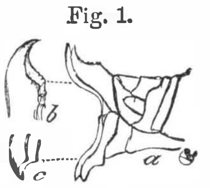
important and practical one; and as assisting to a decisive answer, I have carried on a series of experiments which will be presently detailed. To make the experiments the more intelligible, I will first give the reader a deeper insight into the philosophy of the processes of egg-laying and of hatching than I have hitherto done, and this the more readily that it has never been given by any other author.

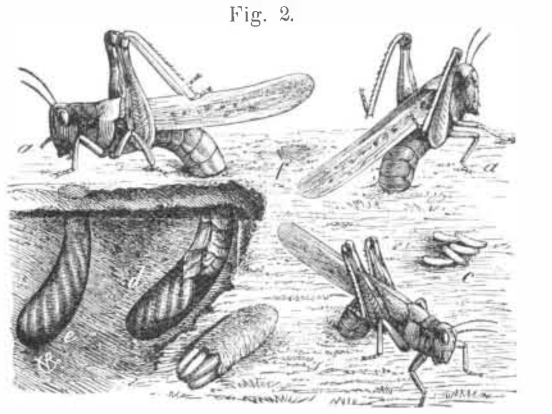
I have already explained (Report VII, page 122) how, by means of the horny valves at the end of her abdomen (Fig. 1), the female drills a cylindrical hole in the ground in which to consign her eggs. The curved abdomen stretches to its utmost for this purpose, and the hole is generally a little curved and is always more or less oblique. (Fig. 2, *e d*.) If we could manage to watch a female during the arduous work of ovipositing, we should find that, when the hole is once drilled, there commences to exude at the dorsal end of the abdomen, from

Fig. 1.



ROCKY MOUNTAIN LOCUST: Anal character of female, showing horny valves.

Fig. 2.



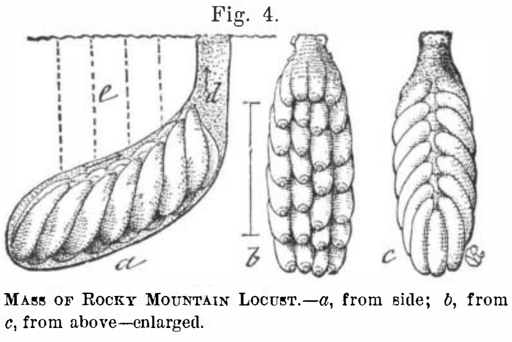
ROCKY MOUNTAIN LOCUST.—*a, a, a*, female laying; *b*, egg-pod partly broken; *c*, loose eggs; *d*, burrow showing oviposition; *e*, completed pod; *f*, covering to one.

a pair of sponge-like exsertile organs (Fig. 3, *h*) that are normally retracted and hidden beneath the super-anal plate near the cerci (Fig. 3, *i*), a frothy mucous matter, which fills up the bottom of the hole. Then, with the two pairs of valves brought close together, an egg would be seen to slip down the oviduct (*j*) along the ventral end of the abdomen, and, guided by a little, finger like style (*g*), pass in between the horny valves (which are admirably constructed, not only for drilling, but for holding and conducting the egg to its appropriate place), and issue at their tips amid the mucous fluid already spoken of. Then follows a period of convulsions, during which more mucous material is elaborated, until the whole end of the body is bathed in it—when another egg passes down and is placed in position. These alternate processes continue until the full complement of eggs are in place, the number ranging from 20 to 35, but averaging about 28. The mucous matter binds all the eggs in a mass, and when the last is laid, the mother devotes some time to filling up the somewhat narrower neck of the burrow with a compact and cellulose mass of the some material, which, though light and easily penetrated, is more or less impervious to water, and forms a very excellent protection. (Fig. 4, *d*.)

Fig. 3.

OVIPOSITION OF THE ROCKY MOUNTAIN LOCUST.

Fig. 4.

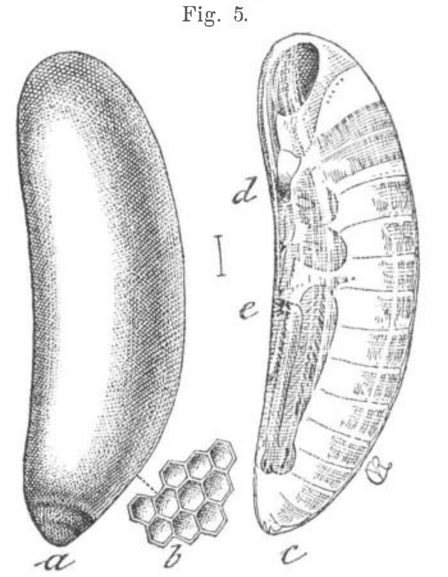


EGG MASS OF ROCKY MOUNTAIN LOCUST.—*a*, from side; *b*, from beneath; *c*, from above—enlarged.

PHILOSOPHY OF THE EGG MASS.

To the casual observer the eggs of our locust appear to be thrust indiscriminately in the hole made for their reception. A more careful study of the egg mass or egg pod will show, however, that the female took great pains to arrange them, not only so as to economize as much space as possible consistent with the form of each egg, but so as to best facilitate the escape of the young locust; for as the bottom eggs were the first laid, and are generally the first to hatch, their issue would, in their efforts to escape, disturb and injure the other eggs, were there no provision against such a possibility. The eggs are, indeed, most carefully placed side by side in four rows, each row generally containing seven. They oblique a little crosswise of the cylinder. (Fig. 4, *a*.) The posterior or narrow end which issues first from the oviduct is thickened and generally shows two pale rings around the darker tip (Fig. 5, *a*). This is pushed close against the bottom of the burrow, which, being cylindrical, does not permit the outer or two side rows to be pushed quite as far down as the two inner ones; and for the very same reason the upper or head ends of the outer rows are necessarily bent to the same extent over the inner rows—the eggs when laid being somewhat soft and plastic. There is, consequently, an

Fig. 5.



EGG OF ROCKY MOUNTAIN LOCUST.—*a*, sculpture of outer shell; *b*, same more enlarged; *c*, with the outer shell removed, just before hatching; *d e*, points where the shell is ruptured.

irregular channel along the top of the mass (Fig. 4, *c*) which is filled only with the same frothy matter which surrounds each egg, and occupies all the space in the burrow not occupied by the eggs. The whole plan is seen at once by a reference to Fig. 4, which represents, enlarged, a side view of the mass within the burrow (*a*) and a bottom (*b*) and top (*c*) view of the same, with the earth which adheres to it removed.

HOW THE YOUNG LOCUST ESCAPES FROM THE EGG.

Carefully examined, the egg shell is found to consist of two layers. The outer layer, which is thin, semi-opaque, and gives the pale cream-yellow color, is seen, by aid of a high magnifying power, to be densely, minutely, and shallowly pitted; or, to use still more exact language, the whole surface is netted with minute and more or less irregular, hexagonal ridges (Fig. 5, *a*, *b*). The inner layer is thicker, of a deeper yellow, and perfectly smooth. It is also translucent, so that, as the hatching period approaches, the form and members of the embryon may be distinctly discerned through it. The outer covering is more easily ruptured and is rendered all the more fragile by freezing; but the inner covering is so very tough that a very strong pressure between one's thumb and finger is required to burst it. How, then, will the embryon, which fills it so completely that there is scarcely room for motion, succeed in escaping from such a prison? The rigid shell of the bird's egg is easily cracked by the beak of its tenant; the hatching caterpillar, curled within its egg shell, has room enough to move its jaws and eat its way out; the egg coverings of many insects are so delicate and frail that the mere swelling of the embryon affords means of escape; those of others so constructed that a door flies open or a lid lifts up by a spring, whenever pressure is brought to bear; in some, two halves open, as in the shell of a muscle; whilst in a host of others the embryon is furnished with a special structure, called the egg burster, the office of which is to cut or rupture the shell, and thus liberate its occupant. But our young locust is deprived of all such contrivances, and must use another mode of exit from its tough and subelastic prison. Nature accomplishes the same end in many different ways. She is rich in contrivances. Every one who has been troubled by it must have noticed that the shanks (tibiæ) of our locust, as of all the members of its family, are armed with spines. On the four anterior legs these spines are inside the shank; on the long, posterior legs, outside. The spines of the hind shanks are strongest, and the terminal ones, on all legs, stronger than the rest. There can be no doubt that these spines serve to give a firm hold to the insect in walking or jumping; but they have first served a more important pre-natal purpose.

When fully formed, the embryon is seen to lie within its shell, as at Fig. 5, *c*. The antennæ curve over the face and between the jaws, which are early developed, and with their sharp black teeth, reach on to the breast. The legs are folded up on the breast, the strong terminal hooks on the hind shanks reaching toward the mesosternum.

Now, the hatching consists of a series of undulating contractions and expansions of the several joints of the body, and with this motion there is slight but constant friction of the tips of the jaws and of the sharp tips of the tibial spines, as also of the tarsal claws of all the legs, against the shell, which eventually weakens between the points *d* and *e*, and finally gives way there. It then easily splits to the eyes or beyond, by the swelling of the head. By the same undulating movements the nascent larva soon works itself entirely out of the egg, when it easily makes its way along the channel already described without in the least interfering with the other eggs, and finally forces a passage way up through the mucous filling in the neck of the burrow. (Fig. 4, *d*.) Once fully escaped from the soil, it rests from its exertions, but for a short time only. Its task is by no means complete: before it can feed or move with alacrity, it must molt a pellicle which completely incases every part of the body. This it does in the course of three or four minutes, or even less, by a continuance of the same contracting and expanding movements which freed it from the earth, and which now burst the skin on the back of the head. The body is then gradually worked from its delicate covering until the last of the hind legs is free, and the exuvium remains, generally near the point where the animal issued from the ground, as a little, white, crumpled pellet. Pale and colorless at first, the full-born insect assumes its dark gray coloring in the course of half an hour. From this account of the hatching process, we can readily understand why the female in ovipositing prefers compact or hard soil to that which is loose. The harder and less yielding the walls of the burrow, the easier will the young locust crowd its way out.

The covering which envelops the little animal when first it issues from the shell, though quite delicate, undoubtedly affords protection in the struggles of birth from the burrow; and it is an interesting fact that, while it is shed within a few minutes of the time when the animal reaches the free air, it is seldom shed if, from one cause or other, there is failure to escape from the soil, though the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the young animal possesses great forcing and pushing power, and, if the soil be not too compact, will frequently force a direct passage through the same to the surface, as indicated at the dotted lines, Fig. 4, *e*. But it can make little or no headway, except through the appropriate channel (*d*), where the soil is at all compressed. While crowding its way out, the antennæ and four front legs are held in much the same position as within the egg, the hind legs being generally stretched. But the members bend in every conceivable way, and where several are endeavoring to work through any particular passage, the amount of squeezing and crowding they will endure is remarkable. Yet if, by chance, the protecting pellicle is worked off before issuing from the ground, the animal loses all power of further forcing its way out.

THE BRITISH IRONCLAD ALEXANDRA.

On page 258, we present a fine sectional view of a vessel that is now one of the strongest in the English navy. Judging by the past history of ironclad ships, in a very few years hence the Alexandra will be deemed weak, or else withdrawn from service altogether, adding another to the long list of armored vessels which have been set aside as useless because of the progress made in the construction of artillery capable of perforating their plates. Even now the heavy Krupp guns and the 100-ton English cannon not only pierce 12-inch iron plating, which is the thickest carried by the Alexandra, but send their bolts through two plates of that thickness separated by 9 inches of solid oak. It will be seen, therefore, that against such weapons the sides of the Alexandra offer little resistance, and that the ship before such artillery is practically as vulnerable as a wooden frigate. Nor are there any vessels now afloat which can oppose the shot of the 100-ton gun successfully. The Inflexible, now the most powerful of British ironclads, has 24 inches of plating, and the Dandolo and Duilio, new Italian ironclads, nearly the same; yet the recent trials of the great cannon above mentioned, at Spezzia, show that targets representing sections of these vessels were quickly destroyed. The ironclad of the near future must carry either the 40-inch plates which Sheffield makers have promised to roll, or else be incased in steel; for steel armor, it now appears, has offered the best resistance to the shot of the 100-ton gun. The thickest armor of the Alexandra, the belt at her water line, is the 12-inch plating referred to. About her batteries the iron is only 8 and 5 inches thick, so that the men at the guns and the guns themselves are virtually unprotected against shot from modern artillery of even moderate weight.

Though laboring under a great disadvantage in point of vulnerability, the Alexandra embodies some of the newest and most important improvements in naval construction. She is a central battery ship, and is able to train four guns, including the two heaviest of her armament of twelve, straight ahead and two straight astern. This capability is of the greatest moment, since the vessel thus has a range of fire around the entire horizon.

The section of the ship given in our engraving is taken through the battery, showing the two gun decks. The sills of the ports of the lower deck are 9 feet, and those of the upper deck ports 17 feet above the water. The guns are of the Fraser pattern, and are constructed of steel tubes surrounded by coils of wrought iron increasing in number and thickness toward the breech. There are two 25-ton and ten 18-ton guns. The Alexandra is an ocean-going cruiser, and is now flagship of the British Mediterranean squadron. Her dimensions, etc., are as follows: Length between perpendiculars, 225 feet; extreme breadth, 63 feet 8 inches; depth of hold, 18 feet 7⅝ inches; tonnage, 6,049; displacement, 9,492 tons; draught forward, 26 feet; indicated horse power, 8,000; speed per measured mile, 16 knots.

A MARBLE statue of Sir William Fairbairn has now been completed. The statue, which is to stand in the new Town Hall, Manchester, England, is eight feet high, and represents Sir William standing with papers in his hand as if delivering an address to a scientific audience; the head is bare and slightly inclined, and the statue is an admirable likeness, in the features as well as in the thoughtful expression and quiet energy characteristic of the man.

STATISTICS show that about 250,000 barrels of apples were exported from America last year to Europe. More than half this quantity was sent to England, and about 11,000 barrels went to St. Petersburgh.