hive-bees is ascertained beyond question.

As the pairing of these has never been actually observed, many conjectures respecting it have been published. One of the most ingenious appears to have been suggested by Aristotle, aud revived by Maraldi, the celebrated inventor of glass-hives, viz.

* J. R.

that the males fertilize the eggs after they are deposited in the cells, in the same way as male fish fecundate the spawn which has been previously deposited amongst sand or gravel,—a notion that also struck Swammerdam, who asserts the same of the day-flies (*Ephemeridæ*)*. In 1777, Mr. Debraw, an apothecary at Cambridge, made some observations which appeared strongly to countenance the opinion. Having discovered, at the bottom of cells containing eggs, a substance of a different appearance from that which bees commonly collect around their newly-hatched young, he conjectured it might be what Maraldi had supposed, and he became on that account anxious to watch the proceedings of every male bee in the hive. He accordingly observed some of the smaller males, which are produced in workers' cells, visiting the cells containing eggs, for the purpose, as he supposed, of fertilizing them; and farther, he found that those eggs actually did become productive, whilst others remained sterile. By repeating these observations, and by devising various experiments to verify it, he proved to his own satisfaction that the opinion of Maraldi was correct†. Bonnet objected at first that the ordinary sized males were too bulky to be able to reach the eggs in the bottom of the workers' cells. One day, however, he observed one of the larger males repeatedly striking the mouths of cells, containing eggs, with his abdomen,—a circumstance which he inferred to be favourable to the theory‡.

But Réaumur, as Bonnet himself confesses, had proved, by the most careful and rigorous experiment, that from August till April there is not, in ordinary cases, a single male, though the queen lays eggs in

* Book of Nature, i. 221.

† Philosophical Trans. vol. 67.

‡ Contempl. de la Nature, Œuvres, x. 136, note.

February and March, which fail not to be productive; and this is not explicable by the preceding theory. The elder Huber repeated the observations of Debraw, and was disposed at first to think them correct; but more minute investigation convinced him that what Debraw had taken for a fluid was nothing more than a peculiar reflection of light from the bottom of the cells, no vestiges of a fluid being perceptible when the cells were detached and cut asunder. But Huber did not rest contented with this; for, taking advantage of the fact that bees can remain under water a considerable time without much injury, he had several swarms immersed for the purpose of examining whether any males were present. In his first experiment of this kind, having ascertained that there were no males present, not even in embryo, as soon as the bees were dry, he replaced them, with their queen, in the hive, taking the precaution to barricade the entrance so as to prevent the intrusion of any males from without. This was done the 6th of August, and the same day the queen deposited fourteen eggs in workers' cells, which were all duly hatched four days afterwards. This experiment appeared to be decisive; but lest it might be alleged that the workers, when deprived of males, might search for the fecundating matter in other hives, and bring home what was wanted, Huber tried another experiment, rigidly confining all the bees, which had as before undergone immersion, from the 10th till the 14th of August; yet in this case he found forty young larvæ just hatched. He even immersed this hive a second time, examining every individual bee by hand, with a similar result. He therefore came to the conclusion that Debraw had employed in his experiments queens, with whose previous history he was not acquainted *.

Swammerdam, again, was inclined to adopt the still

* Huber on Bees, p. 14.

more fanciful opinion that the eggs were fecundated by some subtle effluvia, or aura, which he imagined he could distinguish himself by its peculiar odour. In his case this was the more singular, as he rarely travels out of the path of legitimate induction, and generally rests satisfied with recording facts. He appears to have been misled by trusting to the analogy of the experiments of Harvey respecting some other animals *; and had he lived in our own day, he might have taken similar advantage of the recent oues of Treviranus and Tiedemaun. He also refers us to "seeds committed to the earth, or being only on its surface, which are affected by the moisture of the soil;" but, from his concluding remarks, he appears to distrus this own theory. "God," he says, "even in those minute insects and their parts, has concealed from the incurious eye stupendous miracles; nor is it difficult to discover and illustrate those things, provided one sedulously applies to their investigation. Consider, therefore, what progress the acute and sagacious may make in these inquiries, if they will industriously search into them. What I have hitherto described and exhibited are, indeed, but light shadows of the things themselves: it would be easy for ingenious persons to discover and lay open all these things thoroughly, and more perfectly, to the glory of the great God. As for myself, I do most willingly confess that my capacity is so slender, that I am able to behold the works of God only at a distance; nay, the more frequently I view them, the more I am convinced of my ignorance, and I know my own weakness †."

Hattarf, on the other hand, as well as Schirach, supposed the queen-bee to be self-impregnated; for having excluded a queen from all access to the males,

* Exercit. de Generatione Animal. p. 228, &c.
† Book of Nature, i, 223.

she nevertheless deposited eggs *. Huber, likewise, repeated this experiment; but when he employed a queen which had never left the hive from her birth, she always remained barren. Huber thus finding that none of these opinions are tenable, set himself to investigate the circumstances, by further experiments, which were rewarded by the discovery that the queen-bee always leaves the hive for the purpose of pairiug, flying high in the air, and generally returning in about half an hour. We shall use his own words in relating the more conclusive of these interesting experiments.

"From a very great number of hives," says he, "I removed all the reigning females, and substituted for each, a queen taken at the moment of her birth. These experimental hives were divided into two classes,—from the first, all the males, both large and small, were taken, and I adapted a glass tube at the entrance so narrow that no male could pass, while it admitted a free passage to the workers. In the hives of the second class, I left the whole of the males belonging to them, and even introduced more, while, in order to prevent their exit, a glass tube similiar to the former was fixed to the entrance. For more than a month, I carefully watched the progress of these experiments; but, much to my surprise, every queen remained barren; and thence I concluded that pairing could not take place within the hive.

"Knowing that in summer the males usually leave the hive in the warmest part of the day, I inferred that if the queens did go out to meet them, it must be about the same time. Accordingly, at eleven in the forenoon, on the 29th of June, 1788, we placed ourselves opposite a hive containing a virgin-queen, five days old. The sun shone brightly, the air was warm, and the males began to go abroad.

* Schirach, Hist. Nat. de la Reine des Abeilles, 8vo. 1771.

We then enlarged the entrance of the one selected from which the males immediately took flight, and soon afterwards the young queen made her appearance; but she remained at first on the board, traversing it and brushing herself with her legs, and apparently unnoticed either by the workers or the males. At length she took flight, but proceeded only a few feet from the hive, to which she immediately returned, as if for the purpose of examining objects that she might again recognise. She then flew away, describing horizontal circles, twelve or fifteen feet above the earth. In order that she might not escape our observation on her return, we contracted the entrance of the hive, and placed ourselves at the centre of the circles described in her flight, that we might the more easily witness her movements; but to our great regret and disappointment, she rapidly rose out of sight. We resumed our place before the hive, and in seven minutes she returned to the entrance, probably to make another survey of its locality. We permitted her to enter the hive, and in a quarter of an hour she re-appeared, and after brushing herself as before, took to flight, soon rising so high that we lost sight of her. This second absence was much longer than the first, lasting for twenty-seven minutes; but we found her, at her return, in a different condition, which left no doubt of her having paired. We then confined her rigidly to the hive, and within two days she deposited nearly a hundred fertile eggs in workers' cells. The same experiments were repeated on virgin-queens, eleven, twenty, twenty-five, and thirty days old, with similar results*."

These observations seem now to be universally admitted among scientific naturalists; though it is the general opinion, we believe, of those who only keep

* Huber on Bees, page 23.

bees for economical purposes, that a queen never leaves the hive, except to accompany a migrating swarm, which, according to Huber, is only true of an old queen, all the young ones proceeding as we have just detailed, within twenty days after their birth, provided they are left at liberty.

It only remains for us to relate the subsequent history of the males, whose life, as in the case of other insects, is extremely short; the eggs from which they are hatched being usually laid in April and May, and their destruction terminated in July and August. It had long been remarked that the drones or male bees of a hive perished towards the end of summer, caused by the persecution of the workers, who, according to John Hunter, drive them from the hive by pinching them with their mandibles. Réaumur also remarked that, though the males are superior in size to the workers, their want of a sting disqualifies them for withstanding the assaults of the latter. He does not seem, however, to have observed the actual massacre, as he terms it, of these devoted males. Swammerdam says that "about the beginning of August the common bees become inflamed with so much hatred against the males, that they unmercifully, and for no crime, kill them; whereas, in May or sooner, they build houses for them, carefully nourish them, and bring them there, and take all possible care of them. Nor indeed is it difficult for the bees to kill these males, for they are not furnished with any weapon to defend themselves *."

Bonnet, on the other hand, upon examining with the utmost care the bodies of those males which he found dead, could discover no wound nor other mark of violence; and besides, he has frequently seen the workers mounted upon the backs of males as if they had been about to exterminate them, and yet they

* Book of Nature, i. 169, 191.

did them no injury; but in other cases, he has observed them chased into a corner behind the combs, where he imagines they must die of hunger. He consequently objects to Réaumur's expressions of "massacre," "frightful carnage," and "horrible slaughter," as not borne out by facts*. The researches of Huber, however, proved that Réaumur was right. In his letter to Bonnet he remarks, that though it was probable they might die of hunger, the carnage might notwithstanding take place in the bottom of the hive, and might have escaped observation, because the observer could not see what took place there.

"In order," he adds, "to aseertain this point, a glass table was constructed, on which were put six hives with swarms of the same year; and placing ourselves below, to see what passed in the scene of action, we endeavoured to discover how the drones were destroyed. This contrivance was completely successful. On the 4th of July we saw the workers actually massacre the males, in the whole six swarms, at the same hour, and with the same peculiarities. The glass table was covered with bees full of animation, rushing upon the males as they came from the bottom of the hive: they seized them by the antennæ, the limbs, and the wings, and after having dragged them about to the place they deemed most fit for execution, they killed them by repeated stings, directed between the rings of the belly. The moment when they felt the weapon was the last of their existence; they stretched their wings and expired. At the same time, as if the workers did not consider their victims quite dead, they pushed their stings still deeper, so that they could not easily withdraw them without turning themselves round for the purpose.

* Contempl. de la Nature, Œuvres, x. 118, note.

"Next day, having renewed our former position, we witnessed fresh scenes of carnage. During three hours the workers slaughtered the males with the utmost fury. On the preceding evening they had massacred all which belonged to their own hive, but now they attacked those which had been driven from the neighbouring hives, and had taken refuge among them. We likewise saw them tear some remaining male pupæ from the cells, and having first greedily sucked all the fluid from their bodies, they carried them off. The following day not a single male could be discovered in the hives*."

This appears to be so very unnatural a proceeding, that but for the concurring testimony of observers of the highest authority, we should be almost disposed to reject it as chimerical; and yet it is not, perhaps, subjecting them to a more cruel fate than awaits most other insects, which all perish of hunger or disease, within a few days after pairing. That it is not the consequence of a blind indiscriminating instinct, we may infer from the remarkable circumstance that no massacre of the males occurs when a hive is deprived of its queen. Bonnet, who first remarked this, conjectured that the males were preserved for the sake of the additional heat they would produce during the winter; but Huber solves the question with more plausibility, by the supposition that they are reserved for pairing with a new queen. For a similar reason, the males are preserved in those hives where the queens are only capable of laying the eggs of males, as they always do when pairing has been retarded beyond the twenty-first day of their age.

* Huber on Bees, page 112.

Chapter XI.

MIGRATIONS OF INSECTS.

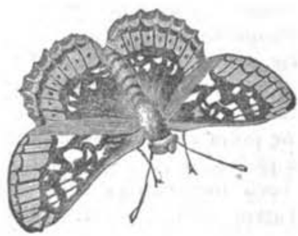
The shepherds of the Alps, as we learn from Saussure, as soon as the snows are melted on the sides of the mountains, transfer their flocks from the valleys below to the fresh pasture revived by the summer sun, in the natural parterres and patches of meadow-land formed at the foot of crumbling rocks, and sheltered by them from mountain storms; and so difficult sometimes is this transfer to be accomplished, that the sheep have to be slung by means of ropes from one cliff to another before they can be stationed on the little grass-plot above *. A similar artificial migration (if we may use the term) is effected in some countries by the proprietors of bee-hives, who remove them from one district to another, that they may find abundance of flowers, and by this means prolong the summer. Sometimes this transfer is performed by persons forming an ambulatory establishment, like that of a gypsey horde, and encamping wherever flowers are found plentiful. Bee caravans of this kind are reported to be not uncommon in some districts of Germany; and in parts of Italy and France the transportation of bees was practised from very early times. But a more singular practice in such transportations was to set the bee-hives afloat on a canal or river; and we are informed that, in France, one bee-barge was built of capacity enough for from sixty to one hundred hives,

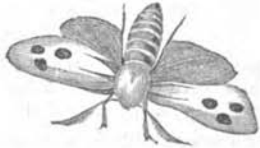
* Voyages dans les Alpes.

and by floating gently down the river, the bees had an opportunity of gathering honey from the flowers along the banks. In Lower Egypt, where the blowing of flowers is considerably later than in the upper districts, the practice of transporting bee-hives is much followed. The hives are collected from different villages along the banks, each being marked and numbered by individual proprietors, to prevent future mistakes. They are then arranged in pyramidal piles upon the boats prepared to receive them, which floating gradually down the river, and stopping at certain stages of their passage, remain there a longer or a shorter time, according to the produce afforded by the surrounding country. In this manner the bee-boats sail for three months: the bees having culled the honey of the orange flowers in the Said, and of the Arabian jassmine and other flowers in the more northern parts, are brought back to the places from which they had been carried. This procures for the Egyptians delicious honey and abundance of bees' wax. The proprietors in return pay the boatmen a recompence proportioned to the number of hives which have been thus carried about from one extremity of Egypt to the other. The celebrated traveller Niebuhr saw upon the Nile, between Cairo and Damietta, a convoy of 4000 hives in their transit from Upper Egypt to the coast of the Delta.

These artificial transportations of a domesticated race of insects exhibit a partial example of what frequently takes place in a natural manner, when it is necessary to shift from one place to another for the sake of a better supply of food. In many cases, however, where food is abundant, and other circumstances favourable, particular insects limit their excursions to a very narrow range. Thus we have observed the forester moth (*Ino statices*, LEACH) literally swarming on the north bank of the Serpentine in Kensington Gardens, though not one was to be seen on the south bank, nor in any other spot in the vicinity. In the same way we once noticed some hundreds of the burnet moth (*Anthrocera filipendulæ*, STEPHENS) on a small portion of the north shore of the Great Cumbra Island in the Firth of Clyde; but though on the same day we made a botanical excursion all round the island, as well as on the opposite coasts of Largs and of the Isle of Bute, we did not elsewhere meet with one of those insects. In the dell below the hanging-wood at Charlton, in Kent, we observed a similar local assemblage of the cinnabar moth (*Calimorpha jacobææ*, LATREILLE), not one being discoverable in

a





b

a, Marsh fritillary (*Melitæa artemis*). b, Six-spot burnet moth (*Anthrocera filipendulæ*).

any of the surrounding fields *. An instance no less marked occurs in the case of the marsh fritillary (*Melitæa artemis*, OCHSENHEIMER), a butterfly so very local, that, according to Harris, who observed it at Wilsden, near Harrow-on-the-Hill, it seldom if ever leaves the field in which it has been bred, though hundreds of them may be seen there flying low, and frequently settling †. It is probable the race is now extinct at Wilsden, at least we have twice failed in discovering them there at the season indicated by Harris.

These, however, are only exceptions to the general rule of nature, which seems to be to diffuse a species over as great a space as possible, and thus to stock every corner of the earth with life and enjoyment. Hence it is that while a very few species of moths and butterflies are confined to certain fields, as a very few species of fish are confined to certain lakes or rivers ‡, by far the greater number may be seen wandering from flower to flower, and from field to field, with no other rule to direct their flight beyond the most wayward caprice. All the movements of insects, however, so far from being capricious, are chiefly if not solely produced by the two great principles of self-preservation and reproduction, though movements may sometimes be observed to which neither of these principles very obviously apply—anomalies which require other circumstances for their explanation, as we shall now endeavour to exemplify.

Were it recorded that a numerous flight of sparrows directed their course in an undeviating straight line towards the ocean, and not having sufficient power of wing to cross it, were seen to drop into the water and perish, it might well be doubted whether

* J. R. † Harris, Aurelian, 28.
‡ Mag. of Natural History, i, 487.

an occurrence so very unnatural ever happened, unless the character of the witnesses thereof was so high as to be beyond suspiciou. Yet this very case is so frequently paralleled among various species of insects, that instead of an anomalous or miraculous fact, it may be considered, under particular circumstances, as the usual order of things. We are told, for example, by Mr. Lindley, that when he was in Brazil, in March, 1803, an immense flight of butterflies of white and yellow colours continued for many days successively. They were observed never to settle, but proceeding in a direction from north-west to south-east, no obstacle appeared to stop them in their course, which lay toward the ocean, where they must all inevitably perish *.

A somewhat different migration of butterflies was recently observed in Switzerland. In the beginning of June, Madame de Meuran Wolff and her family, established during the summer at Grandson, on the lake of Neufchatel, observed with surprise an immense flight of butterflies traversing the garden with great rapidity. They were all of the species called *Belle Dame* by the French, and by the London collectors the Painted Lady (*Cynthia cardui*, STEPHENS). They were all flying close together in the same direction, from south to north, and were so little afraid when any one approached, that they turned not to the right or to the left. The flight continued for two hours without interruption, and the column was about ten or fifteen feet broad. They did not stop to alight on flowers, but flew onwards, low and equally. This fact is the more singular, when it is considered that the caterpillars of this species are solitary from the moment they are hatched †, nor are the butterflies themselves usually

* Voyage to Brazil.

† See Insect Transformations, pp. 69—71.

gregarious. Professor Bonelli, of Turin, however, observed a similar flight of the same species of butterfly in the end of the March which preceded their appearance at Grandson, when it may be presumed they were just evolved from their chrysalides. Their flight, as at Grandson, was from south to north, and their numbers were so immense that at night the flowers were literally covered with them. As the spring advanced their numbers diminished, though even in June a few still continued. A similar flight of butterflies is recorded about the end of last century by M. Loche, in the Memoirs of the Turin Academy*.

The chief extraordinary migrations of insects which have been recorded as occurring in Britain, are those of aphides and their enemies, the lady-birds (*Coccinellidæ*), which accompany them as whales follow a shoal of herrings, or as the locust-eating thrush of Southern Africa follows a swarm of locusts. "I know no other reason," says Kirby, "to assign for the vast numbers that are sometimes, especially in autumn, to be met with on the sea-coast, or the banks of large rivers. Many years ago those of the Humbec were so thickly strewed with the common lady-bird (*Coccinella septempunctata*), that it was difficult to avoid treading on them. Some years afterwards, I noticed a mixture of species collected in vast numbers on the sand-hills on the sea-shore at the north-west extremity of Norfolk. My friend, the Rev. Peter Lathbury, made long since a similar observation at Orford, on the Suffolk coast: and about five or six years ago (in 1807), they covered the cliffs at Brighton, and of all the watering-places on the Kentish and Sussex coasts, to the no small alarm of the superstitious, who thought them forerunners of some direful evil, and who were ignorant that their

* Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève.

little visiters were emigrants from the neighbouring hop-grounds *."

The aphides upon which they prey, in like manner shift their quarters; and amongst other instances on record, White informs us that about three o'clock in the afternoon of the 1st of August, 1785, the people of the village of Selborne were surprised by a shower of aphides which fell in those parts. Persons who walked in the street at this time found themselves covered with them, and they settled in such numbers in the gardens and on the hedges as to blacken every leaf. Mr. White's annuals were thus all discoloured with them, and the stalks of a bed of onions were quite coated over for six days afterwards. These swarms, he remarks, were then no doubt in a state of emigration, and might have come from the great hop-plantations of Kent and Sussex, the wind being all that day in the east. They were observed at the same time in great clouds about Farnham, and all along the vale from Farnham to Alton †. It would have been well if the particular species had been ascertained, so as to make sure whether they belonged to the hop-fly (*Aphis humuli*). White, however, was not so minutely acquainted with insects as to notice the difference of species; but this could scarcely be the case with Kirby, whose knowledge of the science is second, we believe, to that of no living naturalist, yet he leaves us equally in the dark, when he says, "A similar emigration of these flies I once witnessed, to my great annoyance, when travelling later in the year in the Isle of Ely. The air was so full of them, that they were incessantly flying into my eyes, nostrils, &c., and my clothes were covered by them; and in 1814, in the autumn, the aphides were so abundant for a few days in the vicinity of Ipswich, as

* Introduction, ii. 8; and i. 264.
† Natural History of Selborne, ii. 101.

to be noticed with surprise by the most incurious observers *."

We confess we feel not a little disappointed that the species is not mentioned in these instances, as it might serve to fill up a blank in the history of some of those which are most destructive. In the case of the hop-fly, we have remarked for several successive years, that soon after Midsummer they all disappear, though the leaves have only a few days before been literally covered with them in millions. The same is the case with those called the dolphin, which infest the bean (*Aphis fabæ*), and that named the zebra (*A. sambuci*). It is highly probable that all these perish soon after the deposition of the eggs for the succeeding spring; but it is by no means an easy matter to ascertain this. If they migrate to the sea-coast and are drowned, as we are partly entitled, from the statements just given, to infer, their fate is similar to another still more destructive insect, the locust (*Locusta migratoria*, Leach) †.

The prophet Joel, who has given so striking a picture of the devastation produced by locusts ‡, has not forgotten to notice their destruction, when he says, "I will remove far off from you the northern army, and will drive him into a land barren and desolate, with his face toward the east sea, and his hinder part toward the utmost sea, and his stink shall come up, and his ill-savour shall come up because he hath done great things §." Mr. Barrow tells us, that in Southern Africa, in 1784 and 1797, they covered, during their progress, an area of nearly two thousand square miles, but were ultimately driven into the sea by a north-west wind, where they formed upon a shore, for fifty miles, a bank three or four feet high, and when the wind was south-east their

* Intr. ii. 9. † See Insect Transformations, p. 251.
‡ Ibid, p. 246. § Joel, chap. ii. 20.

stench was so powerful as to be perceptible at the distance of a hundred and fifty miles *.

The account given by Jackson of their progress and final destruction in northern Africa is precisely similar. Before the plague, in 1799, the face of the country from Mogador to Tangier was covered with them and ravaged, as well as the whole region from the confines of the Sahara; but on the other side of the river El Kos not one was to be seen, though there appeared nothing to prevent them from flying over. The water of the river seemed to be a barrier to their progress, for they were proceeding northward until they arrived at its bauks, when they immediately turned to the east; and in consequence all the country north of El Araiche remained uuravaged, and abundant in grain, pulse, and fruits, exhibiting a very striking contrast to the desolation of the adjacent district. The usual fate awaited this desolating swarm: a violent hurricane drove them in a cloud into the Western Ocean, and the shore was rendered sn nnxious by their carcasses, that it is believed to have been the cause of a pestilence which followed †.

Hasselquist, the disciple of Linnæus, who went to the east expressly to study its natural history, tells us, that the "locust is not formed for travelling over the sea; it cannot fly far, but must alight as soon as it rises; for one that came on board us, a hundred certainly were drowned. We observed in the months of May and June a number of these insects coming from the south, and directing their course to the northern shore; they darken the air like a thick cloud: hut scarcely have they quitted the shore, when they, who a moment before ravaged and ruined the country, cover the surface of the sea with their dead

* Travels in S. Africa, p. 257.

† Travels in Morocco, p. 54.

bodies. By what instinct," he adds, " do these creatures undertake this dangerous flight? Is it not the wise institution of the Creator to destroy a dreadful plague to the country *?" We thiuk that it is more consisteut with other instances of extensive destruction among particular species to refer it to the design of Providence to furnish food for carnivorous animals. The day-flies (*Ephemeridæ*), for example, are a harmless race, and yet the numbers of them which perish only a few hours after they acquire wings is scarcely inferior to those of the locusts †. Like the locusts, too, they chiefly perish in the water, both affording an abundant banquet for the fishes.

There is one circumstance in these migrations, which is remarked by most observers, that appears to corroborate these views; we refer to the direction commonly taken by them being towards the sea, and their pursuing their course with little deviation. The locusts seen by Captains Irby and Mangles, on the southern shore of the Dead Sea, were said to be on their way to Gaza, to which they pass almost annually ‡; those observed in Barbary by Dr. Shaw " marched directly towards the sea §;" and Hasselquist tells us they seldom or never deviate from the direction of their course. These very singular facts are strikingly illustrated by the migrations of a much larger, though it would appear no less destructive animal, the lemming rat (*Mus lemmus*, LINN.), which inhabits the north of Europe, and lives on vegetable food. The migrations of the lemming take place at uncertain intervals of about ten years, from Lapland towards the southern parts of Sweden, induced, it is supposed, by the foresight of a severe

* Hasselquist's Voyage, p. 444.
† See Insect Transformations, pp. 218 and 373.
‡ Travels in Egypt and Syria, 443.
§ Travels, 287.

winter, to escape to a more genial climate; though the migration has the effect, like that of the locusts, of reducing an overgrown population, and at the same time of supplying food to many animals who might otherwise have starved. In their journeys, they always endeavour to keep in a direct line; and hence multitudes of them perish in their endeavours to cross lakes and rivers. If they are disturbed or pursued while swimming over a lake, and their phalanx chances to be separated by oars or poles, they will not recede; but keep swimming directly on, and soon get into regular order again. So obstinate, indeed, are they in holding on their direct course, that they have sometimes been known to try to pass over a vessel. This army of rats moves chiefly by night, or early in the morning; and makes such destruction among the herbage, that the surface of the ground over which they have passed appears as if it had been burned. Their numbers have at times induced the people of Norway to believe that they descended from the clouds; and the multitudes that are sometimes found dead on the banks of rivers, or other places, corrupt the whole atmosphere around *.

We recollect another remarkable migration of a different species of animal also towards the sea-coast, but for a very different purpose, and we mention it here more particularly, because it will lead us back by a natural transition to families of insects influenced by similar motives,—we refer to the land-crab of the West Indies (*Ocipoda ruricola*, LATREILLE). The usual residence of this species is the inland mountains and woods, where they live in holes dug by themselves. Annually, about the months of April and May, they set forth in a body, often consisting of some millions, for the sea-coast. They always march in a direct line to their place of

* Pennant, Arctic Zoology.

destination, and are said seldom to turn out of their way, on account of intervening obstacles, and even if they encounter a lofty wall or a house, they will attempt to scale it; but when they meet with a river they follow the course of the stream, as if instinctively aware that it will ultimately lead them to the sea, as was probably the case with the African locusts, mentioned by Jackson. These multitudinous hordes of crabs, however, do not perish in the sea, but go there to spawn; though from this spawn forming a rich banquet for the sea-fish, the providential effect is nearly the same as in the instances of locusts, aphides, lady-birds, and sawflies.

Some of the more remarkable migrations of insects are, in the same way, for the purpose of depositing their eggs, or disposing of their supernumerary progeny in suitable localities, in the case, for example, of ants and bees. Kirby and Spence have given the following animated and eloquent account of the migrations of the former. "In the warm days that occur from the end of July to the beginning of September, and sometimes later, the habitations of the various species of ants may be seen to swarm with winged insects, which are the males and females, preparing to quit for ever the scene of their nativity and education. Every thing is in motion—and the silver wings, contrasted with the jet bodies which compose the animated mass, add a degree of splendour to the interesting scene. The bustle increases, till at length the males rise, as it were by one general impulse, into the air, and the females accompany them. The whole swarm alternately rises and falls, with a slow movement, to the height of about ten feet, the males flying obliquely, with a rapid zig-zag motion, and the females, though they follow the general movement of the column, appearing suspended in the air, like balloons, seemingly with no individual motion, and having their heads turned towards the wind.

"Sometimes the swarms of a whole district unite their infinite myriads, and, seen at a distance, produce an effect resembling the flashing of an aurora borealis. Rising with incredible velocity, in distinct columns, they soar above the clouds. Each column looks like a kind of slender net-work, and has a tremulous, undulating motion, which has been observed to be produced by the regular alternate rising and falling just alluded to. The noise emitted by myriads and myriads of these creatures does not exceed the hum of a single wasp. The slightest zephyr disperses them; and if in their progress they chance to be over your head, if you walk slowly on, they will accompany you, and regulate their motions by yours. The females continue sailing majestically in the centre of these numberless males, who are candidates for their favour, each till some fortunate lover darts upon her, and, as the Roman youth did the Sabine virgins, drags his bride from the sportive crowd, and the nuptials are consummated in mid-air; though sometimes the union takes place on the summit of plants, but rarely in the nests*. After this *danse de l'amour* is celebrated, the males disappear, probably dying, or becoming, with many of the females, the prey of birds or fish†; for since they do not return to the nest, they cannot be destroyed, as some have supposed, like the drone-bees, by the neuters. That many, both males and females, become the prey of fish, I am enabled to assert from my own observation. In the beginning of August, 1812, I was going up the Orford river, in Suffolk, in a row-boat, in the evening, when my attention was caught by an infinite number of winged ants, both males and females, at which the fish were

* De Geer, ii. 1104. † Gould, p. 99.

everywhere seen darting, floating alive on the surface of the water. While passing the river, these had probably been precipitated into it, either by the wind or by a heavy shower which had just fallen: and M. Huber, after a similar event, observed the earth strewed with females that had lost their wings, all of which could not form colonies.

"Captain Haverfield, R. N., gave me an account of an extraordinary appearance of ants observed by him in the Medway, in the autumn of 1814, which is confirmed by the following letter, addressed by the surgeon of the Clorinde, now Dr. Bromley, to Mr. MacLeay: 'In September, 1814, being on the deck of the hulk to the Clorinde, my attention was drawn to the water by the first-lieutenant (Haverfield) observing there was something black floating down with the tide. On looking with a glass, I discovered they were insects. The boat was sent, and brought a bucket full of them on board; they proved to be a large species of ant, and extended from the upper part of Salt-pan Reach out towards the Great Nore, a distance of five or six miles. The column appeared to be in breadth eight or ten feet, and in height about six inches, which I suppose must have been from their resting one upon another.' These ants were winged—whence this immense column came was not ascertained. From the numbers here agglomerated, one would think that all the ant-hills of Kent and Surrey could scarcely have furnished a sufficient number of males and females to form it.

"When Colonel Sir Augustus Frazer, of the horse-artillery, was surveying, on the 6th of October, 1813, the scene of the battle of the Pyrenees, from the summit of the mountain called Pena de Aya, or Les Quartres Couronnes, he and his friends were enveloped by a swarm of ants, so numerous as entirely to intercept their view, so that they were glad to remove to another station in order to get rid of them *."

Our readers will feel equal interest in a migration of ants of a different kind, which was first circumstantially recorded by the younger Huber, though it attracts and has attracted the notice of every observer. There are few gardens, even of small extent, which do not contain one or more colonies of the negro-ants (*Formica fusca*), or the turf-ants (*Myrmica cæspitum*), and these are, perhaps, the most restless emigrants of the whole family (*Formicidæ*, LEACH); for their edifices being constructed among the grass or in the sand, are liable to be destroyed by the foot of every passenger, if not in the operations of gardening, and whenever such accidents occur, they become fidgetty and dissatisfied with the old place, and soon set about selecting a new one. When watching their architectural proceedings, accordingly, we have been frequently disappointed in our expectations by the little colonists decamping altogether, instead of making good the bits of wall which we had broken down for the sake of experiment †. During the summer of 1830, we paid considerable attention to a numerous colony of the negro-ant (*F. fusca*), established on a sloping border at the root of a carnation; but soon after the plant came into flower, the ants resolved to migrate to the other side of the gravel-walk—having been probably disturbed by gathering the flowers, or invited by the shelter of a thick pear-tree that overhung the border to which they had removed. Their march, as is usual, was very orderly, confined to a direct line, sufficiently broad to let two pass without jostling; and their first

* Intr. ii. 54.

† See Insect Architecture, p. 270.

concern was to form a covert way at the end, which terminated in the new establishment. Along this high-road might be seen the busy inhabitants carrying off eggs and pupæ from their former domicile, and in the earlier part of the removal some were carrying their companions, for the purpose of showing them the road; but when once it was sufficiently imbued with their odour to be recognised, this clumsy method of imparting information was given up. We found, however, that we could again set them upon the carrying process by pressing our foot across their track, or otherwise obliterating the odour left by their previous passengers. In this case, an emigrant is completely bewildered the instant he arrives at the broken line, as much as a hound would be if a bush-harrow had been dragged across the track of the hare or the fox, of which he is in chase.

In another garden, in which there are at least a dozen colonies of the turf-ant and of the red ant (*Myrmica rubra*), we seldom go round it without seeing some of them moving their pupæ to a newly selected spot, or dragging each other from one chink in the soil or plot of grass to another. A notice to quit the settlement is generally obeyed with alacrity, the whole colony immediately undertaking the labour of constructing a new encampment, as well as of removing thither all that they esteem most valuable, following the individual ant that first decides on the new location, (as the Americans term it)*.

These observations, in which we took more interest and pleasure than most readers may do in the perusal of our imperfect sketch, were, we confess, suggested by the curious details of Huber, without which they might have escaped our notice; but every body

* J. R.

may readily repeat them without going to the trouble of constructing artificial formicaries. The three species which have just been mentioned will be found to be better adapted for such observations than the yellow ants (*F. flava*), which are by no means of a migratory disposition, perhaps because their hills are of more laborious and extensive construction, and a general movement is not therefore so easily effected. The wood-ants (*F. rufa*), again, appear, from the observations of Huber as well as our own, to be considerably addicted to emigration; though from their preferring to live in woods, they are not so convenient for most observers to study. Huber one day deranged the dome of one of the encampments of the latter, at which they took offence and emigrated.

"I saw," says he, "at the distance of ten paces from their nest, a fresh ant-hill, which communicated with the old by a path struck out in the grass, along which the ants were passing and repassing in great numbers. I remarked that all those going towards the new establishment were loaded with their companions, whilst those moving in a contrary direction were running one after the other. From that period, I put several of these republics to the same proof. I destroyed so often the roof of their underground city, that I succeeded in driving them from their residence. The first and second times they repaired the breaches, but the third they resolved to seek an asylum less exposed to such accidents. I then observed one of the labourers leave the nest, carrying one of its companions, and I watched it till it deposited its burden at the margin of a subterranean cavity. This little carrier was soon succeeded by others, whose numbers, at first but trifling, increased every moment. After several had been carried in this manner to the new ant-hill to begin operations, a portion of them returned to the old for recruits, and it was not a little interesting to observe their procedure. They accosted the first they met, caressing them with their antennæ, and no doubt proposing in their way the journey; and when they succeeded in persuading them, they laid hold of them with their mandibles, coiled them up into the smallest possible compass, and bore them off. All this took place in the most amicable manner, with much the same gesticulations as when one supplies another with food. But it sometimes happened that the individuals of the emigrant party seized the other ants by surprise, dragging them out of the ant-hill, and without allowing them time either to make up their mind or to offer resistance, hurrying them off with great rapidity."

"My glass frames," continues Huber, "often permitted me to see what occurred in the interior during emigration, for when the labourers espied any issue that had escaped my vigilance, they profited by it to go in search of a place more to their liking. They spread themselves at first separately over the floor, and observed all the corners of my study, hoping to discover an asylum in which they might be sheltered, and on the moment they discovered this, they commenced recruiting. The individual which had found a place of safety went immediately to seek its companions, one after the other on the floor, and then in the glass formicary; but it was sufficient, as I discovered, to stop the emigration, by simply taking away at the time the first recruit, and it was not renewed till some other individual had made a suitable discovery. The recruiting continued several days; but when the whole labourers knew the route to their new habitation, they ceased to carry each other.

They had by this time constructed large vaulted chambers, avenues, and lodges; they first brought off the pupæ and larvæ, and then the males and the females. When the removal was complete, they for ever abandoned the artificial ant-hill, and the road leading thereto.

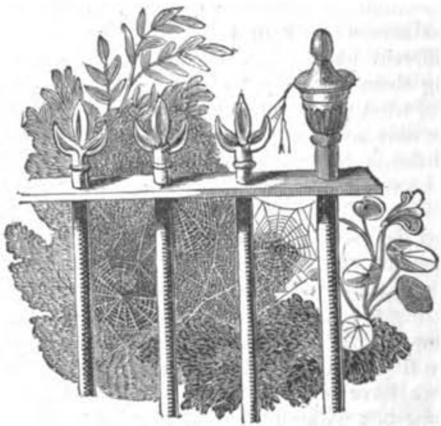
"Upon opening the shutter of my formicary whilst the emigration on the exterior was in full activity, all appeared tranquil within; those recruiting arrived at the very gate of the ant-hill, but the ants, who were not immediately the object of their search, paid no attention to their proceedings; they continued, as usual, their ordinary avocations, and did not appear to suspect what was going forward so near them. It now and then happens that several workers undertake at the same time to found a new city, and conduct there the whole colony, which gives place to a temporary existence of several ant-hills; but these insects are soon aware of this division, and do not delay in the last recruiting to bring the whole colony into one encampment.

"When the ants are displeased with the city they have chosen, they quit it for a third, and sometimes even for a fourth, where they definitively fix. We even see them very frequently return to the ancient nest before being fully established in the new. The recruiting then takes place in a contrary direction, and the couples meet each other in the same road, but the last has always the advantage over the preceding emigrations. When the new ant-hill is at a considerable distance from the old, the ants commonly establish some intermediate residence, in which they deposit the recruits, the larvæ, the males, and the females, which they are unable to carry in one journey to their proper destination. I have seen several relays established upon the same route; they consisted of cavities pierced in the earth, containing sufficiently spacious apartments, generally covered with fragments of straw, and resembling small ant-hills. We might there observe some sentinels doing daily duty, that is to say, opening and closing the gates of the ant-hill morning and evening. Sometimes these asylums become little colonies, which maintain a close connection with the principal ant-hill; they are different habitations, common to the same ants, serving them for places of refuge on any derangement of what we might term their capital *."

The only analogous instance of a number of establishments formed in the vicinity of the parent nest, occurs among spiders, who do not, like the ants, live in communities, but every individual forages for itself. Redi and some recent naturalists mention the experiment of confining young spiders for a long time without food, and talk of their even devouring the bodies of their brethren; but however that may have been after their separation, we are certain that it could not have happened before: at least we have very often confined them together in the same box without food for weeks together, and never saw anything to countenance the supposition. But it is chiefly their proceedings after leaving the nest which here claim our notice. From fifty to a hundred or more are usually produced by one mother, and as soon as they are strong enough to make their way, they quit the maternal nest, to commence war upon every insect that flies. When the nests of several of the geometric spiders are placed, as they often are, near the iron railings of our squares, every interval may be seen filled with the nets of the little emigrants, as if in their journeyings from home each had appropriated to its exclusive use the half of

* Huber on Ants, p. 166.

a pair of the iron bars. Sometimes again the points of the arrow heads at the top of the bars are selected, and in that case it is a pretty sight, particularly in a dewy morning, to see them fringed with the neat and regular lace-work of the spiders, glittering with dew-drops all round the square *.

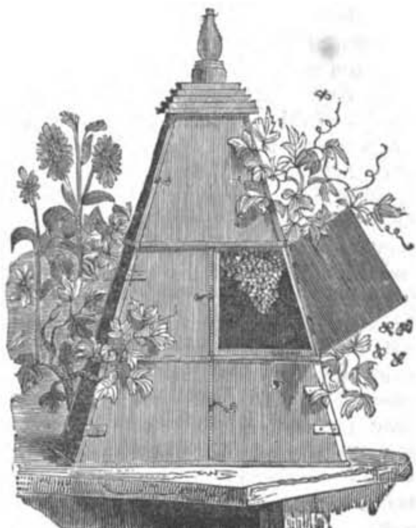


MIGRATIONS OF BEES.

THE migrations of the hive-bee are very different, both in principle and procedure, from any of the foregoing instances. The ants in many cases can extend their premises indefinitely, and therefore can have little inducement to emigrate, unless they exhaust all the provision obtainable in their neighbourhood. With hive-bees the case is different; for being confined within a limited space, they cannot there increase and multiply beyond a certain point, and conse-

* J. R.

quently, when the hive becomes too crowded for the population, it is expedient to thin their numbers by emigration. That a too crowded hive, however, is not the only cause of emigration was proved from several experiments by Réaumur. He frequently possessed hives so full of bees that a portion of them were compelled to remain on the outside, conglomerated in a mass, and yet no swarm was sent off to thin their numbers. In other hives, on the contrary, where there was much spare room, more than one swarm was thrown off. To assure himself of this, he placed a colony in a very large pyramidal hive, of



Réaumur's large pyramidal hive.

which they only filled three-fourths, and yet a body of emigrants took their departure.

The researches of naturalists, indeed, have discovered many curious facts relative to the proceedings of the bees in such cases; but still many things, like the immediate cause of their swarming, remain doubtful or obscure. We have seen that the ants are generally influenced in their change of residence by some individual who has discovered a spot that appears preferable; but authors are by no means agreed whether bees are similarly guided. Dr. Warder is of opinion that they always send out scouts to select a suitable place several days before swarming, and infers that their usually clustering together upon a bough soon after their departure arises from their wish to form a united body prior to their last flight. Mr. T. A. Knight mentions several circumstances corroborative of this opinion. In one case, he observed from twenty to thirty bees paying daily visits to some decayed trees, about a mile distant from his garden; all of them appearing to be busily employed in examining the hollow parts, and particularly the dead knots around them, as if apprehensive that the knots would admit moisture. These surveyors, if such they were, in about a fortnight after were followed by a large swarm from one of his hives, which was tracked the whole way till it alighted in one of the cavities that had been thus pre-examined, and it was observed to take nearly a direct line from the parent hive to the tree. On another occasion, Mr. Knight remarked a number of bees occupying one of the cavities for some time before; but having offered them better accommodation in a hive, they deserted the tree *.

Dr. Evans also mentions an instance in which a

* Phil. Trans. 1807.

swarm made its way either over the tops of some very high houses, or through several winding streets, to an old house in the centre of Shrewsbury, and passing through an aperture in the wood-work to a room on the first floor, were there hived by the family. In another case, he had permitted a hive, whose tenants had died in the winter, to remain upon the stand till spring, when he observed several bees paying it daily visits, and busily employed within, but leaving it at the close of evening. These, he infers, were the precursors of a swarm which took possession of it in the following June *.

Réaumur, on the other hand, looks upon these opinions as altogether fabulous; since, if the bee-queen is thus provided with spies and quarter-masters, he thinks them very ignorant of their duties,—at least the choice of a place does but small credit to their foresight,—as they for the most part fix upon the bough of a tree, where they are exposed to all the vicissitudes of the weather. Mr. T. A. Knight seems to think, however, that their settling on the branch of a tree is nothing more than a resting-place, where the whole may rendezvous, and that this is previously fixed upon by the scouts as well as the spot intended for their final establishment. But Réaumur mentions a fact which will not at all accord with this, namely, that upon whatever branch or other place they thus alight, combs are always found to be commenced, even though their stay may be very short; which proves, he thinks, that they intended it for a permanent abode. Were they left to themselves, indeed, they would not remain there; but they would only leave it when, upon trial, they found it inconvenient, from being too hot or too cold, or exposed to rain and wind †.

* The Bees, a Poem; Notes.

† Mémoires, v. 621.

Swarm of bees on a laburnum tree branch.

What is better ascertained with respect to the original formation of swarms is, that in a populous hive, containing a fertile queen, a prodigious quantity of the eggs of male bees are laid in the course of May, and at the same time royal cells are constructed by the workers, to the number of from sixteen to twenty-seven, but the queen lays only a single egg in one of these on the same day, as it is important that no two queens should be of the same age. When the grubs hatched in the royal cells are ready to be transformed into pupæ, the mother-queen leaves the hive, together with a large number of the workers of all ages, the original hive remaining without a queen till the transformation of the eldest royal pupa. All the royal cells are after her departure assiduously watched by the workers. "At length," says the elder Huber, "the female hatched from the first egg laid by the old queen leaves her cell; the workers then treat her with indifference. But impelled by the instinct which urges her to destroy her rivals, she seeks the cells where they are enclosed; yet no sooner does she approach than the sentinel bees bite, pull, and harass her, so that she is forced to remove, though the royal cells being numerous she can scarcely find a place of rest. Incessantly animated with the desire of attacking the other queens, and as continually repelled, she becomes agitated, and hastily traverses the different groups of workers, to which she communicates her disorder. At this moment numbers of bees rush towards the aperture of the hive, and, accompanied by the young queen, forsake it to seek another residence. After the departure of this second colony, the remaining workers set another queen at liberty, and treat her with equal indifference as the first. They drive her from the royal cells; she also, from being perpetually harassed, becomes agitated, departs, and carries along with her a third swarm. In a populous hive this scene is repeated with the same circumstances three or four times during the summer. The number of bees being then so much reduced, they are no longer capable of preserving a strict watch over the royal cells; several females are enabled to leave their confinement at once, when they seek each other, fight, and the queen who is at last victorious reigns peaceably over the republic*."

For two or three nights previous to the departure of a swarm, a singular humming sound is heard in the hive. The sounds, which are sharp and clear,

* Huber on Bees, 176.

seem to proceed from a single bee, but they cannot always be distinguished unless the ear be placed near the mouth of the hive. John Hunter compared the sound to the lower A in the treble of the piano-forte, and others think it resembles the stridulous *toot, toot*, of a child's penny trumpet. It has been supposed by Wildman that this sound proceeds from the contest of the rival queens about sallying forth, but the facts above given show this to be an unfounded conjecture; and with still less truth Butler supposes it to be a parley between the young and the old queen—the former at the bottom of the hive requesting leave to emigrate, and the latter answering in her bass note from the top *. Others gravely construe the sound into a harangue of the queen to animate her subjects to the meditated undertaking of founding a new empire.

On the other hand, there is also for the most part unusual silence in the hive, that is, little of the ordinary hum; the intended emigrants being, it is supposed, busily engaged in eating a hearty meal, and laying in a cargo of honey as a provision for bad weather previous to their departure. In proof of this, John Hunter, upon opening the crops of the emigrants, found them full of honey, whereas he found but a small portion in the crops of those which remained. Perhaps it may be this circumstance which produces their obvious neglect of collecting, as well as of other labour, some days previous to emigration. One of the most indubitable signs of swarming, according to Réaumur, is when—particularly on a sunny morning, the weather being favourable to their labours—few bees go out of a hive, from which on the preceding day they had issued in great numbers. He is of opinion that this proves all, or almost all

* Monarchia Femina, 1634.

the inhabitants of a hive to be aware of a project which will not be put in execution before noon, or some hours later; otherwise, why should bees, who worked the day previous with so much activity, cease their labours in a habitation they are to quit at noon; There is a well-known anecdote of an old grenadier, who, being seen resting inactive, while his less experienced comrades were busily pitching their tents, Marshal Turenne, his general, asked him why he did not bestir himself like the rest,—"Because," he replied, "we shall have to march again in a few hours"—a reason which the bees, intending to emigrate, well understand*.

About the same time an unusual number of male bees may be observed on the outside of the hive, as well as a body of workers clustered together at its entrance, driven thither, it has been conjectured, in consequence of the heat of the hive, arising from the agitation among the inhabitants,—the usual spring temperature of the hive from 90° to 97° being thus augmented to 104°. This is farther increased by the heat of the sun, for a swarm is seldom, if ever, seen, except when the sun shines and the air is calm,—so much so, that if but a cloud pass before the sun, all the agitation coincident with their preparation to depart is intermitted. It has even been imagined that they can foresee fine weather, though the circumstance just mentioned shows that their foresight in this respect must be very limited; besides, swarms are not unfrequently caught in a shower and obliged to return to the hive for shelter. Réaumur had one which set out at one o'clock and was caught in a shower at three. At the same time, it is certain that they are always feverishly alive to the state of the weather; and while ranging in the

* Réaumur, Mém. v. 611.

fields, a chance cloud passing over the sun will induce their precipitate return, though, when the sky is totally overclouded, they are not deterred from collecting, and in such a case the commencement of a soft rain does not alarm them.

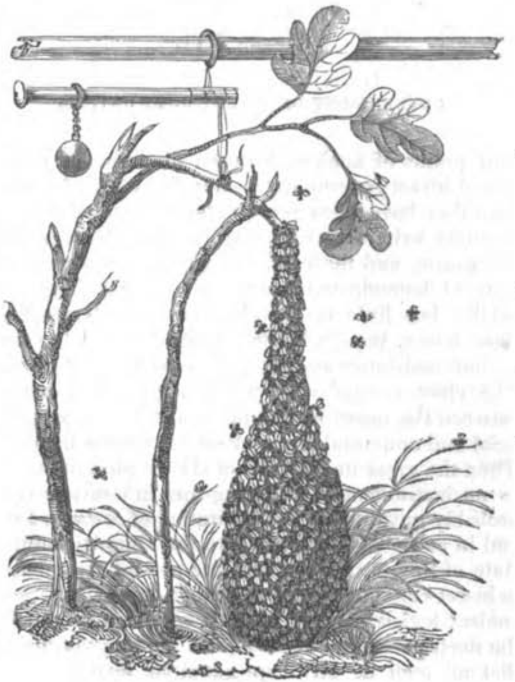
"I am persuaded," says Huber, "that the necessity of a fine day for swarming is one reason for the protracted captivity of the young queens in their cells, though in some cases this appears to be quite arbitrary; but it is always remarkably extended when bad weather continues for several successive days. The providential reason appears to be, that if the young queens were at liberty to leave their cradles during intemperate weather, a plurality of queens and constant warfare between them would be the consequence. Instead, therefore, of the multiplication of the species being left to the chance of rain or fine weather, it is by the wise disposition of Providence rendered independent of either. By allowing only a single queen to escape at once, the formation of swarms is insured. Another important circumstance resulting from the temporary captivity of the young queens is, that they are in a condition to fly the instant they are set at liberty, and consequently can take advantage of the first moment of sunshine to head the emigrants*."

At first, the queen does not alight on the branch where the swarm settles, but waits till a number of the bees are formed and clustered before she joins them. Immediately afterwards the clustering becomes more dense, all the bees in the air hastening to join their companions, each clinging to one another by the claws of their feet as when they form a curtain during the production of wax†;

* Huber on Bees, p. 179.

† See Insect Architecture, p. 119, for a figure of this.

and a singular spectacle it is to see from twelve to forty thousand bees thus conglomerated in a living mass.



Swarm of 40,000 bees on a branch of fig-tree, with Réaumur's apparatus for weighing them, and computing their number.

Chapter XII.

GOVERNMENT OF INSECT COMMUNITIES

The points of analogy between the forms of human and of insect government are much fewer and slighter than they have been represented by fanciful and inaccurate writers; for, among the termites, the ants, the wasps, and the bees, though we find their associations denominated monarchies and republics, they exhibit but little of what is usually understood by those terms, though the bonds of union arising from mutual assistance and protection are much the same. The chief coincidences which appear obvious are between the insect communities and certain very artificial and unnatural forms of society among mankind. Thus the great importance of the division of labour, as an instrument of civilizing men in a savage state, probably gave rise to the institution of *castes* in India and in ancient Egypt*, and to the singular military state of Sparta, which bears the nearest resemblance to insect communities of any other on record. Some ancient legislators, indeed, carried into rigid practice the doctrine maintained by some modern visionaries, that all men at birth are equal in faculties; and therefore, like a piece of clay, of which a potter can make "one vessel to honour and another to dishonour," men might be moulded at the will of their instructors into priests, soldiers, herdsmen, agriculturists, or artisans, as in Egypt, according to Diodorus; or into philosophers, cultivators, herdsmen,

* Herodotus, ii. and iii.; Diod. Sic. i.; and Strabo, xvii.

merchants, warriors, overseers, or counsellors, as in India, according to Arrian.

Though this doctrine, however, as far as regards mankind, is contrary to universal observation, it is strictly true in the case of social insects, which, as soon as they arrive at maturity, are invariably endowed with the same powers, unimprovable also, so far as we are aware, by any mode of management or of instruction. A spider, the moment it issues from the maternal nest, can spin a web as neatly as it can ever afterwards do during the experience of a long life; and we have just been observing a worker ant (*Myrmica rubra*) which had begun to move about for the first time, and still wore the pale hue peculiar to this species in infancy, set to work in removing rubbish and assisting to place the pupæ of the formicary with as much dexterity and skill as its old, experienced, dark-coloured compatriots*.

Human society is united chiefly by the bonds of mutual protection and assistance, the latter leading to the multifarious arrangements of the divisions of labour; but in the case of insects, as has been well remarked by Kirby and Spence, the great end being the multiplication of the species, "Providence has employed extraordinary means to secure the fulfilment of this object, by creating a particular order of individuals in each society, which, freed from sexual pursuits, may give themselves wholly to labour, and thus absolve the females from every employment but that of furnishing the society from time to time with a sufficient supply of eggs to keep up the population to its proper standard†." Yet it is proper to repeat, that notwithstanding all which has hitherto been discovered respecting social insects, we are still much in the dark as to many important points. "The more I am engaged," says Bonnet,

* J. R. † Intr. ii. 30.

"in making fresh observations upon bees, the more firm is my conviction, that the time is not yet arrived in which we can draw satisfactory conclusions respecting their policy. It is only by varying and combining experiments in a thousand ways, and by placing these industrious flies in circumstances more or less removed from their ordinary state, that we can hope to ascertain the right direction of their instinct, and the true principles of their government*." What we have to state, therefore, concerning these interesting communities, must be considered only an approximation to the truth as near as we can bring it from the facts already ascertained.

GOVERNMENT OF WHITE ANTS, OR TERMITES.

THE government of the extraordinary insect colonies belonging to the genus *Termes* does not appear to be quite so well understood as their labours in architecture and their destructive propensities; for though the different orders are sufficiently distinct, their analogies to bees and ants have not yet been clearly ascertained. From what has been observed by Smeathman†, it appears there are four different descriptions of these insects in each community; and Latreille has discovered a fifth, whence we have workers, nymphs, soldiers, males, and females.

The *workers* or labourers are not in their perfect state, like the workers among the common ants, but are only grubs (*larvæ*) as hatched from the egg. When full-grown they are about a quarter of an inch long, and they constitute the most numerous part of the population, there being at least a hundred workers to one of the soldiers, from which they differ in having round heads and short mandibles. They are the most active members of the community,

* Œuvres, x. 194. † Phil. Trans. vol. lxxi.

being incessantly employed in erecting, enlarging, or repairing the buildings, foraging for provisions, or in attending to the eggs and the young.

The *nymphs* or pupæ which were discovered by Latreille, differ little from the workers, except in having the rudiments of wings, or rather wings folded up, as happens with butterflies in the state of chrysalis*. They seem to be equally active as the workers, which probably led Smeathman to overlook their difference †.

The *soldiers* were supposed by Smeathman to be nymphs or pupæ, but Latreille discovered that they form a distinct order of perfect insects of neither sex, and not imperfectly developed females, as is the case with the workers among bees and common ants. There is about one of these soldiers for every hundred of the workers, and they are distinguished by their being more than half an inch in length, nearly fifteen times as large as a worker, and furnished with a formidable pair of awl-shaped, jagged mandibles, as hard as a crab's claw, and capable of inflicting a painful wound. Their head likewise is strong, horny, and larger than all the rest of the body. It is the part of these to guard the colony, and defend it from attack.

The *males* and *females*, unlike the preceding, become furnished with wings for the purpose of migrating to establish new colonies, but afterwards lose these wings, as do the females of common ants. Like the males and females of the hive-bee, they are exempt from all labour. These Smeathman has denominated kings and queens; though we must caution our readers not to take these terms according to the strict letter, for they have, apparently, neither power nor authority in the community, and are more

* See Insect Architecture, p. 287.

† See Insect Transformations, p. 294, 5.

like state prisoners. We may remark, however, that each colony possesses only one male and female, which are, it would appear, *elected* after taking wing.

"Some," says Smeathman, "being found by the labouring insects that are continually running about the surface of the ground under their covered galleries, are elected kings and queens of new states; all those which are not so elected and preserved, perish. The manner in which these labourers protect the happy pair from their innumerable enemies, not only on the day of the massacre of almost all their race, but for a long time after, will, I hope, justify me in the use of the term election. The little industrious creatures immediately enclose them in a small chamber of clay* suitable to their size, into which at first they use but one entrance, large enough for themselves and the soldiers to go in and out, but much too little for either of the royal pair to use; and, when necessity obliges them to make more entrances, such entrances are never larger, so that the voluntary subjects charge themselves with the task of providing for the offspring of their sovereigns, as well as of working and fighting for them, until they have raised a progeny capable of at least dividing the task with them †."

The king and queen, after having been enclosed in this solitary cell, never afterwards quit it, but are kept close prisoners. The abdomen of the queen soon begins to enlarge, stretching out like a bag, till it becomes nearly two thousand times the size of her body. Smeathman says, he has seen it five inches long, of an irregular oval shape ‡, and containing a countless number of eggs, of which she has been observed to lay as many as sixty in a minute. Instinct

* See Insect Architecture, p. 292, 3.

† Phil. Trans. vol. lxxi.

‡ See Figure in Insect Architecture, p. 295.

directs the labourers to surround the queen at this period *, and carry off the eggs as soon as laid to nurseries prepared for the purpose, where they attend them till hatched, and then provide for the wants of the young. The royal cell is also provided with a few soldiers, who seem to do the duty of a body-guard to the king and queen; and the surrounding apartments always contain a number of both labourers and soldiers in waiting, that they may be in readiness when wanted to attend upon and defend the common father and mother, on whose safety the happiness and even the existence of the whole community depend; and whom these faithful subjects never abandon, even in the last distress. Yet withal it does not appear that they exert the least authority, or indeed that any part of the population rules another. All seem to know their several duties, and to perform them without being ordered or commanded; and consequently no police nor punishments for neglect or breach of order are required—a state of things which is in a great measure inconceivable, were we to take human society as a standard, in which there are always so many of the selfish passions in active play as to produce incessant breaches of the admirable order and mutual subordination, without individual superiority, conspicuous in these insect communities.

GOVERNMENT OF ANTS (*Formicidæ*).

THE charter according to which a community of ants is regulated, resembles very much that of the termites, the exceptions being rather in the details than in the leading principle. The worker ants, for example, are ascertained to be females imperfectly developed, incapable of producing eggs; but hence, the better capable of attending to the nursing of the young hatched from the eggs of the perfect females,

* See Figure in Insect Transformations, p. 15.

which are, like the preceding, kept imprisoned, though not so strictly, while the males are neglected, and left to perish a few days after their disclosure. The male ants, consequently, are as idle as the males (*drones*) of a bee-hive; but not so the females, which are as active as the workers in placing the eggs, larvæ, or pupæ in the most suitable temperature which the hive affords; though, after the original establishment of a colony by a single mother, we are not aware that the females ever provide food for the young, or for themselves, a task which is wholly performed by the workers, as well as the buildings or galleries requisite for the lodgment of the community.

When the females, deprived (as we have seen in a preceding page) of their wings, are established in the original colony, they lose all desire of making their escape, and though no longer detained prisoners, and dragged about by the workers, yet each, according to Gould and Huber, is attended by a body-guard, a single ant, accompanying her every where, and providing for her necessities. Kirby and Spence, apparently from mistaking an expression in Huber, tell us that the station of this sentinel "is remarkable, it being mounted upon her abdomen, with its posterior legs upon the ground *;" but we venture to say, that such an occurrence is not, at least, the common order of things, for among the numerous instances examined by us, we have never observed anything like this; and Huber says expressly, that it "rests upon its abdomen, with its hind legs stretched out." This sentinel is frequently relieved by others, the female never being left by herself for an instant; but no sooner does she begin to lay, than her attendants are increased, from ten to fifteen constantly following her, and rendering her

* Intr. ii. 55.

similar homage to that evinced by bees for their queen. Crowds eagerly press around her, presenting her with food, and conducting her through the steep and difficult passages, to the galleries, by carrying her in their mandibles, in which case she coils herself up into a round ball, so as to incommode her bearer as little as possible. "The eggs," says Huber, "taken up by the labourers, at the instant of their being laid, are collected around her. When she seeks repose, a group of ants environ her. Several females live in the same nest; they show no rivalry; each has her court; they pass each other uninjured, and sustain in common the population of the ant-hill; but they possess no power, which, it would seem, entirely lodges with the workers*."

"You may sometimes," says Gould, "expect to find two queens in the same colony. I have once or twice met with three. They most usually reside in the same lodgment, and live together in perfect harmony and union." We have recently visited a numerous colony of the red ant (*Myrmica rubra*), in which we saw no less than eight females without wings, all residing in the same large chamber, and no (apparently) distinct group of attendants round each, though a crowded body of workers indiscriminately surrounded the whole eight. In the under-ground chambers, which we did not open, there might, perhaps, have been others†. Gould further tells us, that "in whatever apartment a queen-ant condescends to be present, she commands obedience and respect. A universal gladness spreads itself through the whole cell, which is expressed by particular acts of joy and exultation. They have a peculiar way of skipping, leaping, and standing upon their hind legs, and prancing with the others. These frolicks they make use of both to congratulate

* Page 133. † J. R.

each other, when they meet, and to show their regard for the queen. Some of them gently walk over her; others dance round her, and all endeavour to exert their loyalty and affection. She is generally encircled with a cluster of attendants, who, if you separate them from her, soon collect themselves into a body, and inclose her in the midst. However romantic this description may appear, it may easily be proved by an obvious experiment. If you place a queen-ant with her retinue under a glass, you will, in a few moments, be convinced of the honour they pay and the esteem they entertain for her *."

The same ingenious observer remarked, however, that as soon as a female ant had laid eggs in any cell, the attentions of her followers became obviously less, their chief concern then being the care of the eggs. She herself also exhibits uneasiness, and, becoming unsettled, she wanders away to another apartment, where she obtains renewed homage from another party, who, in turn, abandon her as soon as she furnishes them with a deposit of eggs. Huber preserved a family of the yellow ant (*Formica flava*) all the winter, and in April, taking a glass with a little earth, let down a piece of wood about midway into the vessel, upon which he placed some plants, aphides, and the ants with their larvæ, and one female. "They gathered together," he adds, "a little earth which they found scattered over the leaves, and constructing therewith a little lodge between the branches, they placed their queen in it. In a few days they discovered a narrow passage between the glass and the border of the plank, and finding moist earth underneath, they lost no time in constructing in this place lodges, paths, and vaulted chambers. Thither they transported the greater part of the larvæ; but they could not so easily in-

* Account of English Ants.

troduce the female. She had descended to the border of the plank very willingly, and endeavoured to pass the opening which lay between it and the side of the glass. She placed her head almost every moment at this opening, and made every effort to enter, as if she were aware there was a space underneath where she could be more conveniently lodged. She at length found a place of sufficient width to thrust in the whole of her head. The ants in the lower story rubbed her with their mandibles and caressed her with their antennæ, as if to invite her to follow them. Some seized her by their mandibles, others mounting on the plank drew her by the legs towards the lower apartment. She made several vain attempts to insinuate her body, and the workers collecting around seemed desirous of repairing the injury her unfruitful efforts had occasioned. I now seconded the wish of my little protegées by slightly moving aside the plank, when the workers were enabled to lead the female to the bottom of her abode without further obstacle. We see by these details of the conduct of workers in regard to females, that if they deprive them of their liberty and sometimes of their wings, it is only with the view of insuring the population of the ant-hill; and that the condition to which nature destines them yields in no respect to that of queen-bees. The attachment of the labourers to the females would appear to continue after their death; for, when a pregnant female dies, five or six labourers rest near her, and during several days brush and lick her continually, either in token of lasting affection, or that by these means they hope to re-animate her *."

In all this, however, these females, or queens (if we must call them so), exercise none of the functions of sovereignty in issuing orders or enforcing obedience; nay, it would appear that, but for the eggs

* Huber, p. 140.

which they furnish to recruit the population of the ant-hill, they would receive no attention nor respect whatever. The males again have still less right to the title of kings; and nothing could be more correct than the statement of Solomon that they have "no guide, overseer, or ruler *," for no individual seems endowed with any authority over the others. Each seems to act independently of its companions, and yet all seem to agree in forwarding the same designs. In their structures and galleries, whether mined into the soil, hewn out of wood, or built of masonry †, the first who conceives a plan of easy execution immediately gives the sketch of it, and others have only to continue what this has begun, inferring from an inspection of its labours what they ought to engage in. It would appear, also, that planning is confined to no particular order, every individual exercising an equal right in this, as well as in the execution, or in foraging for provisions. In the still more important measure of fixing upon a spot to which the whole community migrate, a chance individual seems to originate the measure, to which all the others accede, according to Huber, without a single dissentient. From some facts, however, which he has elsewhere stated, as well as from several observations which we have made, these views seem to require some modification.

We have mentioned above that the red ant, and particularly the turf-ant (*Myrmica cæspitum*), are seldom satisfied for any length of time with the spots selected for their nests. In consequence of this they are constantly pulling about and carrying their companions to places supposed to be more eligible; but although in many cases these go quietly along, in others they are quite refractory, and retaliate upon

* Proverbs, vi. 6.

† See Insect Architecture, chapters xiv. and xv.

the reformers by seizing their legs or antennæ in no very gentle manner; for they sometimes go the length of biting them through, and even, if we do not greatly mistake, of devouring those they succeed in mutilating and mastering. We have seen several instances of this in those we accidentally observed in the fields; but as we could not, in such cases, be certain whether both individuals belonged to the same community, and as those even of the same species are always at deadly enmity, we placed several nests of the red ant (*Myrmica rubra*) in glass frames, in order to watch their proceedings. The result was, that when they were confined within narrow limits, they all lived amicably enough, and did not attempt any change, because there was only a single place at all fit for their purpose: but when a passage was allowed them to several places at a distance, the desire for change put them all in agitation, and we soon witnessed scenes of dragging and mutilation such as we had previously seen in the fields. We had, consequently, no doubt that the plans of individuals often meet with opposition which lead to violent feuds, sometimes ending in the death of the proposer or of individuals who refused to agree to his plans *. To many all this may appear an imaginary sketch suggested by theory, but we have not stated one circumstance which we have not actually seen in repeated instances. The following remarks by Huber partly corroborate the preceding facts.

"I have been enabled," he says, "to observe, through the glasses of my artificial ant-hill, the great care taken of the larvæ. They were generally guarded by a body of ants, who were raised upon their feet, with their tail between their legs ready to cast their venom upon all intruders, whilst, here and there, other

* J. R.

workers were engaged in clearing the passages by removing the materials which were out of place; a great number of their companions taking at the same time their repose, and appearing to be fast asleep: but a busy scene occurred at the moment of transporting their little ones to enjoy the warmth of the sun. When the sun's rays fell upon the exterior portion of the nest, the ants which were then on the surface descended with great rapidity to the bottom of the ant-hill, struck with their antennæ the other ants, ran one after the other, and jostled their companions, who mounted at the moment under the bell-glass and redescended with the same speed, putting in their turn the whole colony in motion, so that we could observe a swarm of workers filling up all the passages; but what proved still more their intention by these movements, was *the violence with which the workers seized, with their mandibles, those who did not appear to understand them*, dragging them forth to the top of the ant-hill, and immediately leaving them, to go and seek those still remaining with the young *."

Gould's testimony to the same circumstance is still more pointed, and he is of opinion that they kill and devour individuals which from accident or illness are unfit to labour for the benefit of the common weal, as the hive-bees massacre their males. "The red colonies," he says, "are the only ones I could ever observe to feed upon their own species. You may frequently discern a party of from five or six to twenty surrounding one of their own kind, or even fraternity, and pulling it to pieces. The ant they attack is generally feeble and of a languid complexion, occasioned, perhaps, by some disorder or other accident †." An old naturalist mentions a very similar circumstance in still stronger terms. "If,"

* On Ants, p. 73. † Account of English Ants, p. 104.

says he, "they see any one idle, they not only drive him as spurious, without food, from the rest, but likewise a circle of all ranks being assembled, cut off his head before the gates, that he may be a warning to their children not to give themselves up for the future to idleness and effeminacy *." That the writer may have witnessed such an occurrence is exceedingly probable, though the inference he draws is evidently too refined. Kirby, on quoting these passages, says, "I once saw one of these ants (*Myrmica rubra*) dragged out of the nest by another, without its head; it was still alive and could crawl about. A lively imagination might have fancied that this poor ant was a criminal condemned by a court of justice to suffer the extreme sentence of the law. It was more probably, however, a champion that had been decapitated in unequal combat, unless we admit Gould's idea, and suppose it to have suffered because it was an unprofitable member of the community. At another time I found three individuals that were fighting with great fury, chained together by their mandibles; one of these had lost two legs of one side, yet it appeared to walk well, and was as eager to attack and seize its opponents as if it was unhurt. This did not look like languor or sickness †."

With reference to the notion of the feeble or the sick being persecuted or expelled, we may mention that it is not uncommon in artificial formicaries to see individuals become ill and die, either from confinement, from surfeit, or from improper food; but in two colonies of the red ants now under our eye, where several individuals are obviously in a dying state, the active members of the community seem to take no more notice of them than if they were a bit of earth, and

* Mouffet, Theatrum Insect. 241.

† Intr. ii. 71.

even walk over their bodies, if they chance to be in their way, with the greatest indifference. When they actually die, however, they in general, though not always, remove their bodies to some distance, but in such cases we never saw any instance of their devouring their unfortunate compatriots*.

GOVERNMENT OF WASPS AND BEES.

THE communities of the social wasps and of humble-bees (*Bombi*) are constituted in a very similar manner to those of ants, though they differ in several remarkable particulars. A colony of ants, for example, particularly of the jet-ant (*Formica fuliginosa*), and others which build in trees, may continue in the same spot for a number of years; we have known a hill built in a meadow by the yellow ant (*F. flava*) continue for five successive years, its dimensions being annually enlarged, and its population at the same time increased. But it is seldom if ever that wasps or humble-bees continue in the same spot for two successive years, inasmuch as their societies do not hybernate as the ants do, being always broken up at the close of autumn, and all the population perishing, with the exception of a few females which survive the winter. Each of these survivors becomes the foundress of a summer colony, like those female ants who escape the scouting parties despatched from the parent communities to capture them †. These females are six times the size and weight of one of the workers, and may be seen in the early spring eagerly prying into every hole and crevice of a hedge-bank for the purpose of discovering a suitable place for their nest. Afterwards they are rarely seen, keeping themselves, like the queen of the hive-bee, entirely at home; but they are not like her idle, for they con-

* J. R. † See page 244.

tinue to labour in the building of cells, with the same assiduity as their progeny. The foundress wasp, or humble-bee, also, is not the mother of the colony, as is the case with a hive-queen; for instead of producing at her first laying the eggs of workers only, she deposits those of both males and females: but the latter, when hatched, and come to maturity, are only a sixth part of the size of their mother, and only lay the eggs of males.

Such are the various orders among the population of a community of social wasps or humble-bees; but it does not appear that there prevails among them anything like what we understand by subordination. Every one, indeed, seems to do what seems right in its own eyes, without taking counsel of its neighbour. The only circumstances which look like appointments to particular duties, occur in the instance of the male wasps, which are not an idle race, like those among ants and hive-bees. They do not, indeed, forage for building-materials or provisions, nor take any concern in the business of nursing; but, if we may trust the younger Huber, they act as the scavengers of the nest, by sweeping the floors of the terraces and the passages leading to them, carrying off every species of rubbish, as well as the bodies of those individuals which chance to die. When a burden, also, is too heavy for the strength of an individual, two unite in the task, as is done by the workers among ants, and sometimes recourse is had to the expedient of lightening the load by dividing it. It may be, that their rendering themselves useful in this manner is the reason why they are not massacred like the males of hive-bees.

Mr. T. A. Knight, when quite a boy, discovered that wasps seem to appoint sentinels at the entrance of their nest to give the necessary alarm in case of danger, and that the intimations of no other individual are attended to. For if these sentinels be taken by surprise and destroyed, and their communication with the interior prevented, no provocation will excite the wasps arriving from the fields to attack an intruder; but if one escape from within, it immediately proclaims war, and is seemingly commissioned to avenge the invasion of the state, and prepared to sacrifice its life in the execution of its orders*. It further appears to arise from some public order that each individual wasp has its own particular portion of work assigned in the task of building, the extent of this being from an inch to an inch and a half; a circumstance that does not occur among ants, where a bit of wall is usually raised by several individuals coming to it in succession, and who, merely by chancing to pass that way, perceive what is requisite to be done.

Amongst the humble-bees the most remarkable circumstance is, the jealous rivalry of the larger female, who has founded a colony for the small females, which she has just before been so careful in rearing. The younger Huber, while watching at midnight the proceedings of a nest which he kept under a bell-glass, observed the bees to be much agitated, and discovered the cause to be the construction of a nurse-cell, in which several of the small females were busily engaged. Their mother, upon perceiving their object, came and drove them off; but she, in turn, was attacked by others who came to their assistance, and, pursuing her with the utmost fury and beating her with their wings, drove her to the bottom of the building. The original builders then returned and finished the cell, and two of them laid eggs in it at the same time. Their mother, however, soon returned to the charge, seeming to be in a great rage at their proceedings, and again chasing away her disobedient and pertinacious chil-

* Phil. Trans. for 1807, p. 242.

dren, she thrust her head into the cell, seized the eggs which they had deposited, and devoured them with great avidity. A similar scene was repeated some time after; and subsequently one of the small females returned and covered in with wax the cells which the mother had despoiled of their eggs; and when she was afterwards removed, the small females contended for a cell with similar animosity, all of them being eager to deposit in it at the same time*.

These contentions, however, do not appear, in this case, as in the instance of the hive-bees, to arise from the wish for supreme dominion, as nothing of that kind has place in these communities. Even the mother-bee of the hive, who has been dignified by all writers with the title of queen, has apparently less authority than any individual in the community, her sole employment being to people the state by laying eggs, and though she has been said to lead the bees in the case of swarming, the fact appears to be, that she is as much a follower as a leader. Swarms, indeed, will not settle nor work without a female along with them, but this arises from her being indispensable to add to their numbers, and not that her superintendence is wanted, much less indispensable. So far, however, as increasing the population is concerned, a hive is essentially monarchical, and hence everything is arranged, in the management of the state, so as to have always one female and no more. The queen-regnant is on that account inspired with deadly enmity towards her own offspring, should any other female be evolved while she remains in the hive; and when she has migrated with a swarm, the same animosity is shown by a young queen towards her juniors, even while they are still in their cells; and what is most wonderful, her murderous purposes seem to be expressly abetted by the royal

* Linnæan Trans. vol. vi.

grubs not spinning complete cocoons, as is done by the other bees,—leaving an opening through which she can easily sting them to death *.

"In one of my hives," says the elder Huber, "there were five or six royal cells, each including a nymph. When the eldest was transformed, scarcely ten minutes elapsed from the time of her leaving her cradle, when she visited the other royal cells; and furiously attacking the nearest, she succeeded by dint of labour in opening the top, by tearing the silk of the cocoon with her teeth. Probably, however, she found her efforts inadequate to effect her purpose, for she abandoned this and attacked another, in which she succeeded in making a wider breach. In this aperture she thrust her abdomen, and, after several abortive efforts, she at last succeeded in giving the helpless nymph a mortal sting. Upon her quitting the cell, a number of bees, who had previously been spectators of her attack, began to enlarge the opeoing, and drew forth the dead body of the embryo queen, just disclosed from her envelope.

"In the meanwhile, the queen was proceeding in her work of assassination by attacking another royal cell; but as the nymph in this was not so mature as in the former, she did not sting it. It appears probable, indeed, that the immature nymphs inspire their rivals with less animosity, though they do not, on that account, escape destruction; for whenever a royal cell has been, as this was, prematurely opened, the workers always extract the contents, whether in the state of grub, nymph, or queen, and accordingly, as soon as she had left it, a party of workers enlarged the breach she had begun, and dragged out the included nymph. The queen was, in the meanwhile, attacking a third cell; but as she laboured in a languid manner, being exhausted perhaps by her pre-

* See Insect Transformations, p. 331.

vious exertions, she did not succeed in tearing open the silk. We removed the other royal cells with the design of procuring queens for future experiments *."

Schirach and Reim, observing that when there were two queens in a hive, one soon disappeared, were led to suppose that one was killed or expelled by the workers; but Huber found that the workers take no part in the affair, which is left wholly to the rival females themselves, while Mr. Dunbar observed that a stranger queen was not stung to death, but closely confined by a body of workers, till she was either suffocated or perished from hunger. We shall give Huber's observations in his own words.

"Two young queens," he says, "quitted their cells in one of our thinnest hives almost at the same moment, and immediately, when they came within sight, rushed upon each other with the most ungovernable fury. They placed themselves in such an attitude that the antennæ of each were held by the antagonist's mandibles, head being opposed to head, trunk to trunk, and abdomen to abdomen. They had, indeed, only to bend their tails, and they would have fallen reciprocal victims to each other's sting. But it having been so ordered by Providence that these duels should not prove fatal to both combatants, upon finding themselves in this perilous situation, a panic fear seemed to strike them, and they disengaged themselves with the utmost precipitation, and fled. I have repeated this observation very often, so that it leaves no room for doubt. A few minutes after they had separated, their terror abated, and the attack was renewed, but the result was the same as before. During all this time, the workers seemed in great agitation, and the tumult seemed to increase when the combatants separated. Twice I observed them stop the flight of the queens, seize their limbs,

* Huber on Bees, p. 93.

and retain them prisoners above a minute. At last, the queen which was either the strongest or the most skilful warrior, darted on her rival at a moment when unperceived, caught one of her wings near its joint, and rising exultingly above her, inflicted a mortal sting. Quitting hold of the wing she withdrew the weapon, while the wounded queen fell down, dragged herself languidly along, and her strength failing, she soon expired *."

Experiments in proof of this were varied in every possible way, both with impregnated and virgin queens, and always with similar results. Réaumur has said, that when bees have a queen they are satisfied with, they are nevertheless disposed to give a good reception to any female seeking refuge among them. This, however, does not at all agree with the experiments of Huber and Dunbar, and it appears probable that Réaumur mistook for caresses the anxiety of the crowd which surrounded the stranger, on her introduction, in order to keep her in confinement, his hives being too thick for him to observe what followed. Huber introduced into a very thin hive, containing a fertile queen, another in the same condition, after painting her thorax for the sake of distinction. "A circle of bees," he says, "quickly formed round the stranger, but not with the intention of caressing and receiving her well; for their number soon increased so much, and they surrounded her so closely, that in less than a minute, she lost her liberty and became a prisoner. It was remarkable that other workers at the same time collected around their legitimate queen, and restrained all her motions, for we saw her imprisoned as closely as the stranger. It may be said that the bees anticipated the combat in which these queens were about to engage, and were impatient to behold the issue of it, for they retained their prisouers only

* Huber on Bees, p. 93.

when they appeared to withdraw from each other, and opened their ranks to allow them to fight. The cluster around the reigning queen having allowed her a little freedom, when she advanced all receded till she came in sight of the stranger, upon whom she precipitately rushed, and seizing her by the wing near its origin, plunged her sting in her body *."

A queen appearing thus to be indispensable in a hive, the question may be asked, what are they to do, if they are by accident deprived of her? The social wasps, in such circumstances, are said to become restless and idle, wandering away from their nest, and never returning. But though the loss of a queen spreads temporary consternation through a hive of bees, the population do not abandon themselves to despair; but make all haste to supply their loss by means of an expedient, which is, perhaps, one of the greatest singularities in insect history, since they can actually, it would appear, form a queen out of the grub of a worker, by feeding it in a particular manner, and by enlarging its cell. This circumstance is said to have been known to the Greeks and Italians from time immemorial, and even acted upon in practice, particularly in the little Sicilian island of Favignana; but it does not appear to have been at least published before the appearauce of Schirach's celebrated work. It is but right to state, however, that the doctrine was far from being universally received. Needham, though an advocate for the absurd doctrine of the transformation of plants into animals †, attacked the opinion with violence ‡; and even John Hunter published some sarcastic strictures upon it §; while a more practical, though less profound man, Keys,

* Huber on Bees, page 99.

† See Insect Transformations, p. 129.

‡ Bonnet, Œuvres, ix. 128, note. § Phil. Trans. for 1792.

treated it with equal ridicule*. The subsequent experiments, however, of Huber, Dunbar, and others, have now established the fact beyond all question. "During ten years," says Huber, "that I have studied bees, I have repeated Schirach's experiment so often and with such uniform success, that I can no longer entertain the least doubt on the subject." But it also appears that Schirach made several mistakes, supposing, for example, that it is necessary for the grubs selected for becoming queens, to be at least three days old, and also that the cells which are enlarged for them are precisely similar to those regularly built for queens; neither of which is the fact. It may be as well, for the satisfaction of our readers, to prove the point by experiments made subsequent to the discovery.

In July, when a mirror-hive had become filled with comb and bees, and well stored with honey, the queen being very fertile, laying a hundred eggs a-day, Mr. Dunbar opened the hive and took her away. It was eighteen hours before the bees appeared to miss her, at least they continued their labours; bnt no sooner was their loss discovered than all became agitation and tumult, and they rushed to the entrance as if preparing to swarm. They remained, however, in the hive, and immediately set about providing for their loss, as, on the succeeding morning, he observed that they had begun no fewer than five royal cells, and by the afternoon four more were founded in a part of the comb containing eggs, which had been deposited only a day or two before. On the fourteenth day after he had removed the queen, a young queen made her appearance, and proceeded towards the other royal cells, for the purpose of attacking them. She was, however, pulled

* Trans. of the Bath Society.

violently away by the workers; but at every repulse from the cells of her rivals, she appeared sulky and cried *peep, peep*,—one of the unhatched queens responding, though in a somewhat harsher tone; a circumstance which explains the two different sounds heard prior to the issuing of second swarms. On the afternoon of the second day, another queen was hatched, and was immediately surrounded by a cluster of bees. Next morning Mr. Dunbar found her dying, having no doubt been slain by her rival. Contrary to the statements of Huber, therefore, Mr. Dunbar found that the artificial queens are surrounded by a guard, and that they are not mute *.

Bonnet, to whom Schirach communicated his experiments, remained long unconvinced, as well as Wilhelmi, Schirach's brother-in-law; but the uniform success of the experiment made them ultimately renounce their scepticism. Bonnet, also, was successful in repeating it †; and Mr. Payne, of Shipham, in Norfolk, told Kirby that he accidentally observed the bees of one of his hives, which had lost their queen, erecting some royal cells on the ruins of the common ones. Their usual mode of proceeding, indeed, is to throw three contiguous common cells into one, two of the three grubs which occupy them being sacrificed, and the remaining one liberally fed with *royal jelly*. This is a pungent food, prepared by the workers exclusively for the purpose of feeding such of the grubs as are destined for queens. It is not so mawkish and is more stimulating than the food given to the common grubs, having a perceptibly spicy acescent taste. "It does not appear to me improbable," says Bonnet, "that a certain kind of nutriment, and in more than usual abundance, may cause a development, in the grubs of bees, of organs

* Bevan on Bees, p. 22.

† Contempl. de la Nature, Œuvres, ix. 27.

which would never be otherwise developed. I can readily conceive, also, that a habitation, considerably more spacious and differently placed, is absolutely necessary to the complete development of organs which the new nutriment may cause to grow in all directions*."

Instances of analogous development, as well as the contrary, might be produced to infinity in all the departments of nature; though those are perhaps more abundant in the vegetable than in the animal world. We have but small room to spare for illustrating this, and shall content ourselves with mentioning a single experiment by Mr. T. A. Knight. Wishing to ascertain the effect of stimulating manure, he took a plant of the cockscomb (*Celosia cristata*), and kept it regularly moist with water, in which pigeons' dung had been steeped, and at the same time had it successively shifted into larger pots, as the roots reached the sides. The latter, to some, may appear very superfluous labour, as the plant might have been placed from the first in a pot sufficiently large; but in that case it would have wanted the stimulus arising from the roots impinging on the sides of the pot. The result was, that the plant produced a flower of larger dimensions than had ever been witnessed†. This experiment illustrates the effects both of stimulant food and space for enlargement. On the contrary, confined space not only retards the growth, but prevents the due development of peculiar functions; in proof of which it is stated by John Hunter, that when a cow brings forth two calves, and one of them is a female, it is always barren ‡.

It would be leaving this curious point imperfect, were we not to add to the preceding proofs some of

* On Bees, p. 56. † Horticult. Trans.
‡ On the Animal Economy, p. 65.

the experiments of Huber, undertaken at the instance of Bonnet, to ascertain how far Schirach was to be trusted. "I placed," says he, "in a hive deprived of the queen, some pieces of comb containing eggs of workers, in cells of the same kind as those already hatched. The same day several cells were enlarged by the bees and converted into royal cells, the grubs being supplied with a thick bed of jelly. We then removed five of the grubs from those cells (to remove the possibility of their being from royal eggs), and substituted for them five common grubs, which had been hatched forty-eight hours previously under our eyes. The bees did not seem to perceive the change, watching over the substituted worms as over those of their own selection; and continuing to enlarge the cells, they closed them at the usual time. Seven days afterwards we took away the cells to preserve the queens that would be produced; and in due time two were excluded almost at the same moment, of the largest size, and in every respect well formed. No queens having appeared in the other cells, we opened them, and found two with only the dried skins of the grubs, and in the other a dead queen-nymph. I can conceive nothing more conclusive than this experiment, since it demonstrates the power possessed by the bees of converting the grubs of workers into queens,—for they did so with grubs which we ourselves had selected; and it also proves that it is not indispensable for these grubs to be three days old."

"A hive in my possession," continues Huber, "having been long deprived of the queen, contained neither egg nor grub, and I provided for it a queen of the greatest fertility. She immediately began laying in the cells of workers, but I removed her before she had been quite three days in the hive, and before any of her eggs were hatched. The following morning, being the fourth from her introduction, we counted fifty minute worms, the oldest scarcely hatched twenty-four hours. Already, however, several were destined for queens, indicated by the bees depositing around them a much more abundant provision of food than is ever supplied to the grubs of workers. Next day, the grubs being then nearly forty hours old, the bees had enlarged their cells, and had converted them from the hexagonal to the cylindrical form of greater capacity. They continued their attention to them during the succeeding days, and on the fifth from the hatching of the grubs they closed them. Seven days after the first of these royal cells had been closed, a queen of the largest size issued from it, and immediately rushing towards the other cells, endeavoured to destroy their nymphs and grubs *."

It appears that the cells of workers, which are contiguous to royal cells, frequently, if not always, produce workers capable of laying eggs,—the circumstance arising, it is supposed, from their receiving by accident a portion of the royal jelly. Huber, indeed, ascertained this from several experiments; and he also found the queen to attack these fertile workers with as much fury as she would have done a rival queen †.

From all these details it is evident that the only attention, homage, and respect, paid by bees to their queen arises from the affection they have for her progeny. In order to ascertain the extent of the loyalty of the bees to their sovereign, Dr. Warder ran the hazard of destroying a whole swarm. With this view, having shaken on the grass all the bees from a hive where they had only been settled on the preceding day, he stirred them about with a stick till he found the queen, whom he placed, with a few

* On Bees, p. 69. † Ibid. Letter v.

attendants, in a box. He took this into his parlour, and opened it, when she flew immediately to the window with her attendants. He then cut off one of her wings, and returned her to the box, where he confined her for above an hour. The swarm, in less than a quarter of an hour, ascertained their loss, when, instead of clustering as before in a conglomerated mass, they spread themselves about, became agitated and restless, and uttered a doleful sound. About an hour after, they all took flight and settled on the hedge where they had first alighted on migrating from the parent hive; but instead of hanging together, as is usual with swarms accompanied by a queen, they scattered themselves along the hedge, in small parties of forty or fifty. In these circumstances the Doctor presented them with their queen, around whom they immediately congregated, uttering a joyful hum, and uniting in a suspended cluster. He hived them again at night, and on the following morning repeated his experiment, to ascertain whether they would rise, for the queen, in consequence of the loss of her wing, could not fly to accompany them; but they continued with her for several hours, appearing to be willing to die rather than desert her. Upon removing her a second time, they again spread about as if in search of her; and when she was restored to them repeatedly, at different parts of their circle, "these poor loyal and loving creatures (in the words of the Doctor) always marched and counter-marched every way the queen was laid." He continued the same experiments for five days and five nights, during which period they had not tasted food, and at length the whole perished, the queen surviving the others only a short period. He infers that the queen was no less attached to the bees than they to her, for she uniformly refused to take the honey which he offered her when separated from the swarm *.

Dr. Evans relates a case in which also the queen's guard, if we may call them so, remained faithful to the death. In a thinly peopled hive he observed a queen lying on some honey-comb apparently dying, and surrounded by six bees with their faces turned towards her, quivering their wings and holding their stings unsheathed and brandished, like a sentinel with his fixed bayonet. He presented these guardian bees with honey, but though it was eagerly eaten by the other bees, they seemed so completely absorbed in their care of the queen, that they would not touch a drop. The queen died; yet on the following day he found her body still guarded, and though supplied with honey the bees gradually pined, and in three or four days they were all dead †.

It was by taking advantage of this attachment that Wildman was wont to perform feats with bees, which astonished all that witnessed them, as Dr. Evans gives it:

> "Such was the spell, which round a Wildman's arm
> Twin'd in dark wreaths the fascinated swarm;
> Bright o'er his breast the glittering legions led,
> Or with a living garland bound his head.
> His dexterous hand, with firm yet hurtless hold,
> Could seize the chief, known by her scales of gold,
> Prune, 'mid the wandering throng, her filmy wing,
> Or o'er her folds the silken fetter fling."
>
> *The Bees.*

"Long experience has taught me," says Wildman himself, "that as soon as I turn up a hive, and give some taps on the sides and bottom, the queen immediately appears. Being accustomed to see her, I

* Warder's True Amazons, or Monarchy of the Bees.

† The Bees, a Poem; notes.

readily perceive her at the first glance; and long practice has enabled me to seize her instantly, with a tenderness that does not in the least endanger her person. Being possessed of her, I can, without exciting any resentment, slip her into my other hand, and returning the hive to its place, hold her, till the bees, missing her, are all on the wing and in the utmost confusion." It was then, by placing the queen in view, he could make them alight wherever he pleased, and sometimes using a word of command to mystify the spectators, he would cause them to settle on his head, and even to hang from his chin like a living beard, from which he would order them to his hand, or to an adjacent window. But, however easy such feats may appear in theory, Wildman cautions those who are inexperienced not to put themselves in danger by attempting to imitate him. A liberated Roman slave, C. F. Cnesinus, being accused before the tribunals of witchcraft, because his crops were more abundant than those of his neighbours, produced as his witnesses some superior implements of husbandry, and well-fed oxen, and pointing to them, said, "These, Romans! are my instruments of witchcraft; but I cannot show you my toil, my perseverance, and my anxious cares." "So," says Wildman, "may I say, These, Britons! are my instruments of witchcraft; but I cannot show you my hours of attention to this subject, my anxiety and care for these useful insects; nor can I communicate to yon my experience acquired during a course of years *."

* Treatise on Bees, 1769.

Chapter XIII.

WARS OF INSECT COMMUNITIES.

When the population of a rookery resolve to feast in security upon the helpless cockchafer grubs of a particular field, they have always a sentinel rook posted on some adjacent tree, who may give timely intimation of any threatening danger; but whether this watch-bird is elected by vote, or whether the office is held in rotation by tacit consent of the whole colony, we have no means of ascertaining. Their sociality, however, approaches much nearer the principles of human policy, than the instinct displayed by the chance crowds of blow-flies collecting round a carcass, or of frogs in a pond, which manifest not, at least to our observation, any bond whatever of social union. In some of the circumstances which we have now to mention, the uniting together to perform one common object is much more distinct and obvious; and, in the case of some of the European ants, leads to consequences more calculated perhaps to excite wonder, than any other circumstance connected with insect history. Before coming to this peculiarity of the ants, however, we shall take brief notice of what may justly be termed wars, both offensive and defensive, among other families of social insects.

BEES AND WASPS.

The singular wars of bees were observed by the most ancient naturalists, and are recorded by Aristotle *, Virgil, and Pliny. "If it happens," says the latter, that the meat in one hive be spent, the bees belonging

* Hist. Anim. ix. 25.

thereto will assaile their next neighbours, with intent to rob and spoile them of their provision. But those on the coutrary side put themselves in battel aray, with full intent to take them again. And if there chance to be a keeper by to see the combat, that party which perceives him to favour their side, will not once make at him for to sting him; other causes there are which make them often go together by the ears, and then shall ye have two severall captaines to arrange their battalions one against another †." Virgil exhibits such a battle with great splendour of diction, and the passage loses none of its magniloquence in the hands of one of his translators:

"If to fight they issue forth—(for oft
Between two kings fierce discord reigns)—
The pop'lar rage and courage, while their hearts
Tremble with eager appetite for war,
You may foreknow. A clarion, shrill as brass
Rouses the laggers, and a martial noise
Afar is heard, like trumpets' broken sounds.
Then trembling they rush on with quiv'ring wings,
And *with their sharp proboscis whet their stings*
And trim their claws; while round their leader's court
They crowd and muster, and with loud acclaim
Provoke the foe. Now having gained a sky
Serene, and open fields of vernal air,
They issue from their gates and join the shock
Of battle; humming through the ethereal void,
In one huge cluster they conglobe, and fall
Precipitant: nor thicker falls the hail,
Nor showers of acorns from a shaken oak.
The leaders also, 'twixt the middle ranks,
Conspicuous shine, and spread their glistening wings;
Their tiny breasts inspired with mighty souls,
Resolute not to yield till these or those
Vanquished inglorious turn their backs in flight."

Trapp, Georg. iv. 100.

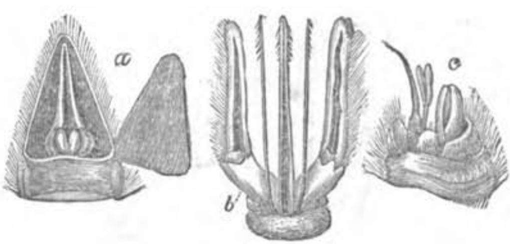
† Holland's Plinie, p. 320.

The correction of one error into which Virgil has fallen in this passage, will lead us to describe the singularly ingenious structure of the bee's sting. This weapon never requires to be whetted, and, if it did, it could not be reached for that purpose by the proboscis or tongue. The formidable instrument consists, like the ovipositor of the saw-flies*, of an extensile sheath, enclosing two needle-shaped darts much finer than a human hair. The latter can seldom be distinguished by the naked eye, what is usually taken for the sting being only the sheath. Swammerdam, however, could never ascertain whether the bee can wound or pierce the skin with the sheath only†; being very sharp, it may possibly be used to make the first puncture before the darts are thrust out. The fineness of the point of the sheath may be strikingly inferred from the observations of Hook: "An exceedingly small needle," he tells us, "being examined by a microscope, the point thereof appeared above a quarter of an inch in breadth; not round or flat, but irregular and unequal; and the surface, though extremely smooth and bright to the naked eye, seemed full of ruggedness, holes, and scratches. In short, it resembled an iron bar out of a smith's forge." The sheath of a bee's sting, on the other hand, viewed through the same instrument, showed every where a polish most amazingly beautiful, without the least flaw, blemish, or inequality, and ended in a point too fine to be visible‡. The two darts are distinctly separate, even to the base; and though so very close to one another, they can be made to act independently, for Swammerdam has often seen one thrust out farther than the other. Towards their extremity these darts are armed with ten minute teeth, standing obliquely like those of a saw, and

* See Insect Architecture, p. 153.

† Biblia Nat. i. 200. ‡ Hook's Micrographia.

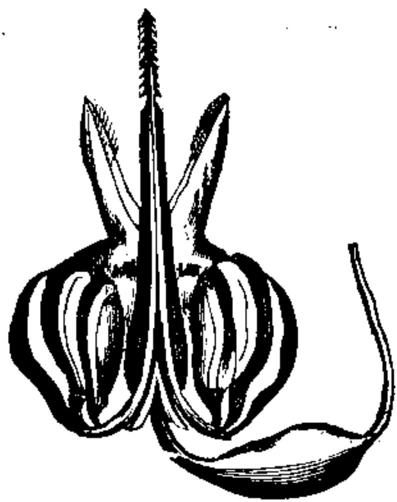
hence it happens, when they are plunged into a bit of leather or the human skin, the bee can seldom withdraw them again. The consequence is, that both they and their sheath, with all the parts connected, are forcibly wrenched out of the insect's body, a mutilation which must prove fatal.



Structure of the sting of the common bee. *a*, Terminal ring of the abdomen, cut open, and the sting and its appendages exhibited. *b*, Sting and its appendages taken out from the abdomen. *c*, Profile of the sting and appendages. All greatly magnified, but in different degrees.

The sting is articulated to the lower end of the bee's body by thirteen scales, and moved by muscles, which, though so small as to be indistinct to the naked eye, are yet strong enough to force the sting to the depth of the twelfth of an inch into the thick skin of a man's hand. Swammerdam found these muscles to be eight in number, into which the horny parts of the sting are inserted. When the insect is prepared to sting, one of the darts, having its point a little in advance of the other, first plunges into the skin, and being fixed by its foremost barb, the other strikes in also, and they alternately penetrate deeper and deeper, till they acquire a firm hold of the flesh with their hooks.

This is not all: the mere darts of the bee would not, of themselves, produce any more pain than the puncture of a needle, as Swammerdam indeed ascertained by experiment; but in such cases, he carefully wiped the sting to free it from the poison which it usually carries, and which is the main cause of the pain and swelling of the part stung. This poison is secreted into a bag or bladder, situated near the base of the sting, and communicating



Poison-bag of the bee attached to the base of the sting; very greatly magnified.

with the tube of the sheath. It is moreover furnished with a very strong muscle, which twines itself around it, and has its tendon in the middle. When this muscle contracts itself, the poison is thereby forcibly squeezed out, and thrown into the wound, so that the sting may be compared to a small syringe, the little bladder, with its muscle, acting the part of the impelling plug*.

The poison is a transparent fluid, and when tasted is sweetish, followed by a hot acrid sensation, similar to the milk of the spurge (*Euphorbium*). It is soluble in water, but not in spirits of wine, and in this it resembles the poison of the viper, as well as when dry and chewed, appearing tenacious, gummy, and elastic; but the poison of the viper is tasteless, and has none of the chemical characteristics of acidity. The poison of the bee, however, affects vegetable blnes, and hence the Abbé Fontana concludes, that it at least contains a portiun of some acid†. Dr. Bevan says, "if a humble-bee be irritated to sting paper tinged with litmus, or any other of the vegetable blues, the colour is changed, by the acid of the venom, to a bright red." He adds that it does not seem to differ from the bombic or the formic acids‡; but this we should be much disposed to doubt, for the formic is now known to be a mixture of the acetic and malic acids§, and can be made artificially, which the bee's poison cannot be‖. Be this as it may, the poison of the bee is so very active that Fontana supposes a grain of it would be sufficient to kill a pigeon. Mr. Talbot informs us that during the summer of 1820, the Rev. R. Leeming having sent a fine horse to grass at a neighbouring farmer's, who kept about twenty stocks of bees, the animal got upon the lawn, where the hives were placed, and by accident overturned one of them, the bees of which attacked him with great virulence. The horse, rearing and kicking from agony, overthrew another hive, and having thus doubled the

* Swammerdam, i.

† Pontana on Poisons, i. 265—9. ‡ On Bees, p. 284.

§ Nouv. Dict. Hist. Nat. xli. 94. ‖ Rennie's Sup. to Phar.

number of his assailants, his sufferings brought him to the ground, and in less than five minutes from the commencement of the attack, the poor animal was literally stung to death *.

A similar fact is recorded by Mungo Park. His people, while searching for honey, disturbed a large colony of bees, who sallied forth in myriads, and attacking men and beasts indiscriminately, put them all to the rout. One horse and six asses were either killed or missing in consequence of their attack; and for half an hour the bees seemed to have completely put an end to their journey. On another occasion, one ass was lost and a man almost killed by the bees †. Lesser relates, that in 1525, during the confusion occasioned by a time of war, a mob of peasants assembling in Hohorstein, attempted to pillage the house of the minister of Eleude, who, having in vain employed all his eloquence to dissuade them from their design, ordered his servants to fetch his bee-hives, and throw them into the middle of the enfuriated multitude. The effect answered his expectations, for they were immediately put to flight ‡.

Besides attacking the larger animals, however, individuals of adjacent hives often engage in fatal duels. Sometimes a bee, while sitting peaceably on the outside of a hive or walking about, is rudely jostled by another, when the combat immediately commences with such bitter violence, that they permitted Réaumur to examine them quite closely with a magnifying glass. They wrestle, turn, pirouette, and throttle each other; and after rolling about in the dust, the victor, watching the time when the enemy uncovers his body by elongating it in the

* Five Years' Residence in the Canadas.

† Park's last Mission to Africa, pp. 153—297.

‡ Insecto-Theologie, ii. 171.

attempt to sting, thrusts its weapon between the scales, and the next instant its antagonist stretches out its quivering wings, and expires; for the stroke of the sting, when it once penetrates the muscles, is mortal. In these engagements the conqueror is not always able to extricate his sting, and then both perish. The duration of such duels is uncertain; sometimes it lasts an hour, and at others is very soon determined: and occasionally it happens that both parties, tired with their fruitless struggles, give up the contest and fly off*.

Though it seems natural for bees to be industrious, in hives ill managed or not properly supplied with food, the inhabitants, instead of continuing a well-constituted civil society, become a formidably organized band of robbers. Schirach denominates these corsair bees †; the English writers call them robbers. The robbing season, according to Keys, occurs sooner or later as the summer has been more or less favourable; but in general, it happens in March or August. He once had a stock attacked in August and again in October. When a hive determines to commence robbing, Keys says, "they send spies to discover the state of neighbouring stocks. A few of the spies for several days dodge about the doors, trying to get in to obtain more knowledge of their strength and riches; but are driven away by the powerful stocks, who plant guards at their door, and as the weak stocks do not, they are therefore the first to be assaulted. The next day they return in force, and begin a violent siege; and a desperate conflict ensues, both within and without the hive, neither side giving quarter. The stoutest warriors make a desperate attempt and rush forward, and seize the queen; knowing that, by

* Réaumur, Mém. v. 360—5.

† Schirach, sur la Reine des Abeilles, p. 49.

despatching her, instant victory is the consequence; for the assaulted bees always desist and join the victors, the moment they are apprised of their queen's death, become as one fraternity, and assist to carry their own treasure to their new habitation. But in case the queen is protected, they fight on with rage and fury, and death and pillage soon destroy the stock *."

Mouffet's account is somewhat different. "Theeves," he says, "being naturally odious to the bees, steal upon their labours when they are absent, wasting and spoyling their provision of honey. Yea, they do so glut themselves in the meanwhile, that they are not able many times to get out again, they are so full, or to stand in their own defence; whereupon the bees, at their return, without any more adoe, severely punish them, and, according to their just demerits, kill them outright." Again he says, "the bees have watchmen which observe at night when they come home, and they defend and secure them from the theeves, and if they spie a thief come in they set upon him and beat him, throw him out of doors, and there leave him for dead, or half dead at least; for so it happens, that the thief having filled himself with honey is not able to fly away, but tumbles up and down at the door of the hive, till they that goe out finde him, and having branded him with ignominy and scorn, deprive him of his life †." Keys says, that when a hive does not appoint watch-bees, nor show resentment upon the intrusion of robbers, it is a sure sign of their weakness ‡.

Sometimes, it is reported, small parties of three or four will unite to rob, as we may say, on the highway. These waylay straggling individuals, or a humble-bee (*Bombus*) as it returns to its hive loaded with honey. The robbers then make their

* Keys's Treatise, p. 174; ed. 1814.

† Theatre of Insects, p. 921.

‡ Keys, p. 175.

attack: one seizes by a leg, another by a wing, or perhaps there are two on each side confining or pulling its limbs while they maul and pummel its chest or bite its head. This maltreatment obliges it to unfold its tongue and disgorge its honey, which the robbers eagerly lap till they are satisfied, and then let their prisoner go*.

Wasps are also audacious robbers of bee-hives, and one wasp is said to be a match for three bees. This is partly owing to their reckless temerity or courage, for they will boldly encounter evident danger, and one wasp will fearlessly oppose a whole host of bees to filch a bellyful of honey†.

WHITE ANTS, OR TERMITES.

As the white ants (*Termites*) have a portion of their commnnity expressly set apart for the dnties of war, they may be expected to exhibit the most perfect form of insect tactics; and such, indeed, is the fact, though the details hitherto published by those who have had an opportunity of observing them are not so particular respecting many points as we could have wished. Upon making a breach in one of their castles‡ a general alarm is excited amongst all ranks of the inhabitants; but the labourers, previously the most conspicuous, being incapable of fighting, immediately betake themselves to the interior, while the soldiers take their places. Immediately upon striking the wall, a soldier, probably a sentinel, starts out, walks rapidly over the breach to reconnoitre, and after ascertaining the nature of the danger threatened, retires to give the alarm. Upon this two or three more hurry out, and the intelligence spreading, the breach is soon filled with soldiers

* Kirby and Spence, ii. 208. † Keys, p. 180.
‡ See Insect Architecture, p. 300.

rushing out to defend their citadel, which they do with indescribable fury. Apparently they can only direct their movements by feeling, though they do not spend much time in deliberating, but bite fiercely at every thing within their reach, and in their haste they frequently lose their footing and tumble down hill. In biting they frequently strike their forceps upon the wall, which makes a crackling noise somewhat shriller and quicker than the ticking of a watch, and this, which may be heard at the distance of several feet, the labourers within seem to understand, as they reply to it with a kind of hissing. "I one day," says Smith, "attempted to knock off the top of one of the hills with my cane, but the stroke had no other effect than to bring thousands of the insects out of doors to see what was the matter; upon which I took to my heels, and ran away as fast as I could." Others have had more courage than Smith to renew their attack, in which case the bustle and fury increase in a tenfold degree. If, in their rage, they come in contact with the hands or legs of their assailant, they make their mandibles meet through the skin at every stroke, and inflict considerable pain, while the blood from one of their wounds will stain the stocking to more than an inch in width. They never quit their hold, but will suffer themselves to be pulled limb from limb, without making any attempt to escape.

"If, on the other hand," says Smeathman, "you cease to batter, in half an hour they retire into the nest, as if they supposed the wonderful monster that had battered their castle to be beyond their reach. The labourers, who had fled on the first alarm, are now seen hastening to repair the breach, every one with a burthen of ready-tempered mortar in its mouth. This they stick on to the breach with such wonderful celerity and order, that although thousands, nay, millions, seem employed, yet they never embarrass one another. While the labourers are thus engaged, the soldiers retire, save here and there one who saunters about, never touching the mortar. One in particular places itself close to the part undergoing repair; it may be seen turning leisurely on all sides, and every now and then, at an interval of a minute or two, lifting up its head, and with its forceps beating upon the building and making a vibrating noise, on which a loud hiss, apparently from the whole body of labourers, issues from withinside the dome and all the subterranean passages: that it comes from the labourers is very evident, for all these may be seen hastening at every such signal, redoubling their pace, and working as fast again."

A renewal of the attack instantly changes the scene. "At the first stroke," continues Smeathman, "the labourers run into the many pipes and galleries with which the building is perforated, and this they do so quickly that they seem to vanish, for in a few seconds all are gone, and the soldiers rush out as numerous and as vindictive as before. On finding no enemy they return leisurely into the hill; and soon afterwards the labourers appear loaded as at first, with soldiers here and there among them, who act in the same manner as before, one or other of them giving the signal to hasten the business. Thns the pleasure of seeing them come out to fight and to work alternately may be obtained as often as curiosity excites, or time permits; and it will certainly be found, that the one order never attempts to fight nor the other to work, let the emergency be ever so great*."

The furious valour and pertinacity of these soldier-insects present a serious obstacle to those who have

* Phil. Trans. vol. lxxi.

the curiosity to explore the interior structure of their edifices, which is also increased by the mutual dependance of the walls and archways, and the activity of the labourers in building up with almost magical celerity the parts broken down. The soldiers, Smeathman tells us, "fight to the very last, disputing every inch of ground so well, as often to drive away the negroes, who are without shoes, and to make the white people bleed plentifully through their stockings. Neither can we let a building stand so as to get a view of the interior parts without interruption; for, while the soldiers are defending the out-works, the labourers keep barricading all the way against us, stopping up the different galleries and passages which lead to the various apartments, particularly the royal chamber, all the entrances to which they fill so artfully as not to let it be distinguishable while the work remains moist; and, externally, it has no other appearance than that of a shapeless lump of clay. It is, however, easily found, from its situation with respect to the other parts of the building, and by the crowds of labourers and soldiers which surround it, and which exhibit their loyalty and fidelity by dying under its walls. The royal chamber is often capacious enough to hold many hundreds of the attendants, besides the royal pair, and is always found as full of these as it can hold. These faithful subjects never abandon their charge, even in the last distress; for, whenever I took out the royal chamber, as I often did, and preserved it for some time in a large glass bowl, all the attendants continued to run round the king and queen with the utmost solicitude, some of them stopping at the head of the latter, as if to give her something*."

* Phil. Trans. vol. lxxi.

WARS OF ANTS.

THE wars of ants have furnished a theme not peculiar to modern times, though it belongs to living naturalists to have traced many interesting circumstances respecting these, which could scarcely have been dreamed of, and would certainly not have been credited but upon the very high authority of the witnesses. One of the older records of an ant-battle is given by Æneas Sylvius, afterwards Pope Pius II., which was contested with obstinacy by a great and a small species, on the trunk of a pear-tree. "This action," he states, "was fought in the pontificate of Eugenius the Fourth, in the presence of Nicholas Pistoriensis, an eminent lawyer, who related the whole history of the battle with the greatest fidelity." Another engagement of the same description is recorded by Olaus Magnus as having happened previous to the expulsion of Christiern the Second from Sweden; and the smallest species, having been victorious, are said to have buried the bodies of their own soldiers that had been killed, while they left those of their adversaries a prey to the birds *. Our readers, however, we are persuaded, will listen with more interest to some of the minutely circumstantial narratives of the chief historian of ants, the younger Huber. "If," says he, "we are desirous of beholding regular armies wage war in all its forms, we must visit the forests in which the wood-ant (*Formica rufa*) establishes its dominion over every insect within the neighbourhood of the colony. We shall there see populous and rival cities, and regular military roads diverging from the ant-hill like so many rays from a centre, frequented by an immense number of combatants of the same species, for they are naturally

* Mouffet, Theatrum Insect. 242.

enemies, and jealous of any encroachment upon the territory which surrounds their capitals. I have witnessed in these forests the inhabitants of two large ant-hills engaged in spirited combat; two empires could not have brought into the field a more numerous or more determined body of combatants. The rival cities were situated about a hundred paces from each other, and alike in extent of population: what occasioned their discord I cannot pretend to say.

"Let us figure to ourselves this prodigious crowd of insects covering the ground lying between these two ant-hills, and occupying a space of two feet in breadth. Both armies met at half-way from their respective habitations, and there the battle commenced. Thousands of ants took their station upon the highest ground, and fought in pairs, keeping firm hold of their antagonists by their mandibles: a considerable number were engaged in the attack and leading away prisoners. The latter made several ineffectual efforts to escape, as if aware that, upon their arrival at the camp, they would experience a cruel death. The scene of warfare occupied a space of about three feet square; a penetrating odour exhaled from all sides; numbers of dead ants were seen covered with venom. The ants, composing groups and chains, laid hold of each other's legs and pincers, and dragged their antagonists on the ground. These groups formed successively. The fight usually commenced betweeu two ants, who seized each other by the mandibles, and raised themselves upon their hind-legs, to allow of their bringing their abdomen forward, and spurting the venom upon their adversary. They were often so closely wedged together, that they fell upon their sides, and fought a long time in that situation iu the dust, till a third came to decide the contest. It more commonly happened that both ants received assistance at the same time, when the whole four, keeping firm hold of a foot or antennæ, made ineffectual attempts to win the battle. In this way they sometimes formed groups of six, eight, or ten firmly locked together, the group being only broken when several warriors from the same republic advanced at the same time, and compelled the enchained insects to let go their hold, and then the single combats were renewed: on the approach of night, each party retired gradually to their own city.

"Next morning, before dawn, the combatants returned to the field of battle, the groups again formed —the carnage recommenced with greater fury than on the preceding eveniug, and the scene of combat occupied a space of six feet in length by two in breadth. The event remained for a long time doubtful; but about mid-day the contending armies had removed to the distance of a dozen feet from one of the cities, whence I conclude some ground had been gained. The ants fought so desperately that they did not even perceive my presence; for though I remained close to the combatants, not one of them attempted to climb my legs, seeming to be wholly absorbed in the object of finding an enemy to wrestle with. During this furious warfare the common operations of the two colonies were not suspended, for the paths, which led to a distance in the forest, were as much thronged as in time of peace, and all around the ant-hill order and tranquillity prevailed. On that side alone where the battle raged were seen crowds of the colonists running to and fro, some to join the army and some to escort the prisoners. This war terminated without any disastrous results to the two republics. In fact it appeared that its duration was shortened by long-continued rains, which compelled each of the belligerents to keep within their walls, and the warriors ceased to frequent the road which led to the camp of the enemy*."

It may surprise some of our readers, that among ants "the battle is not to the strong," for those of larger size seem as much if not more afraid to encounter the smaller than those apparently more powerful than themselves. Any of our readers, who have the curiosity, may verify this by throwing a parcel of small ants, with their eggs, larvæ, or pupæ, into the nest of a larger species, when the giants will be seen every where retreating before the pigmies. A small black species (*Myrmica* ——— ?), little more than a line in length, of which we have thrown two or three dozen into a hill of the miner (*Formica cunicularia*), which is nearly three times the size, put to flight every one that attempted to carry their property into the undergrouod apartments, though the miners had the advantage of being at home. The cause of the superiority of the smaller is their dexterity in seizing the others by the antennæ or the legs, and their obstinacy in retaining their hold, even should they be pulled to pieces. These small ones, also, like the red and the turf-ants, had the advantage of a sting, of which the miners were destitute; but we seldom observed them use it, seeming to trust more to their mandibles†. Hnber says, "when the large attack the small, they appear to do it by surprise, most likely to prevent the latter from fastening on their legs: they seize them in the upper part of the body, and strangle them immediately between their pincers. But when the small ants have time to guard against an attack, they intimate to their companions the danger with which they are threatened, when the latter arrive in crowds to their assistance." It does not, however, agree with anything which we have observed in these com-

* On Ants, p. 194. † J. R.

bats, that assistance is ever rendered to an individual by its fellow colonists, for the numerous combats which we have witnessed have been exclusively duels, and though many of these duels were contested within a few inches of each other, no combatants ever interfered with the antagonist of another*. The larger species appear to stand most in need of assistance, for when a small ant fixes upon their legs or antennæ it never lets go its hold, and may often, even after it is dead or half of its body bitten off, be seen remaining immoveable, subjecting the individual it has thus fixed upon to no little inconvenience. Huber's observations, however, do not relate to the same species as ours.

One of the battles which he witnessed was between a colony of the Herculean ant (*Formica Herculanea*), which is nearly half an inch long, and has not been found in Britain, and the sanguine ant (*F. sanguinea*), only half the size, and rare in Britain, though Mr. Stephens has taken it near London. "These Herculean ants," says Huber, "quitted the trunk of the tree in which they had established their abode, and marched up to the very gates of the nest of the sanguine ants. The latter had the advantage in point of number; yet they acted on the defensive. The earth, strewed with the dead bodies of their companions, bore witness that they had suffered the greatest carnage, and it was no doubt on this account that they had taken the prudent part of fixing their habitation elsewhere, and with great activity transported to a distance of fifty feet from the spot, the several objects that interested them. Small detachments of the workers were posted at little distances from the nest, apparently placed there to cover the march of the recruits, and to preserve the city itself from any sudden attack. They

* J. R.

struck against each other when they met, and had always their mandibles separated in the attitude of defiance. As soon as the Herculean ants approached their camp, the sentinels in front assailed them with fury. They fought at first in single combat. A sanguine ant threw itself upon a Herculean, fastened upon its head, turned its abdomen against the chest of its adversary, or against the lower part of its mouth, and inundated it with venom. It sometimes quitted its antagonist with great quickness; more frequently, however, the Herculean ant held between its feet its audacious enemy. The two champions then rolled themselves in the dust, and struggled violently. The advantage was at first in favour of the largest ant; but its adversary was soon *assisted by those of its own party*, who cullected around the Herculean ant, and inflicted several deep wounds with their teeth. The Herculean ant yielded to numbers; it either perished the victim of its temerity, or was conducted a prisoner to the enemy's camp*."

Not the least wonderful circumstance connected with these insect battles is the instinct which enables each ant to know its own party, more particularly when the combatants on both sides are of the same species, and thousands of individuals mingle in the strife, who appear, at least to onr senses, to be precisely alike in shape, size, and colour. Sometimes, indeed, according to Huber, they do attack those of their own party, but on recognising them immediately relax their hold; while it often happens that the individuals who have been the sufferers from this temporary error, caress their companions for the purpose, it would appear, of appeasing their anger.

The warfare, however, is conducted in various manners according to the genius of the species

* Huber on Ants, p. 187.

engaged in it; and when a party of the wood-ant (*F. rufa*) attacks a party of the sanguine ant (*F. sanguinea*), the manœuvring reminds us strongly of our own battles. The sanguine ants, in this case, go and await the enemy in little troops at some distance from the nest, advancing in a body without separating, and seize all those of their enemies who venture too far from the camp. "The two parties," says Huber, "place themselves in ambuscade, and suddenly attack each other in turns; but when the sanguine ants perceive that the wood-ants are advancing in force against them, they inform those at the ant-hill, by messengers, of the need in which they stand of their assistance. Immediately a considerable army is despatched from the sanguine city, advances in a body, and surrounds the enemy. I have witnessed instances of this kind every day for several weeks, the ant-hills being in the same hedge, but at some distance from each other, and the combats renewed every day."

Contiguity, however, is not always the cause or such warfares, for we have seen innumerable instances of colonies of different species, not only in the same hedge, but with their boundary walls almost touching each other, without any appearance of hostility. Nay, we have more than once seen colonies of three different species established under the same stone. In an instance of this kind there were separate colonies of the yellow ant (*F. flava*), the negro ant (*F. fusca*), and the red ant (*Myrmica rubra*); though the latter is most pugnacious perhaps, and certainly the most virulent of the whole tribe, yet all the three were living in harmony, though the stone which served them as a common covering was not a foot in diameter. Even in this case, however, it was by no means safe for an individual to cross its own boundaries and venture into its neighbour's territory, and when we forced one to encroach in this way, it always scampered off with the utmost trepidation, as if well aware, without consulting Vattel or Puffendorf, that it had infringed an international law *. It is of importance, as will presently appear, to state that these three colonies were all quite distinct, and none subjected to another in the relation of masters and slaves, as, strange to tell, sometimes occurs in ant communities. The details on this curious subject are well worthy our attention.

ANT EXPEDITIONS TO CAPTURE SLAVES.

THE following history of the mode in which communities of ants obtain labourers is altogether so extraordinary, that, did the evidence rest upon the testimony alone of one observer, we might be disposed to believe that it had originated in some imperfect observation, where the fancy had influenced the judgment of the observer. But when the testimony of the younger Huber is confirmed by such men as Professor Jurine and M. Latreille, we have no room left for scepticism. From our own experience, indeed, we can well believe Huber when he says, "the more the wonders of nature have attractions for me, the less do I feel inclined to alter them by a mixture of the reveries of imagination." We may premise that the ant named by him the Legionary, or Amazon (*F. rufescens*), is a large iron-brown coloured species, not hitherto found in Britain.

"On the seventeenth of June, 1804," says Huber, "whilst walking in the environs of Geneva, between four and five in the evening, I observed, close at my feet, traversing the road, a column of legionary ants. They moved with considerable rapidity, and occupied a space of from eight to ten inches in length, by three

* J. R.

or four in breadth. Quitting the road in a few minutes, they passed a thick hedge, and entered a meadow, where I followed them, and observed them winding along the grass without straggling, their column remaining unbroken, in spite of the obstructions in their way. They soon approached a nest inhabited by a colony of the negro-ant (*F. fusca*), the dome of which rose above the grass, at a distance of twenty feet from the hedge. Some of the negroes were guarding the entrance; but, on the discovery of an approaching army, darted forth upon the advancing legion. The alarm instantly spread into the interior, whence their companions rushed forth in multitudes to defend their homes. The legionaries, the bulk of whose army lay only at the distance of two paces, quickened their march, and when they arrived at the hill, the whole battalion fell furiously upon the negroes, who, after an obstinate, though brief conflict, fled to their subterranean galleries. The legionaries now ascended the dome, collected in crowds on the summit, and taking possession of the principal avenues, left some of their companions to excavate other openings in the exterior walls. They soon effected this, and through the breach the remainder of the army made their entrance; but in abont three or four minutes afterwards issued forth again, each carrying off a pupa or a grub, with which booty they retraced their ronte, in a straggling, irregular march, very different from the clnse orderly array they had before exhibited."

Our author followed them for some time, but lost sight of them in a field of ripened corn; and on returning to examine the state of the assaulted city, he found a small number of the defeated negro-workers perched on the stalks of plants, holding in their mouth the few grubs they had succeeded in rescuing from the pillage. Next morning, Huber returned at the same hour with the hope of ascertaining the nature of these proceedings, when he discovered a numerous encampment of the legionaries." "These formed," he tells us, "into column, set forth in a body, and fell upon one of the negro hills, which they triumphantly entered after a very feeble opposition. One division immediately returned with the grubs which they had captured, while another party less fortunate came away empty-handed; but resolved, it would appear, not to go home without booty, they marched in a body upon another negro establishment, where they were abundantly successful. The whole army now forming two divisions, hastened to their own encampment, which I took care to reach a little before them; but what was my surprise to observe all around a great number of that identical species, the negroes, which they had gone forth to attack. I raised up a portion of the building, and upon still perceiving more, I conjectured that it was one of the encampments which had already been pillaged by the legionaries, but I was set right by the arrival at the entrance of the very army I had been watching, laden with the trophies of victory. Its return excited no alarm among the negro-ants, who, so far from offering opposition to the entrance of the triumphant army, I even observed to approach the warriors to caress them, and present them with food, as is the custom among their own species, whilst the legionaries in turn consigned to them their prisoners to be carried into the interior of the nest *."

They do not always complete the pillage at the first, or even the second attack, for this negro colony was successively invaded in the same manner three several times. The third time, however, the invaders

* Huber on Ants, p. 254.

had to undertake a siege in regular form, for the negroes, as if conscious of their own weakness, lost no time in throwing up trenches, barricading the several entrances, and reinforcing the guard of the interior, in order to provide for future safety. With the same view, they had brought together all the little pieces of wood and earth within reach, with which they had blocked up the passage to their encampment. Upon discovering these defensive preparations, the legionaries at first hesitated to approach, but rambled about or returned to the rear till sufficiently reinforced; but at length, upou a signal given, they rushed forward in a body with great impetuosity, and began to demolish the barricades with their mandibles and their feet. When they had thus made a sufficieut breach, they entered into the interior by hundreds, in spite of the resistance of the poor negroes, and carried off their remaining property. "I was witness," says Huber "every day during summer to these invasions *."

The negro-ants are most commonly the victims of these hostile excursions, probably in consequence of their pacific and docile dispnsition; but in more than one instance Huber observed successful attacks made upon the more warlike and powerful communities of the mining ant (*Formica cunicularia*), a British species, though not abundant, and uearly resembling the wood-ant (*F. rufa*) in colour, though about a fourth less in size. It is interesting to remark, that though the result of a victory is precisely similar to the case already detailed, the legionaries are obliged to employ a different mode of warfare, as we shall see from Huber's uarrative.

"Between four and five in the evening," he says, "a time when the army usnally commeuces its march, the legionaries were already assembled on

* Huber on Ants, p. 263.

the nest, and ready to set forth. They proceeded like a torrent along a deep hollow, and marched in a more compact body than ordinary, till they arrived at a nest of miners, which they intended to attack. As soon as the invading army began to enter the subterranean city, the miners rushed out in crowds, and whilst some fell upon the invaders with great spirit, others passed through the scene of contest, solely occupied in bearing off the larvæ and pupæ to a place of safety. The surface of the nest was for some time the theatre of war. The legionaries were often despoiled of the pupæ they had captured by the miners, who darted upon them with fury, fighting body to body, and disputing the ground with an exasperation I had never before witnessed. The legionary army, however, gained the victory, and recommenced its march in good order, laden with booty; but instead of proceeding in file, it now maintained close rank forming a compact mass, a precaution more necessary, as the courageous miners hastened in pursuit, and continued to harass their march to within ten paces of their citadel *."

This condnct of Huber's miners contrasts strongly with the behaviour of a colony of the same species, upon which we made some experiments. The difference, no doubt, arose from the very different circumstances of the case. Desirous of seeing what would follow, we threw a considerable number of the minute black ant (*Formica contracta*, Latr.), with their pupæ, upon the surface of a hill inhabited by miners; but the latter, so far from attacking the intrnders, fled from them with the utmost alarm whenever they encountered them. Imagining that his might arise from the virulent character of the black ants, we afterwards introduced a similar number of the more pacific negroes (*F. fusca*); but

* Huber on Ants, p. 292.

the miners seemed to be no less afraid of them, and indeed all the species which we tried in the same way, among which were the carnivorous red ant (*Myrmica rubra*), and the pacific yellow ant (*F. flava*), produced the same effect of fear among the miners, though they now and then snatched up some of the pupæ, and carried them into the galleries below. The red ants, however, in particular, always followed them, and though so much inferior in numbers, succeeded in rescuing their property. In these experiments our miners, it is probable, had a notion that the intruders did not come for the purpose of invasion, otherwise their fear might have changed into courage*.

"During these combats," continues Huber, "the pillaged ant-hill presented in miniature the spectacle of a besieged city; hundreds of the inhabitants being seen to quit it, carrying off their young to preserve them from the enemy. The greater number mounted the neighbouring plants bearing the young in their mandibles, and others hid them under thick bushes. When the danger appeared to be over, they brought them back to the city, and barricaded the gates, near which they posted themselves in great force to guard the entrance. Immediately after the legionaries again departed, and proceeded towards another colony of miners of considerable extent, and threw themselves in a body upon one of the galleries indifferently guarded; but their number not permitting them to enter all at once, the mining ants that were without precipitated themselves upon the invaders; and whilst they were engaged in desperate combat, their fellow-citizens losing, perhaps, every hope of defending their abode and the little ones confided to their care, carried these off, took flight in every direction, and literally covered the ground to a considerable dis-

* J. R.

tance. The contest became every moment warmer between the assailants and the assailed. Legionaries and miners attacked each other impetuously, and often, in the excess of their fury, deceived as to their object, fell upon their companions, whom however they soon released. This commotion was confined to the rear guard of the legionary army; for the main body, laden with booty, having departed on their return from the pillaged city, retraced their steps to their own citadel, constantly assailed by the miners, who continued to harass their march. It was only by their address, indeed, the rapidity of their movements, and the use of their sting, that the legionaries were enabled to disengage themselves. The pillage and skirmishes are not of long continuance, for in less than a quarter of an hour we usually found the legionaries on the road to their garrison *."

Huber's legionary ant (*F. rufescens*) is not the only species which engages in those expeditions; for the sanguine ant (*F. sanguinea*), mentioned by Mr. Stephens as having been discovered near London, is also a capturer of slaves, though the tactics employed for this purpose are considerably different. The sanguine ant is so named from the head, thorax, and feet being blood-red, while the abdomen is ash-coloured and slightly bronzed. They much resemble the wood-ant (*F. rufa*); and their nest, which is usually placed on the slope of a hedge or bank facing the south, is, like that of the wood-ant, covered with fragments of leaves, stalks of plants, moss, and little stones, which form a species of mortar difficult to break. They do not, like the legionaries, send out numerous armies, nor attempt to carry their point by impetuosity; but make their attacks in small successive divisions. As it would diminish the interest to

* Huber on Ants, p. 295.

curtail Huber's narrative, we shall give it in his own words.

"On the fifteenth of July," he says, "at ten in the morning, a small division of the sanguine ants was despatched from the garrison, and arrived in quick march near a colony of the negro-ant (*F. fusca*), situated above twenty paces distant, around which they took their station. The inhabitants, on perceiving these strangers, rushed forth in a body to attack them, and led back several prisoners. The sanguine ants made no further advance, but appeared to be waiting for some reinforcement. From time to time, accordingly, small companies arrived to strengthen the brigade; and when they considered themselves in sufficient strength they advanced a little nearer, as if more willing to run the hazard of a general engagement; yet it was remarkable, that in proportion as they approached the negro encampment, the more solicitous did they seem to despatch couriers to their own garrison, who, arriving in great haste, produced considerable alarm, when another division was immediately appointed to joiu the army. But, though thus reinforced, they evinced little eagerness for the combat, and only alarmed the negroes by their preseuce. The negroes took up a position in front of their encampment of about two feet square, where nearly their whole force was assembled to wait the enemy.

"Frequent skirmishes took place all around the lines, the besieged always attacking the besiegers; and, judging from their numbers, the negro-ants gave token of a vigorous resistance, but distrusting their own strength, they look to the safety of the young committed to their care, and in this respect exhibit one of the most singular traits of insect prudence. Even long before success is at all dubious, they bring up the pupæ from the chambers under ground, and heap them up on the other side of the nest from that where the invading army is making its chief assault, in order that they may be more conveniently carried off, should they lose the battle. Their young females also take shelter on the same side. When the danger becomes more immioent by the sanguine army, after receiving repeated reinforcements, rushing upon the phalaux of the negroes, and pressing them back to the very gates of the city, the latter, after a spirited stand, give way, and seizing upon the pupæ, deposited with that view on the outside, convey them to a place of safety. The invaders pursue and endeavour to rob them of their treasure.

"The whole body of the negroes are now in flight; yet a few, more courageous than their fellows, return through the ranks of the enemy, at the hazard of their lives, and once more enter their encampment to bring off the larvæ that would otherwise be devoted to pillage. The sanguine ants are now, indeed, in the very act of descending into the interior, taking possession of the avenues, and appearing to establish themselves in the abandoned city. Little bands of troops continually pour in from the garrison and begin taking away the remainder of the larvæ and pupæ, establishing an uninterrupted chain from one ant-hill to the other: thus the day passes, and night comes on, before they have transported all their booty. A considerable number of sanguine ants still remain in the negro residence, and on the following morning, at break of day, recommence the transfer of the rest of its contents*."

It would appear, from some notices collected by Kirby and Spence, that some hints at least of these extraordinary proceedings were known to our English

* Huber, *ut supra*, p. 337.

naturalists before the interesting observations of Huber. Willughby, for example, in mentioning the care which ants take of their pupæ, says, "they also carry the aureliæ of others into their nests as if they were their own *;" Gould also remarks of the wood-ant (*F. rufa*), that "this species is very rapacious after the vermicles (*larvæ*) and nymphs (*pupæ*) of other ants: if you place a parcel before or near their colonies, they will, with remarkable greediness, seize and carry them off †." White, of Selborne, made the same observation ‡, which must, indeed, occur to every naturalist who is in the least acquainted with ants. It belongs, however, exclusively to Huber to have developed the use which is made of the purloined pupæ by the legionary and the sangnine ants.

One of the most remarkable circumstances discovered by Huber respecting these expeditions is, that the invaders never captnre the old negroes or miners, aware, it should seem, of the impracticability of taming tnem down to the condition of slaves. Their only object is to obtain a number of pupæ, when the embryo-ants are in a state of repose, and consequently have formed no attachment to their natal colour. The city of the stranger thus becoming the only one with which they are acquainted, they consider it their home, and employ their natural activity in repairing and enlarging it, as well as adding to its provisional stores,—putting forth, in a word, the same exertions which they would have done had they never been captured. "Developed," says Huber, "in the enemy's encampment, they afterwards become house-stewards, and auxiliaries to the western tribe with whom they are associated. Brought up in a strange nation, not only do they live socially with their cap-

* Raii Historia Insect. 69.

† Account of English Ants, p. 91. ‡ ii. 278.

tors, but bestow the greatest care upon their larvæ and pupæ, their males and females, and even evince the same regard for themselves, transporting them from one part of the colony to another, going in search of provisions for them, building their habitation—forming, as occasion reqnires, new galleries, and fulfilling the duties of sentinels, by guarding the exterior of their common abode, apparently not once suspecting that they live with those very insects which kidnapped them in their helpless and unconscious infancy. Whilst the negro-ants are engaged in these laborious employments, their masters rest tranqnilly at the bottom of their subterranean city till the hour fixed for their expeditions arrives; reserving their strength, courage, and skill in tactics, for the pnrpose of bringing in from some adjacent colony hnndreds of pupæ which they confide to the charge of their slaves *."

It is most justly remarked by Kirby and Spence, that, although Providence has gifted these creatnres with an instinct so extraordinary, and seemingly so unnatural, it does not prove, as in the instance of human slavery, a source of misery to the slaves themselves; for their situation is little, if at all, different from what it wonld have been had they never been carried from their native colony; and they are exposed to no nnusual hardships or oppression in consequence of their change of residence. It may be said, indeed, that they have to perform serious additional labours for their warlike masters; but this objection will disappear when the minute division of labour among ants is taken into account, and when we consider that these slaves are commonly very numerous. Above all, it is to be recollected that the species of ants captured appear to place their chief pleasure in incessant labour, and would be as miserable, if compelled to be idle, as the poor animals which we see confined in menageries without space for exercise.

* Huber, *ut supra*, 271.

The warrior ants, on the other hand, seem to have as much dislike to any sort of labour but war, as the barbarous Spartans of old; and, when not in active service in the field, they seem to be as helpless as an Otaheitan prince. They are apparently incapable even of feeding themselves, an office which is always performed by the slaves, on whom therefore they depend, not only for house and home, but even for existence; and so faithful are these devoted negroes, that they seem to begrudge no exertion in providing for their masters. In their turn, however, they also exercise authority; for they will not permit them to leave the colony alone, nor before the proper seasoo; and when they return from a predatory excursion without the expected booty, they meet with a very cold reception, and are often refused admission, or dragged out again if they presume to enter. In these cases, the slaves are evidently the masters, and in no case are the latter ever observed directing their employments or keeping them to their work.

Anxious to learn whether the warrior ants could subsist by their own exertions without the assistance of slaves, Huber tried the experiment of isolating them, to ascertain how they would proceed. "I enclosed," he tells us, "thirty of the legionary ants (*F. rufescens*), with several pupæ and larvæ of their own species, and twenty pupæ belonging to the negroes, in a glass box, the bottom of which was covered with a thick layer of earth. I placed a little honey in the corner of their prison, and cut off all association with their auxiliaries. At first they appeared to pay some little attention to the larvæ: they carried them here and there, bnt presently replaced them. More than one half of the legionaries died of hunger in less than two days. They had not even traced out a dwelling, and the few individuals still in existence were languid and without strength.

I commiserated their condition, and gave them one of their negro servants. This individual, alone and unassisted, established order, formed a chamber in the earth, gathered together the larvæ, extricated several young ants that were ready to quit the condition of pupæ, and, in a word, preserved the life of the remaining legionaries *."

Our naturalist, not satisfied with what he could observe on the exterior of these singular communities, opened one of the hills inhabited by legionary and negro ants. The latter lost no time in carrying away the larvæ and pupæ, which had thence been exposed, to a place of safety, and opening galleries which had been obstructed, while the legionaries appeared to look on their exertions with the utmost indifference, and never deigned to lend the least assistance. They seemed, indeed, so confounded at the altered aspect of the city, that they wandered about quite at random, till the negroes helped them out of their embarrassment by carrying them to some open passage. "I observed one," continues Huber, "after several ineffectual windings, take the precaution of laying on the earth the legionary, who remained in the same spot until the negro returned to its assistance, who, having well ascertained and examined one of the entrances, resumed its burthen and bore it into the interior. If the entrance to any gallery was unluckily obstructed by a mass of earth, and the negro-ant wished to introduce, by that way, one of the legionaries, it quickly deposited its load, and began clearing away the impediment, which was no sooner effected than the Amazon was again taken up and carried triumphantly into the nest. These facts fully prove the harmony which reigns between the two species †."

* Huber on Ants, p. 287.
† Huber, *ut supra*, p. 273.

By means of his artificial glass formicaries, Huber was enabled to try a number of experiments upon these mixed communities of masters and slaves—if we may continue to use terms which are not very strictly appropriate. He had already ascertained that when their habitation is not sufficiently commodious, the negroes alone, and not the legionaries, choose a new locality, decide upon removing, commence building, and as soon as chambers are prepared to receive them, carry thither the legionaries in their mandibles. In one of his experiments he was witness to a similar scene. He put the greater portion of the inhabitants of a mixed colony into a woollen bag which had a wooden tube, glazed at the top, fitted into its mouth, and communicating with a glass formicary*. On the following morning some of the negroes were seen leaving the bag, and traversing the tube; the second day they commenced carrying each other, till at length there was barely room for the crowd of passengers going and returning. When he found they had thus begun to establish themselves, he separated the bag and scattered those which still remained in it about his study, as well as the remainder of the nest which he brought in from the field. Immediately the negroes, who were already settled, eagerly carried all those that were thus scattered about the floor into the formicary, both their own companions and the legionaries, and turned over every clod of earth to extricate pupæ and larvæ accidentally buried, similar to the famous dogs which extricate travellers engulphed in the snows of the Alps. The legionaries, as usual, took no active part in these labours; but the negro-ants appeared very solicitous to conduct them into the interior of the nest, and sometimes, when one did not know what to do, it would implore the assist-

* Figured in Insect Architecture, p. 269.

ance of a negro, which was always most willingly accorded. In eight days the formicary was completely peopled, when it was placed out of doors; and next day the legionaries actually made an expedition, and returned with a rich booty of negro pupæ from a neighbouring colony. By raising the shutters with caution, he could now see everything that was going forward in the interior, and he ascertained in this way most of the facts which we have already detailed. Amongst other things of singular interest, he likewise found that there are never any negro males or females in these communities, but male, female, and neuter legionaries; and the female legionary, like other species of ants, is always the foundress of a colony, performing in the first instance all the duties of a labourer, as Latreille observed at Brive before the discoveries of Huber.

Huber concluded his experiments by bringing two legionary armies into immediate combat, by placing his formicary full in front of an advancing column from another encampment. "After a trifling combat," he says, "which took place at the door of the formicary, those in the interior went out in force, when the enemy's column appeared desirous to avoid battle, taking at first another direction, then returning and re-entering their nest. Several ants from the formicary put themselves in pursuit: some went even as far as the enemy's garrison, where they were retained; two or three only escaped, and these, as I observed, returned in great haste. The entire army now left the formicary, and proceeded to the mixed ant-hill, where I looked forward to a general battle; but when the column had arrived to within a few paces of the entrance, it fell back, with the exception of a small body, composed of about three hundred legionary ants, who continued their route till they reached the ant-hill. The legionaries assembled on the surface appeared extremely agitated, as if they had foreseen the attack with which they were threatened. The combatants fought body to body; but the strangers threw themselves into a gallery with so much impetuosity that the other could not restrain them. This courageous incursion did not succeed; they all perished, not, however, without making great havoc; for, when I saw the legionaries of the natural ant-hill resume their expeditions, I found their army reduced to one half its original number: the formicary had not suffered so great a diminution*."

* Huber on Ants, p. 328.

CHAPTER XIV.

ON THE COLLECTION AND PRESERVATION OF INSECTS FOR THE PURPOSES OF STUDY.

"I COULD wish," says Addison, in 'The Spectator,' "our Royal Society would compile a body of natural history, the best that could be gathered together from books and observations. If the several writers among them took each his particular species, and gave us a distinct account of its original, birth, and education; its policies, hostilities, and alliances; with the frame and texture of its inward and outward parts,—and particularly those which distinguish it from all other animals,—with their aptitudes for the state of being in which Providence has placed them; it would be one of the best services their studies could do mankind, and not a little redound to the glory of the All-wise Creator*." Now, though we can scarcely consider Addison as a naturalist, in any of the usual meanings of the term, it would be no easy task, even for those who have devoted their undivided attention to the subject, to improve upon the admirable plan of study here laid down. It is, moreover, so especially applicable to the investigation of insects, that it may be more or less put in practice by any person who chooses, in whatever station or circumstances he happens to be placed. Nay, we will go farther; for since it agrees with experience and many recorded instances that individuals have been enabled to investigate and elucidate particular facts, who were quite unacquainted with systematic natural history, we hold it to be un-

* Spectator, No. 111.

deniable that any person of moderate penetration, though altogether unacquainted with what is called natural history, who will take the trouble to observe particular facts and endeavour to trace them to their causes, has every chance to be successful in adding to his own knowledge, and frequently in making discoveries of what was previously unknown. We adverted in a former volume to the spider, which M. Pélissan, while a prisoner in the Bastille, tamed by means of music*; and in another place we quoted some observations on hunting-spiders, by the celebrated Evelyn, both of which are strong proofs of our position, and show that though books are often of high value to guide us in our observations, they are by no means indispensable to the study of nature, inasmuch as the varied scene of creation itself forms an inexhaustible book, which 'even he who runneth may read.' It shall be our endeavour, therefore, in what we shall now add, to point out a few particulars by way of assisting young naturalists to read the book of nature with the most advantage. It will be of the utmost importance, in the study here recommended, to bear in mind that an insect can never be found in any situation, nor make any movement, without some motive, originating in the instinct imparted to it by Providence. This principle alone, when it is made the basis of inquiry into such motives or instincts, will be found productive of many interesting discoveries, which, without it, might never be made. With this, indeed, exclusively in view, during an excursion, and with a little attention and perseverance, every walk—nay, every step—may lead to delightful and interesting knowledge.

In accordance with these views, we advise the young naturalist to watch as far as possible the progress of every insect which he may meet with, from

* See Antoine, Animaux Célèbres, i. 24.

the egg till its death, marking its peculiar food, the enemies which prey on it, and the various accidents or diseases to which it may be liable,—the latter appearing, to our limited comprehension, to be some of the means appointed by Providence to restrain excessive multiplication. It is obvious that all this may be done (it actually has been done by an illiterate labourer at Blackheath) without knowing the name of the insect observed, or the rank it holds in any particular system. These, however, it may be interesting for the observer to ascertain afterwards, in order that he may compare his own observations with those of other naturalists. At the commencement, therefore, of such investigations, it may be useful, when the name of an insect is unknown, to mark it with some number by way of distinction, till the name (if it have one) given it by systematists be discovered. In our own researches we have found these numeral names—1, 2, 3, or A, B, C,—of considerable use, when we could not readily trace the names we wanted amongst the almost interminable synonymes to be met with in systems of classification.

If we should be asked, what is the best place to find insects, our answer must be every-where—woods, fields, lanes, hedge-rows, gardens: wherever a flower blooms or a green leaf grows, some of the insects which feed on living vegetables will be sure to be found, as will those which feed on decaying leaves and decaying wood be met with wherever these abound. In the waters, again, both running and stagnant, from the rill to the river, and from the broad lake to the little pool formed in a cow's footstep, aquatic insects of numerous varieties may be seen. Winged insects, of countless species, may be seen in the air during their excursions in search of food, or for the purposes of pairing or depositing their eggs, and the observation of these forms a most interesting branch of the study. The species which prey on animal substances, either living or dead, often possess such habits as may deter some students from attending to them, and yet they fulfil most important purposes in nature, and have furnished the distinguished naturalists, Redi, Swammerdam, Leeuwenhoeck, Réaumur, and De Geer, with highly interesting subjects of research. The history of many of these animals becomes highly interesting, from its relation to our domestic comfort. The house-fly, for instance, is said to breed amongst horse-dung; but that its maggots find food in other substances not hitherto ascertained, is rendered probable by the enormous numbers which are sometimes seen at a distance from places where they could obtain the alleged nutriment, as in Pitcairn's island in the Pacific Ocean *, where there never was a horse. With reference to husbandry, again, the correct history of many insects is perhaps still more important, of which we beg leave to give one striking instance in the case of what is called the turnip-fly (*Haltica Nemorum*, Illiger), which is not a fly, but a small jumping-beetle. "In these circumstances," says Mr. W. Greaves, "I flatter myself will be found the cause of the disease here mentioned: the manure which is taken from the farm-yard, and spread upon the soil already cleared for turnips, is afterwards turned in with the plough; the seed is then put in, and nature does not rest till it is time for hoeing. Now, it must be obvious that manure put into the ground at this season of the year (June) must be full of eggs of flies, which are seen to swarm upon manure heaps in the autumnal season, and there deposit their eggs for future generations in the succeeding years. These eggs are hatched by the heat of

* Beechey's Voyage in the Blossom.

the sun, when the manure is laid upon the ground, or by the warmth of the earth when it is ploughed in, and make their first appearance in the shape of a caterpillar, which may be observed jumping and crawling on the land. The leaves of vegetables are their choicest food, and in turnip land, though they find nothing else, they find plenty of leaf, and on this they feed to the absolute ruin of the root*." But had this writer taken the trouble to confine these dung maggots under a gauze cover till they were hatched, he would have found, instead of the halticæ, some common two-winged flies, which a simple experiment would have convinced him do not eat green leaves of any kind, being incapable thereof for want of eating-organs; and our young naturalists who may wish to try this will be enabled to prove to any farmer, who is in fear of diffusing injurious insects by manure, that no insects bred in dung ever touch a green leaf.

This remark brings us directly back to our subject of instructing the student how to keep such insects as he may find, in order to study their economy. In the case of those just mentioned, which live in dung, in decayed vegetables, or in earth, when they cannot climb upon glass, we have found that open ale-glasses or common tumblers filled with the materials among which they are found, and kept in a due state of moistness, constitute the best apparatus; for even when the animals dig down, their movements can usually be observed through the sides of the glass. In the case of the meal-worm, which lives upon flour, the same expedient answers well, and the whole history of the insect may be read from day to day by simple inspection. We are well aware that it is not common in these collecting days of ours, to take the trouble of breeding any insects besides moths and butterflies; but our design being not to procure spe-

* Treatise on Agriculture.

cimens, but to ascertain facts, we advise the breeding of every insect whose history it is required to investigate.

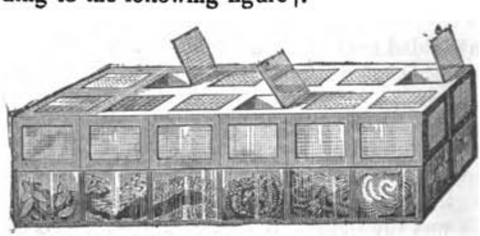
In order to succeed in this object, it will be indispensable to place the insects as much as possible in their natural circumstances. Those who breed moths and butterflies to procure specimens, feed them in boxes, into which a branch of the plant each feeds on is placed in a straight-necked phial of water, to keep it fresh. We have found it preferable to give them fresh leaves twice or thrice a day, for the plants kept in water are apt to scour and kill the insects. When we have been unprovided with boxes, we have used ale-glasses or glass tumblers with success, either turning them bottom upwards, and admitting air round the edges by inserting slips of card, or covering them with gauze at top. Such glasses seem to have been the chief apparatus used by Réaumur, Bonnet, and De Geer, in those researches which are quite unrivalled in our own days. Small pasteboard boxes, like those made for ladies' caps, answer very well when covered with gauze.

The breeding-cage employed by Mr. Stephens he has thus described:—"The length of the box is twenty inches; height twelve; and breadth six; and it is divided into five compartments. Its lower half is constructed entirely of wood, and the upper of coarse gauze, stretched upon wooden or wire frames; each compartment has a separate door, and is, moreover, furnished with a phial in the centre, for the purpose of containing water, in which the food is kept fresh; and is half-filled with a mixture of fine earth and the dust from the inside of rotten trees, the latter article being added for the purpose of rendering the former less binding upon the *pupæ**, as well as

* The French naturalists use fine dry sand. See 'Manuel du Naturaliste Preparateur,'

highly important for the use of such *larvæ* as construct their cocoons of rotten wood. The chief advantages of a breeding-cage of the above description are the occupation of less room than five separate cages, and a diminution of expense, both important considerations when any person is engaged extensively in rearing insects. Whatever be the construction of the box, it is highly necessary that the larvæ be constantly supplied with fresh food, and that the earth at the bottom should be kept damp. To accomplish the latter object, I keep a thick layer of moss upon the surface, which I take out occasionally, perhaps once a week in hot weather, and once a fortnight or three weeks in winter, and saturate completely with water, and return it to its place: this keeps up a sufficient supply of moisture, without allowing the earth to become too wet, which is equally injurious to the pupæ with too much aridity. By numbering the cells, and keeping a register corresponding with the numbers, the history of any particular larvæ or brood may be traced*."

We prefer glass sides to the cells, with gauze doors, opening above, rather than at the sides, according to the following figure†.



Breeding-cage, with gauze doors and glass sides.

Some of the beautiful experiments of Bonnet and Réaumur suggested to us the idea of supplying in-

* Ingpen's 'Instructions,' p. 13. † J.R.

sects with growing food, instead either of gathered leaves or branches kept fresh in water; and we have in several instances, particularly in town, where we could not always procure fresh food for our broods when wanted, kept plants growing in garden-pots, and either confined the insects by means of gauze, or surrounded the pots with water, to prevent their escape. We have since carried this somewhat farther, having procured young plants of forest and orchard-trees and shrubs, and planted them in garden-pots, which are plunged, as the gardeners term it, to defend them from drought, and are ready for any experiment we choose to make. These, besides, have the advantage of attracting into the garden where the pots are plunged the insects peculiar to the several trees; and when we say that the space occupied is only about thirty or forty feet in length, by two in breadth, while none of the trees are suffered to get above two or three feet high, we apprehend that few persons, who have any garden at all, will find such a plantation unsuitable to their convenience, if they are disposed to such pursuits. Herbaceous plants can, for the most part, be procured and planted at any season they may be required, and hence it is not so uecessary to keep any collection of them growing; whereas the transplanting of trees in summer is most likely to kill them*.

This plan has, besides, the peculiar advantage of putting it in our power, by means of sufficiently ample gauze coverings, to make moths, butterflies, and other insects deposit their eggs under our eye on the plants or trees on which they would do so when at liberty,—an interesting part of insect history, which, on account of the difficulties of research, is as yet very imperfectly known.

* J. R.

It would be in vain for us to attempt to enumerate the various plants, trees, and other things on or in which the larvæ or perfect insects should be sought for, as such an enumeration would necessarily be nearly as extensive as the number of known species. A useful little French work, by M. Brez, entitled *Flore des Insectophiles*, was published about forty years ago, containing a systematic list of plants, with the peculiar insects found on each, and though recent discoveries render it very imperfect, it may still be consulted with advantege. But, with all the information we can procure, the remarks of Addison, in the paper we have quoted, still hold true, that "Seas and deserts hide millions of animals from our observation; innumerable artifices and stratagems are acted in the howling wilderness, and in the great deep, that can never come to our knowledge. Besides, that there are infinitely more species of creatures which are not to be seen without, nor indeed with the help of the finest glasses, than of such as are bulky enough for the naked eye to take hold of. However, from the consideration of such animals as lie within the compass of our knowledge, we might easily form a conclusion of the rest, that the same variety of wisdom and goodness runs through the whole creation, and puts every creature in a condition to provide for its safety and subsistence, in its proper season *."

Looking minutely at all the leaves, flowers, and stems of plants and trees, and prying into every corner where insects may lurk, is one means of discovering their haunts,—the only one, indeed, with respect to many species; but collectors are not satisfied with a process so necessarily slow, and take various means for expediting the capture of numbers, rather than observing the natural movements and

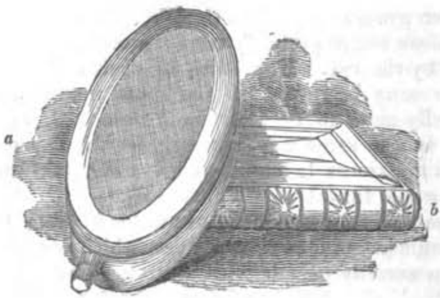
* 'Spectator,' No. 111.

dispositions of a few. We may advantageously adopt these methods when we wish to furnish our cages with live insects, in order to study their economy.

One of the most useful and handy instruments for this purpose is an umbrella. In walking through a meadow, for instance, where the grass is not too short, we may stretch the umbrella, hold the hollow side uppermost, and push it through the grass, when the insects which may be above its level will fall into the trap. In this way we have procured the caterpillars of saw-flies, moths, and butterflies, which feed on grass and on the other herbage in meadows, where we might probably have searched for them in vain by the eye. The sides of drains and ditch-banks may be trailed in the same manner. The butterfly-nets, to be afterwards described, may be used in the same way, and are, we think, superior to the apparatus invented by Mr. Paul, of Starston in Norfolk, for taking the turnip-fly.

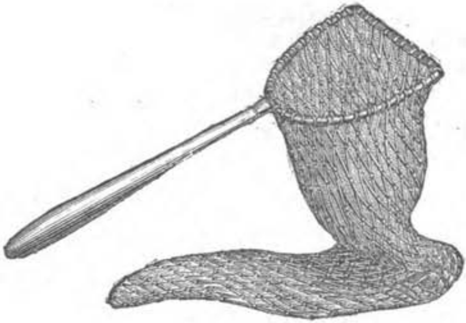
The umbrella is equally useful for holding under the branches of shrubs and trees, which ought to be beaten smartly over it with a strong walking-stick, the shock of the strokes causing the insects to drop down. This, however, will only answer for the smaller and lower branches: when it is required to beat the higher boughs, a long pole must be used, with a sheet or a piece of canvass spread under the tree. The tops of the taller plants may be shaken by the hand over the umbrella.

When insects are thus found, it will be necessary to secure them, in order to take them to the cages uninjured, to be provided with a number of pill-boxes, with pin-holes drilled in them to admit air, and to introduce, particularly along with caterpillars, a bit of the fresh leaf or other substance upon which they have been feeding. We prefer separate, small boxes for such purposes, to the larger larvæ-box in use among collectors; since we can by their means more readily remember the different plants on which several species were found, besides avoiding the risk of one species devouring another,—an incident not uncommon among the caterpillars of moths, as we have recorded in a former page. The collector's larvæ-box is an oblong chip box, such as is used for wafers, with a gauze lid for air, and a hole at one end, furnished with a stopper, for introducing the larvæ.



a, Larvæ-box; and *b*, Pocket collecting box.

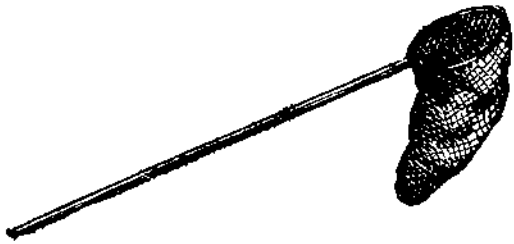
For water-insects a net, similar to a fisher's landing net, is employed, fixing it to a long pole, and raking with it through every piece of water within reach. The net which we have had constructed consists of an interior lining of gauze, as strong as it can be procured, with a strong fish-net on the outside to strengthen this. When canvass is used, the water does not escape through it with sufficient facility. Many interesting water-insects, however, may be procured by mere inspection of water-plants, particularly the under-sides of their leaves, at the edges of ditches, ponds, canals, rivers, and lakes, and when the water is clear, by examining the bottom of the



Water-net.

channel. In consequence of aquatic insects, for the most part, preying upon one another, they are usually very nimble in their movements, so that it requires considerable dexterity and quickness to entrap them. For the same reason a number of phials, containing water, will be as requisite to carry them as pill-boxes to carry the land-insects. But when they are kept in wine or ale-glasses, and supplied with food, they furnish excellent materials for interesting observation. It is easy, indeed, in this way to have several successive generations, and when gnats' eggs are procured the whole history of these curious insects may be traced with little difficulty. When the pupæ are observed to be about to be transformed into winged insects, a gauze covering may be employed to prevent their escape.

Analogous to the water-net in size and construction is the butterfly-net, which is chiefly used on the continent, though seldom, we believe, in this country. It consists of a hoop, about a foot in diameter, of brass or iron wire, jointed or not, so as to fold up into a narrow compass, with a bag-net of gauze or thin muslin, two feet deep, attached to it. This is screwed into a pole about six feet long, for ordinary purposes; but for the purple emperor butterfly (*Apatura Iris*), and other high-flying insects, thirty feet is not too long.

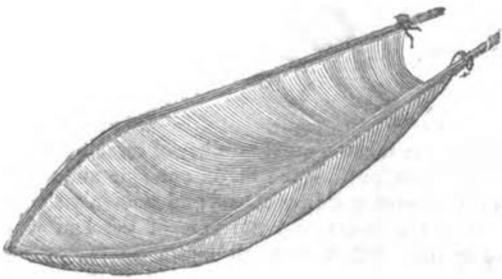


Butterfly net.

The instrument chiefly used for the same purpose in this country is much more unwieldy, though more easily managed by the inexperienced. It is a clap-net*, similar to a bird-catcher's bat-fowling-net, but of slighter materials. The rods of the one which we use are about five feet long, when the three pieces are joined by means of brass ferules. They ought to be made, tapering like a fishing rod, of hazel or any tough wood, with two bent pieces of cane at the end, tightly fitted in so as not to slip when the apparatus is used. The net may be made of fine white muslin, for small insects; but green gauze is best for moths and butterflies, the edges being bound with broad tape all round, so as to form a place for the rods to slip in. When the net is mounted, a rod is held in each hand, and the whole spread out so as

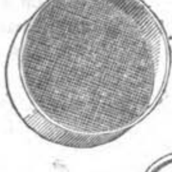
* This and all the other instruments here described are to be procured of Mr. Holmes, 2, Sidney's-alley, Leicester-square.

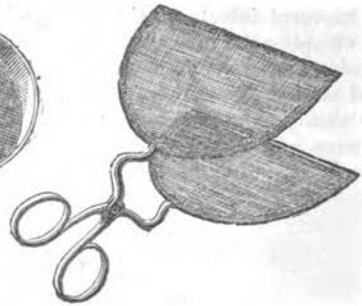
to intercept insects on the wing, which are secured by clapping the rods together. A little practice will render this easy, except when there is much wind, and in that case few insects fly. It is no less useful for throwing over insects when they alight on low flowers, and in this way we have caught some very fine butterflies and moths.



Clap-net.

An instrument still more used by collectors than any of the preceding is the net-forceps, which may be readily constructed out of an old pair of curling-irons, such as have rings for the finger and thumb, binding these with silk or cotton to prevent their hurting the hand. To the blades of these, hoops should be fitted, covered with fine gauze, and made to close accurately when moved like a pair of scissors. It requires some experience and dexterity to catch nimble insects with these; but it is indispensable for a collector to acquire this skill. Without opening them at all, the forceps may be used for securing an insect when alighted on a wall, or other flat surface, by merely covering it; for which purpose some collectors also use a ring-net. We are of opinion, however, that it is more convenient to have few instruments, for multiplicity only serves to embarrass.

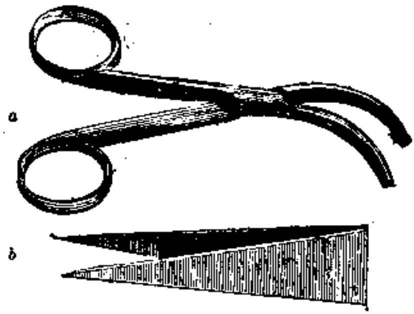




Ring-net. Net-forceps.

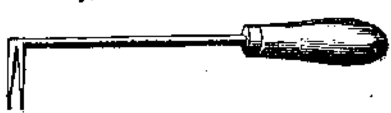
We have taken a great number of insects by means of a pill-box, putting the lid on one side and the bottom on the other side of a leaf, and suddenly shutting in both the insect and the part of the leaf it was sitting on. When a small moth, again, or other insect, is resting on a wall, a pane of glass, or the smooth trunk of a tree, we take off the lid of a pill-box, cover the insect with the bottom part, which we move backwards and forwards till the insect takes refuge from the annoyance at the very bottom, when we cover it as quickly as possible with the lid. This is by far the best way of taking small moths, for their delicate plumage is not injured, as it must inevitably be when they are touched even in the most gentle way.

We purchased last year, in Paris, a pair of insect forceps, which do not seem to be known to our collectors, but which we have found exceedingly useful for taking beetles and other insects out of holes where they cannot be otherwise easily reached. The instrument is made of steel, and resembles a pair of large scissors. In some, the handle-rings are like those of scissors, on a line with the blades; in others, they are at right angles to these. The pliers used by our collectors are much inferior in utility, being too small, short, and slender. The French instrument is farther useful for seizing venomous or dangerous insects. In other cases the fingers alone are often sufficient, and for minute beetles a wetted finger.



a, French beetle-forceps; and *b*, Pliers.

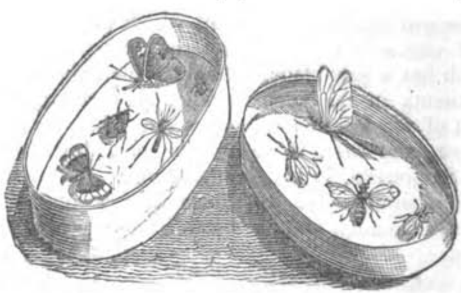
In order to get at beetles and larvæ which feed under the bark, or in the wood of trees, and also under ground, the instrument which we have found most convenient is a very strong clasp-knife: one which has a saw-blade, a hook, a file, and other instruments in the same handle, is preferable; but most of the London collectors use what is called a digger, and first, if we mistake not, described by Mr. Samouelle, in his Compendium. It is made of steel, of from twelve to eighteen inches long, forked at the extremity, and fixed into a wooden handle.



Digger.

In addition to this, we recommend a long slip of very thin and narrow whalebone, which may be introduced into the holes of such insects as burrow in the earth or sand, to direct us in digging down to their nests, the hole being certain to be filled up, and probably lost, without such a contrivance. When a piece of whalebone is not at hand, a long straw will form a good substitute.

When insects are caught merely for the cabinet, and not with reference to their habits and economy, collectors provide themselves with a quill-barrel, sealed at one end with wax, and having a cork stopper at the other, for very minute specimens; with a wide-mouthed phial, containing weak spirits of wine, into which dark-coloured beetles, wasps, and bees, are put, the spirits instantly killing them, and preserving them for future purposes; and with a pocket collecting box or boxes for winged insects. An oblong chip wafer-box, lined at top and bottom with cork, and covered with white paper, will form a very good collecting box, taking care that it is neither too shallow nor too deep; but some have a square



Chip collecting-box, opened.

box, made of mahogany, deal, or cedar, with hinges on one side and a spring on the other, so that it can be opened by the left hand while an insect is held in the right, and figured above (*b*, p. 368). Sparmann, when travelling at the Cape, used to stick his insect specimens on the outside of his hat, to the consternation of the simple Hottentots, who took him for a conjuror. A more judicious plan is for a collector to have the crown of his hat lined inside with cork, which will save him the trouble of carrying a collecting box. When a collector has not his boxes with him, a bit of paper, twisted at each end, will often answer every purpose.

When an insect is caught, before it be placed in the collecting box or the hat-crown, it is necessary to kill it, and this circumstance has given rise to much prejudice, on the charge of cruelty,—the objectors forgetting that most of the insects so killed could not naturally survive many days*, and that their feelings of pain are, in all probability, much less acute than those of animals furnished with a brain, and cerebral and vertebral nerves, of which they are destitute†. Accordingly, a fly without its head will walk about almost as if nothing had happened to it, and a wasp will eat greedily with the head only when it has been separated from the body. We should not like, however, to be considered advocates of any species of cruelty, however slight, and in killing insects for a collection the speediest methods are to be preferred. In the case of butterflies and some moths, as well as other winged insects, a slight pressure upon the breast will instantly kill them, and exposing them to heat is a still more rapid means, plunging those contained in a phial into boiling water, and holding those in pill-boxes near the fire. Suffocating them with sulphur, as some recommend, spoils the colours; and we remarked in the museums of Brussels, Louvain, and Frankfort-on-the-Maine, that all the insects had had their colours injured in this way, the black spots on white butterflies being turned to brown, and the white tinged with yellowish green.

* See Insect Transformations, p. 347, &c. † Ibid. ch. xvii.

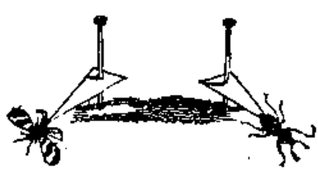
In the case of insects tenacious of life, such as some moths, particularly females which have not deposited their eggs, piercing their breast with a pin dipt in nitric acid will instantly kill them. After killing dragon-flies the intestines must be carefully removed, otherwise the colours will all become black.

To fit insects for a cabinet, they require to be *set*, as it is termed; that is, all their parts must be placed in the manner best fitted to display them. For this purpose each is pierced, when dead, with an insect-

Setting-needles and brush; with the method of setting insects. *a*, Swallow-tailed butterfly (*Papilio machaon*); *b*, Wasp; *c*, Beetle.

pin, a fine slender sort, manufactured on purpose*. Beetles ought to have the pins passed through the shoulder of the right wing-case, and butterflies and other insects through the corslet, on a right line with the head, and a little back from it. While the insect is fresh and flexible, the legs and wings are to be stretched out with a setting-needle, or a large pin bent at the point and fixed into a wooden handle, then stuck upon a board covered with cork and paper, and kept in their proper position by means of pins and braces till they become dry and stiff. The braces are made with slips of fine card, or thick hot-pressed paper, stuck through at one end with a strong pin. When insects have become stiff before being set, they may be rendered flexible again by covering them over for several hours with a damp cloth, which, however, must not be permitted to touch them. A camel-hair pencil is used for brushing off dust. The mode of setting will be best understood from the figures.

When insects are very small, as piercing them with a pin would destroy them, it is usual to gum them on a slip of card or cut wafer, and to arrange this in the cabinet. Minute beetles and flies may thus be preserved, as is shown in the figures.

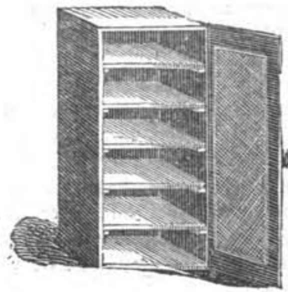


Method of mounting small insects.

The setting-board ought to be kept where there is a

* To be had of Hales, Great Dover-street, Southwark; and of Durnford and Co., Gracechurch-street, London.

free ventilation of air till the set insects are thoroughly dry; but it is necessary that it be also out of the reach of spiders; for we have in several instances had our specimens, while drying, mutilated and destroyed by these prowlers. The most convenient apparatus is an upright box, with grooves, into which the setting-boards may slide, with the door and the side of the box opposite to it covered with gauze.



Setting-board frame.

No other preservative is wanted, after the insects are set and dried, except to keep them from damp, to put a little camphor in the cabinet-drawers to prevent mites, and to take care to prevent them from being destroyed by the larvæ of some small moths and beetles, which the camphor will not do, nor anything else with which we are acquainted. We had once a whole drawer of insects destroyed by mice. Glazing the drawers of a cabinet, and occasional careful inspection, will be indispensable to keep a collection in good condition.

The cabinet may consist of more or fewer drawers, according to the extent of a collection. The most convenient dimensions of the drawers are from a foot to eighteen inches square, and two inches deep; and the best wood is mahogany, cedar, or wainscot, deal being apt to split or warp. The doors ought to have velvet glued round the edges, to keep out dust and small insects. The bottoms of the drawers are lined with sheet cork, about a sixth of an inch in thickness, made uniformly smooth by filing, and having white paper pasted over it.

Where a cabinet has not been procured, collectors make use of store boxes, made on the principle of a backgammon board, each leaf being about two inches deep, and lined with cork and paper. These are convenient, also, for travellers sending home insects from a distance.

The specimens are best arranged in columns from top to bottom of the drawers, with the names attached to each. We are unwilling, amidst the great variety of systems, to recommend any particular one as the best; and prefer leaving our readers to choose for themselves, by giving the outlines of the principal classifications which have been proposed from the earliest times till the present day.

Chapter XV.

SYSTEMATIC ARRANGEMENTS OF INSECTS.

When we consider that the number of known species of British insects alone amounts to more than ten thousand, being about six times more than the species of our plants—that is, six species of insects, on an average, to each species of plant—it will be obvious that, in a collection of specimens, some systematic order of arrangement will be requisite; though, for purposes of out-door study of manners and economy, nice distinctions are less indispensable, as appears from the beautiful and successful researches of Réaumur, Gould, Lyonnet, Bonnet, the Hubers, and other distinguished inquirers, who paid little or no attention to the minutiæ of classification. In consequence, however, of a course diametrically opposite having been pursued by other naturalists of celebrity, we consider it our duty to warn our readers against the error of considering arrangement the sole end and aim of study; whereas the correct view of the matter, as we understand it, is not to neglect or discard system, as was done by Réaumur and Bonnet, but to make it subservient to such details of causes, motives, and effects, as we have endeavoured to exemplify. In every page of these volumes we have accordingly kept systematic distinctions closely, though subordinately, in view. We shall now give a brief sketch of several classifications of insects, invented by celebrated writers, from the earliest times.

THE WING SYSTEM.

The illustrious Aristotle, almost the only genuine naturalist among the ancients, seems to have been the first who distinguished insects by their wings,—a principle followed with greater minuteness, in recent times, by Linnæus and De Geer. Aristotle does not, indeed, put his system in a tabular form; but, for the sake of brevity, we shall draw up a table, founded on indications in his admirable History of Animals.

Aristotle's Classification.

I. Winged Insects *(Pterota,* or *Ptilota).*
  1. With wing-cases—beetles *(Coleoptera).*
  2. With coriaceous wings—grasshoppers *(Pedetica).*
  3. Without jaws—bugs *(Astomata).*
  4. With powdery wings—moths and butterflies *(Psychæ).*
  5. With four transparent wings *(Tetraptera).*
     Without stings, and larger—dragon-flies.
     With stings—bees and wasps *(Opisthocentra).*
  6. With two wings *(Diptera).*
     Without mouth-piercers, and smaller—flies and crane-flies.
     With mouth-piercers—gnats and gad-flies *(Emprosthocentra).*

II. Wingless Insects.
  1. Occasionally acquiring wings:—
     Ants *(Myrmices).*
     Glow-worms *(Pygolampides).*
  2. Without wings *(Aptera).*

Linnæus's Classification.

I. Winged Insects.
  1. *With four wings:—*
     a, Upper wings more or less crustaceous; the under wings membranaceous.

Upper wings quite crustaceous, and not overlapping—beetles *(Coleoptera)*.

Upper wings semi-crustaceous, and over-lapping—bugs and grasshoppers (*Hemiptera*).

b, Upper and under wings of the same texture.

Wings covered with small tiled scales—butterflies and moths *(Lepidoptera)*.

Wings membranaceous and naked.

Without a sting—dragon-flies, &c. *(Neuroptera)*.

With a sting—wasps, bees, &c. *(Hymenoptera)*.

2. *With two wings* :—Flies, gnats, &c. *(Diptera)*.

II. WINGLESS INSECTS *(Aptera)*.

De Geer's Classification.

I. WINGED INSECTS.

1. *Wings four, without wing-cases* :—

a, Wings covered with scales; tongue spiral—butterflies and moths.

b, Wings naked and membranaceous—May-flies and caddis-flies.

c, Wings equal, membranaceous, and netted; the mouth with teeth—dragon-flies and lace-winged flies.

d, Wings unequal; nervures placed lengthwise; mouth with teeth; and the females having a sting or ovipositor—bees, wasps, ants, ichneumons, saw-flies, &c.

e, Wings membranaceous; the tongue bent under the throat—tree-hoppers, &c.

2. *Wings two, covered by two wing-cases* :—

a, Wing-cases partly coriaceous and partly membranaceous, overlapping each other; tongue bent under the throat—bugs, &c.

b. Wing-cases coriaceous, or somewhat crustaceous and wing-like, overlapping; mouth with teeth—locusts, crickets, and grasshoppers.

c, Wing-cases hard and crustaceous, not overlapping, covering the under wings; mouth with teeth—beetles.

3. *Wings two, without wing-cases:*—
   a, Two membranaceous wings, and two poisers behind these; mouth with a tongue, but no teeth—flies, gnats, &c.
   b, Two membranaceous wings in the male, but no poisers, tongue, nor teeth; no wings in the female, but a tongue in the breast—vine-louse, &c.

II. Wingless Insects.

1. *Undergoing transformation:*—
   With six legs, and the mouth having a tongue—fleas.
2. *Undergoing no transformations:*—
   a, With six legs, the head distinct from the trunk—white ants, &c.
   b, With eight or ten legs, and the head not distinct from the trunk—spiders, crabs, &c.
   c, With fourteen or more legs, and the head distinct from the trunk—centipedes, woodlice, &c.

THE LOCALITY SYSTEM.

The next system, in order of time, reckoning from the period of Aristotle, is taken, not from the structure of insects, but the places they frequent. We owe the first sketch of an arrangement on this principle to the great naturalist of Italy, Ulysses Aldrovand, whom it has been the recent fashion to decry as a collector of fables; but whose voluminous works, written in Latin, and never, we believe, translated, must always be consulted with admiration by every genuine inquirer, as a mine of information altogether miraculous as the production of one man.

Aldrovand's Classification.

I. LAND INSECTS (*Terrestria*).
  1. *With feet* (Pedata):—
    a, With wings *(Alata)*.
      Without wing-cases *(Anelytra)*.
      With membranaceous wings *(Membranacea)*.
      Honey-making *(Favifica)*.
      Not honey-making *(Non favifica)*.
      With scaly wings *(Farinosa)*.
      With wing-cases *(Elytrota)*.
    b, Without wings *(Aptera)*.
      With few feet *(Paucipeda)*.
      With many feet *(Multipeda)*.
  2. *Without feet* (Apoda).

II. WATER INSECTS (*Aquatica*).
  1. *With feet* (Pedata):—
    a, With few feet *(Paucipeda)*.
    b, With many feet *(Multipeda)*.
  2. *Without feet* (Apoda).

Vallisnieri's Classification.

I. Plant Insects *(Insetti, che annidano nelle piante e le divorano)*.
II. Water Insects *(Insetti, che nuotano, crescono, vivono, e sempre dimorano ne' soli fluidi)*.
III. Insects inhabiting Earthy or Mineral Substances *(Insetti, che si trovano dentro i marmi, sassi, crete, ossa, e conchiglie)*.
IV. Insects inhabiting Living Animals *(Insetti, che fanno dentro, o sopra i viventi*)*.

Fabricius's Geographical Classification.

This celebrated systematic writer divides the globe into eight insect climates:—

1. Indian.	5. Northern.
2. Egyptian.	6. Oriental.
3. Southern.	7. Occidental.
4. Mediterranean.	8. Alpine.

* Esperienze ed Osservazioni, p. 42, 43; 4to., Padova, 1726.

Latreille's Geographical Classification.

This celebrated French systematist has written a curious and ingenious paper on the Geography of Insects, as a companion to Humboldt's famous Geography of Plants. He divides the globe into twelve insect zones or climates, thus:—

I. Arctic, all North of the Equator.

1. Polar.
2. Sub-polar.
3. Superior.
4. Intermediate.
5. Supra-tropical.
6. Tropical.
7. Equatorial.

II. Antarctic, all South of the Equator.

1. Equatorial.
2. Tropical.
3. Supra-tropical.
4. Intermediate.
5. Superior.

Connected with this subject is the doctrine of *Representation* and *Replacement*, by which it is maintained, that when a particular species of insect, or other animal, is not found in two several countries or districts, such as Britain and New England, it is represented or replaced by some species resembling it in form and in function. Taking a more popular example than insects furnish, it is held, according to this system, that the puma of America *replaces* the lion of Africa, or that the pecari *represents* in Mexico the hog of Europe.

THE TRANSFORMATION SYSTEM.

By consulting our previous volume on Insect Transformations, it may be seen that there are considerable differences in this circumstance among various species. These, the illustrious Swammerdam, whose accurate observations are now as valuable as when they were made nearly two centuries ago, has made the basis of his system.

Swammerdam's Classification.

I. Transformations immediate, the insects being hatched perfectly formed—fleas, spiders, &c.

II. Transformations taking place under a covering*—locusts, crickets, bugs, dragon-flies, May-flies, &c.

III. Transformations with a pupa-case intermediate*—beetles, bees, wasps, saw-flies, gnats, &c.
Transformations in the pupa state obtected—moths and butterflies.

IV. Transformations in the pupa state—coarctate, ichneumons, flies, &c.

Ray and Willughby's Classification.

I. INSECTS UNDERGOING NO TRANSFORMATIONS (Ἀμεταμόρφωτα).

1. *Without feet* (Ἄποδα):—
   a, Land Insects, including worms, &c. (*Terrestria*).
   b, Water Insects, including Leeches, &c. (*Aquatica*).
2. *With feet* (Pedata):—
   a, With six feet (*Hexapoda*).
   Land Insects (*Terrestria*).
   Larger, including lignivorous larvæ (*Majora*).
   Less, including lice and springtails (*Minora*).
   Water Insects, including the river shrimp (*Aquatica*).
   b, With eight feet (*Octopoda*).
   With tails—scorpions (*Caudata*).
   Without tails—spiders, mites (*Non caudata*).
   c, With fourteen feet—woodlice (Τεσσαρεσκαιδεκάποδα).

* In explaining Swammerdam's system, Kirby and Spence use the terms of "complete" and "incomplete," which are not in the original.

d, With twenty-four feet.
e, With thirty feet.
f, With many feet (Πολυποδα).
Land Insects *(Terrestria)*.
With a roundish body—millepedes *(Tereti seu subrotundi)*.
With a flat or compressed body—centipedes *(Plano seu compressa)*.
Water Insects *(Aquatica)*.
With a round body *(Corpore tereti)*.
With a flat body *(Corpore plano)*.
With a double tail *(Bicaudatum)*.

II. Insects undergoing Transformations, (Μεταμορφεμενα),

1. *Transformations instantaneous* (Transmutatio instantanea):—
a, Lace-winged flies *(Libellæ* seu *Perlæ)*, &c.
b, Wild bugs *(Cimices sylvestres)*.
c, Locusts and mantes *(Locustæ)*.
d, Field-crickets *(Grylli campestres)*.
e, Hearth-crickets *(Grylli domestici)*.
f, Mole-cricket *(Gryllo talpa)*.
g, Tree-hoppers *(Cicadæ)*.
h, Cock-roaches *(Blattæ)*.
i, Crane-flies *(Tipulæ)*.
k, Water-scorpion *(Scorpius aquaticus)*.
l, Water-flies *(Muscæ aquaticæ)*.
m, May-flies *(Hemerobii)*.
n, Ear-wigs *(Forficula* seu *Auricularia)*.

2. *Transformations two-fold* (Metamorphosis duplex):—
a, With wing-cases—beetles (Κολεόπτερα seu *Vagini pennia)*.
b, Without wing-cases (Ἀνέλυτρα).
With mealy wings—butterflies and moths *(Alis farinaceis)*.
With membranaceous wings—bees, flies *(Alis membranaceis)*.
With two wings (Διπτερα).

With four wings (Τετραπτερα).
Gregarious *(Gregaria)*.
Making honey—bees, &c. *(Mellifica)*.
Not making honey *(Non mellifica)*.
Solitary *(Solitaria)*.
Bee-formed *(Apiformia)*.
Wasp-formed *(Vespiformia)*.
Butterfly-formed *(Papilioniformia)*.
With an ovipositor *(Seticaudæ* seu *Tripilia)*.

THE CIBARIAN, MAXILLARY, OR MOUTH SYSTEM.

Fabricius, a Danish systematic writer of high celebrity, emulous of the fame of Linnæus, conceived the idea of classifying insects according to the structure of their mouths, or their feeding organs (*Instrumenta cibaria*).

Fabricius's Classification.

A.

1. With the lower jaws naked, free, and carrying palpi—beetles *(Eleutherata)*.
2. With the lower jaws covered by an obtuse shield or lobe—locusts, crickets, &c. *(Ulonata)*.
3. With the lower jaws jointed at the base, and joined with the lip—lace-wing flies, &c. *(Synistata)*.
4. With the lower jaws horny, compressed, and often elongated—bees, wasps, &c. *(Piezata.)*
5. With the lower jaws horny, toothed, and having two palpi—dragon-flies, &c. *(Opontata)*.
6. With the lower jaws horny, vaulted, and no palpi—centipedes, wood-lice, &c. *(Mitosata)*.

B.

7. With the lower jaws horny, and armed with a claw—spiders, &c. *(Unogata)*.

C.

8. With many jaws within the lip, the palpi mostly six *(Polygonata)*.

9. With many jaws, without the lip closing the mouth, *(Kleistagnatha)*.
10. With many jaws without the lip, covered by palpi, *(Exochnata)*.

D.

11. Mouth with a spiral tongue, between reflected palpi—butterflies and moths *(Glossata)*.
12. Mouth with a rostrum and a jointed sheath—bugs, &c. *(Ryngota)*.
13. Mouth with a sucker without joints—flies, &c. *(Antliata)*.

Cuvier's Classification.

I. INSECTS WITH JAWS.

1. Without wings—crabs, spiders *(Gnathoptera)*.
2. With four equal wings—dragon-flies, &c. *(Neuroptera)*.
3. With four unequal wings—bees, wasps *(Hymenoptera)*.
4. With wing-cases—beetles *(Coleoptera)*.
5. With four straight wings—crickets, &c. *(Orthoptera)*.

II. INSECTS WITHOUT JAWS.

1. With upper wings of unequal consistence—bugs, &c. *(Hemiptera)*.
2. With powdery wings—butterflies and moths *(Lepidoptera)*.
3. With two wings—flies, &c. *(Diptera)*.
4. Without wings—fleas, mites, &c. *(Aptera)*.

Lamarck's Classification.

I. INSECTS WITH JAWS.

1. With wing-cases—beetles *(Coleoptera)*.
2. With straight-wings—crickets, &c. *(Orthoptera)*.
3. With four equal wings—dragon-flies *(Neuroptera)*.

II. INSECTS WITH JAWS AND A SORT OF SUCKER.

4. With four unequal wings—bees, &c. *(Hymenoptera)*.

III. INSECTS WITH NO JAWS, BUT HAVING A SUCKER.
5. With powdery wings—moths, &c. *(Lepidoptera)*.
6. With upper wings of unequal consistence—bugs, &c. *(Hemiptera)*.
7. With two wings—flies, &c. *(Diptera)*.
8. Without wings *(Aptera)*.

THE OVARY, OR EGG SYSTEM.

IT has been recently proposed to arrange all animals according to the structure, &c. of their eggs (*ova*); and, in accordance with this principle, an ingenious arrangement has been constructed by a venerable and enthusiastic inquirer, from which we shall give what relates to certain insects forming the eighth class.

Sir Everard Home's Classification.

METAMORPHOGENOA,

Having the embryo produced from an egg which is formed in the ovarium, subjected to transformation, and breathing by air-tubes (*spiracula*); heart wanting; blood white.

1. The embryo developed from eggs attached under the tail. Lobster *(Cancer)*.
2. The embryo developed from eggs carried upon the anterior feet. Spider *(Aranea)*.
3. The embryo developed from eggs deposited under the cuticle of the skin or stomach. Gadfly *(Œstrus)*.
4. Embryos developed from eggs for several generations, impregnated at the same time. Plant-louse *(Aphis)*.
5. Embryos, produced from eggs of one mother, that compose the whole republic. Bee *(Apis)*.
6. Embryos from eggs deposited under water. The water-moth *(Phryganea)*.

THE ECLECTIC, OR MODERN SYSTEM.

M. Clairville appears to have first conceived the idea of uniting the principles of several of the preceding systems, an idea which has been followed up by Latreille, Dr. Leach, and Mr. Stephens.

Clairville's Classification.

I. Winged Insects *(Pterophora)*.
  1. *With jaws* (Mandibulata):—
    a, With wing-cases *(Elytroptera)*.
    b, With coriaceous wings *(Deratoptera)*.
    c, With netted wings *(Dictyoptera)*.
    d, With veined wings *(Phleboptera)*.
  2. *With suckers* (Haustellata):—
    a, Wings with poisers *(Halteriptera)*.
    b, Wings powdery *(Lepidoptera)*.
    c, Wings partly opaque and partly translucent *(Hemimeroptera)*.

II. Wingless Insects *(Aptera)*.
  1. With a sucker *(Haustellata)*.
    With a sharp sucker *(Rophoptera)*.
  2. With jaws *(Mandibulata)*.
    With legs formed for running *(Pododunera)*.

*Latreille's Classification**.

I. Insects with more than Six Feet, and without Wings *(Myriapoda)*.
  1. *With many jaws*—wood-lice *(Chilognatha)*.
  2. *With many feet*—millepedes *(Chilopoda)*.

II. Insects with Six Feet.
  Without wings:—
    a, With organs of motion like feet *(Thysanura)*.
    b, Mouth with a retractile sucker *(Parasita)*.
    c, External mouth with a jointed tube enclosing a sucker *(Suctoria)*.
  With four wings:—
    A, Upper wings crustaceous or coriaceous, at least at the base.
    a, With the under wings folded crosswise—bee-

* Règne Animal, 8vo, Paris, 1829.

tles *(Coleoptera)*. 1. Pentamera; 2. Heteromera; 3. Tetramera; 4. Trimera.

b, With the under wings folded lengthwise *(Orthoptera)*.

Legs formed for running *(Cursoria)*.

Legs formed for leaping *(Saltatoria)*.

c, With a sucker enclosing several bristles *(Hemiptera)*. 1. Heteroptera; 2. Homoptera.

B, Upper wings membranaceous.

a, Wings naked and netted *(Neuroptera)*. 1. Subulicornes; 2. Planipennes; 3. Plicipennes.

b, Wings naked and veined *(Hymenoptera)*. 1. Terebrantia; 2. Aculeata.

c, Wings with dust-like scales *(Lepidoptera)*. 1. Diurna; 2. Crepuscularia; 3. Nocturna.

With two twisted elytra and two wings (*Rhipiptera*).

1. Xenos; 2. Stylops.

With two wings (*Diptera*).

Leach's Classification.

I. Insects undergoing no Transformation (*Ametabolia*).

1. With bristles at the tail *(Thysanura)*.
2. With no bristles at the tail *(Anoplura)*.

II. Insects undergoing Transformation (*Metabolia*).

1. With two wings folded crosswise, and covered with hard wing-cases *(Coleoptera)*.
2. With two wings folded lengthwise and crosswise, and short and softer wing-cases (*Dermaptera*).
3. With two wings folded lengthwise, and wing cases overlapping each other at the edges *(Orthoptera)*.
4. With two wings twice folded lengthwise, and wing-cases obliquely overlapping; mouth with jaws, *(Dictyoptera)*.
5. With two wings, and overlapping wing-cases, having the apex membranaceous *(Hemiptera)*.
6. With two wings, and coriaceous or membranaceous wing-cases *(Omoptera)*.
7. With no wings nor wing-cases *(Aptera)*.

8. With four wings covered with meal-like scales *(Lepidoptera)*.
9. With four membranaceous wings, the wing-bones hairy *(Trichoptera)*.
10. With four nearly equal membranaceous reticulated wings *(Neuroptera)*.
11. With four unequal membranaceous wings, the wing-bones running lengthwise *(Hymenoptera)*.
12. With two wings folded lengthwise *(Rhipiptera)*.
13. With two wings not folded; mouth formed for sucking—flies *(Diptera)*.
14. With two or with no wings; mouth with long jaws—bird-flies, bat-flies *(Omaloptera)*.

Stephens's Classification.

I. INSECTS WITH MANDIBLES *(Mandibulata)*.

1. With hard wing-cases *(Coleoptera)*.
   - *a*, Voracious *(Adephaga)*.
     - Ground feeders *(Geodephaga)*.
     - Water feeders *(Hydrodephaga)*.
   - *b*, Cleansers *(Rypophaga)*.
     - Haunting water *(Philhydrida)*.
     - Feeding on carrion, or putrid wood *(Necrophaga)*.
     - With short wing-cases *(Brachelytra)*.
   - *c*, Chilognathiform larvæ.
     - With clavate sublaminate antennæ *(Helocera)*.
     - With laminate antennæ *(Lamellicornes)*.
     - With filiform antennæ *(Sternoxi)*.
     - With setaceous or abruptly clavate antennæ.
   - *d*, Vermiform larvæ.
     - With a rostrum *(Rhinchophora)*.
     - Without a rostrum *(Longicornes)*.
   - *e*, Anopluriform ? larvæ.
     - Tarsi tetramerous.
     - Body elongate *(Eupoda)*.
     - Body ovoid or oval *(Cyclica)*.
     - Tarsi trimerous *(Trimeri)*.
   - *f*, Heteromerous beetles *(Heteromera)*.
2. With short and somewhat crustaceous wing-cases—earwigs *(Dermaptera)*.
3. With coriaceous wing-cases *(Orthoptera)*.
4. With netted wings *(Neuroptera)*.

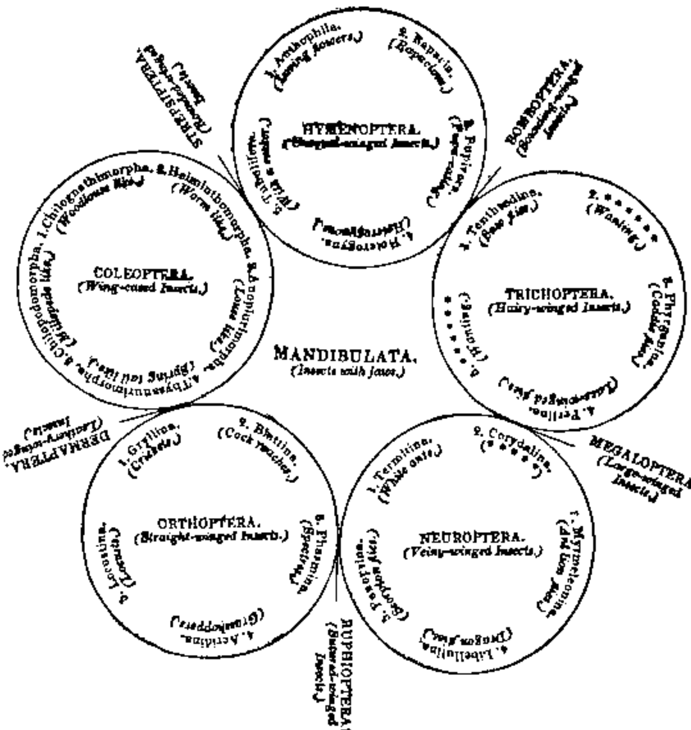
a, Scorpion-flies *(Panorpina)*.
b, Day-flies *(Anisoptera)*.
c, Dragon-flies *(Libellulina)*.
d, White-ants *(Termitina)*.
e, With large wings *(Megaloptera)*.
5. With four hairy wings *(Trichoptera)*.
6. With four unequal wings *(Hymenoptera)*.
a, Borers, *(Terebrantia)*.
b, ——— wasps, bees, ants, &c.
c, ——— ruby tails, &c.
7. ——— stylops *(Strepsiptera)*.

II. INSECTS WITH SUCKERS *(Haustellata)*.
1. With powdery wings *(Lepidoptera)*.
a, Butterflies appearing by day *(Diurna)*.
b, Moths appearing at twilight *(Crepuscularia)*.
c, Moths appearing in the afternoon *(Pomeridiana)*.
d, Moths appearing at night *(Nocturna)*.
e, Moths appearing partly by day *(Semidiurna)*.
f, Moths appearing in the evening *(Vespertina)*.
2. With two wings *(Diptera.)*
3. With elonged jaws and two wings, or none *(Homaloptera)*.
4. With wings not perceptible—fleas *(Aphaniptera)*.
5. Without wings *(Aptera)*.
6. With two wings and overlapping wing-cases *(Hemiptera)*.
a, Land insects *(Terrestria)*.
b, Water insects *(Aquatica)*.
7. With two wings and wing-cases not overlapping each other *(Homoptera)*.

THE QUINARY SYSTEM.

Mr. W. S. MACLEAY, the author of this system, proposes to arrange insects in circular groups of fives, so as to place those which have the nearest resemblance, or (as he terms it) *affinity*, contiguous to one another in their several circles. We shall here give from the Horæ Entomologicæ his arrangement of Clairville's *Mandibulata*, with translations, &c., of his terms.

MacLeay's Classification.



Insects have also been divided according to the condition of their food; but the arrangements on this principle have not, as far as we know, been perfected.

I. INSECTS FEEDING ON LIVING SUBSTANCES (*Thalerophaga*).
   1. Feeding on living flesh (*Carnivora*).
      a, Feeding on aphides (*Aphidivora*).
   2. Feeding on growing vegetables (*Phytophaga*).
      a, Feeding on grain and seeds (*Granivora*).
      b, Feeding on fungi (*Fungivora*).

II. INSECTS FEEDING ON DEAD SUBSTANCES (*Saprophaga*).
   1. Feeding on dead wood (*Lignivora*).
   2. Feeding on dung (*Coprophaga*).
   3. Feeding on dead animals (*Necrophaga*).

ILLUSTRATIONS.

2 M

GENERAL INDEX

TO

INSECT ARCHITECTURE, INSECT TRANSFORMATIONS, AND INSECT MISCELLANIES.

The references to the above volumes are distinguished by the letters *A.*, *T.*, and *M.*, preceding the folio of the page referred to.

FINIS.

W. Clowes, Stamford Street.

15