MECHANISM OF THE OVIPOSITOR DRILL.

BY S. FRANK AARON.

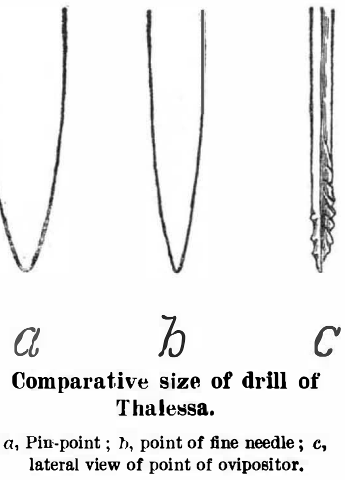
Hamilton Gibson called the wood-piercing ovipositor of the great ichneumon fly (*Thalessa*) "the most wonderful drill in the world." Probably, considering the length of the drill, the mechanism of the cutting points, and the fact that Nature has developed this tool out of animal matter, the artist naturalist's appellation is merited. Knowing what this tiny drill is able to perform, and comparing these performances with the power behind the drill, naturally adds to our interest in determining the character of the instrument. We may also compare the ovipositors of other closely-related species, the hornflies of the genera *Urocerus* and *Tremex*. Of these, the well-known pigeon tremex is the most available for study.

The writer has observed the *Tremex* laying her eggs in a dead apple tree, near the butt of the tree and through the thin bark into the hard, solid wood. In a period of less than two minutes the ovipositor cut its way over half an inch into the wood. It was at once apparent, in watching the progress of the drill and the insect controlling it, that it was not a thrusting force that continually worked the drill. The insect stood widely astride of the spot, and the ovipositor, drawn out of its long sheath, was almost at right angles to the abdomen. The thorax of the *Tremex* moved very slightly from side to side, giving to the abdomen a somewhat twisting motion, and there was a slight downward motion also, evidently in the endeavor to keep the point at work.

Some idea as to the manner in which the boring is done may be gained from an examination of the boring itself in longitudinal section, a piece of the wood having been carefully cut from the tree where the insect's ovipositor is withdrawn. The hole in the wood is exceedingly straight and smooth, with indications of lengthwise cutting marks. Upon capturing the specimen also it will be found that the ovipositor is very much smaller than the boring, possibly not more than one-half its diameter.

It is very obvious that no matter how keen and hard the ovipositor might be, if it were merely thrust into the wood, no material of the kind could be trusted not to bend or break, and even were this not the case, the insect, though stout and active, could not exert a thousandth part of the force needed. It is apparent then that the drill must make its way into the wood by some special mechanism, fitted for cutting the way clearly, and upon examination we find that this is the case. In a construction of this character Nature seems to have rejected the tube, both in the insect's drilling ovipositor and the piercing and sucking proboscis of the flies, so that not only is the protecting sheath in two pieces for its full length, but the harder drill itself is made up of four parts. This allows of greater flexibility and naturally, therefore, in the work it has to do, of greater strength.

The ovipositor of a *Tremex* consists of two outer sheaths, somewhat similar in character to the protecting sheath in which it is carried when not in use, and a central shaft in two parts. The whole is as slender as a horsehair. At the end of this lance the outer sheaths are broadened or swelled, with file-like ridges, and then brought to a point, and within this enlarged end moves the central lance, also toothed, file-like, and bluntly pointed somewhat like the tooth of a saw. When this instrument is at work the sheaths are sufficiently divided at the end, to permit the teeth of the lance to protrude. This latter instrument is worked back and forth, and the small teeth cut away the wood at the bottom of the hole, much as a jig-saw does through the thickness of a board, the ovipositor having the much more difficult task, as it must get rid of its rapidly accumulating sawdust. This dust works its way to the surface, impelled by



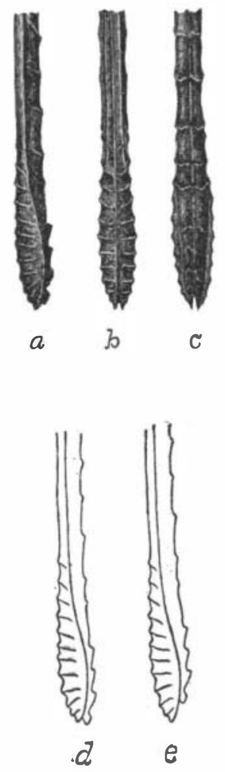
Comparative size of drill of Thalessa.

a, Pin-point; *b*, point of fine needle; *c*, lateral view of point of ovipositor.

Longitudinal section of boring of Tremex.

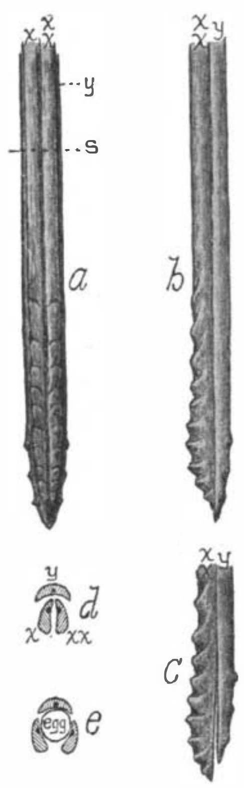
Depth, ¼ inch; diameter $\frac{1}{16}$ inch.

the withdrawing motion of the rasp-like teeth. Upon capturing the specimen observed drilling in the tree and examining the ovipositor with a magnifying glass, the writer observed the central lance protruding from the side of the swelled ends and moving up and down, presumably much as it does when boring, though influenced spasmodically by the struggles of the insect to free itself. It is not certain that it moved in just the same way. As the insect does not turn around, so as to bring the cutting edge of the lance upon all sides of the hole, it becomes somewhat difficult to imagine in just what manner the hole is made so regular and even. It is necessary that the hole be



The Tremex drill contains two gouges and two saws.

a, Side view; *b*, posterior; *c*, anterior view; *d* shows saws extended beyond gouges when at work, and *e* saws withdrawn to expel sawdust from the boring.



The Thalessa drill.

y, The gouge; *x* and *x x*, the two saws; *a*, anterior view; *b*, lateral view; *c*, saws extended below gouge as in drilling. *d* shows section at *s* with dots showing relative position of points. *e* shows position when egg is passing through ovipositor.

larger than the drill ovipositor, in order to permit the swelling of the latter when the egg is passed through it into the bottom of the boring.

A still more wonderful drill is that of the great ichneumon fly, *Thalessa*, two species of which are common. They are known as *Thalessa lunator* and *Thalessa atrata*, the latter shining black and less common. The ovipositor is very much more slender than that of a *Tremex*, and that of the black species is over four times as long. It is, therefore, all the more remarkable to see this insect boring a hole for nearly the full length of its hair-like drill in solid oak, locust, pear, apple, or other equally tough-wooded trees. The drill ovipositor is carried in a long scabbard of two pieces and opening its full length. The drill proper is of three parts, one piece convex on its outer surface, concave within, finely pointed and having near the end three and sometimes four external, blunt, wart-like teeth. The other two pieces are alike, though opposed, flattened and more slender, the ends of each with ten or eleven rasp-like teeth and more prominent nearest the apex. These move freely within the more concave semi-sheath, the points of all working together and alternately effect the cutting, while as in the *Tremex* the rasp-like, rigid teeth, in the withdrawing motion, work out the sawdust, a steady stream of which flows from the boring when the drill is at work.

But there is a problem in what manner these drills effect the initial cutting at the extreme bottom of the boring. It is not difficult to understand from an examination of the file-like teeth of the drills how the boring is made larger than the drill. Gibson does not enter into a description of the mechanism of the instrument, but briefly refers to the boring's being accomplished by the alternate gouging of the chiseled tips of the three long pieces. This is not satisfying. From an examination of the instrument, it is more like the cutting of saw teeth or of file teeth than of chisels. Nor does it at all resemble an auger in its character. Beyond question, it is the withdrawing motion of the cutting pieces that loosens the particles of wood on the sides of the boring, the rigid teeth being all of the hook character, as in a file or saw, with the edges turned upward or backward. In some way the motion of the cutting points of the drill loosens the particles of wood at the bottom of the boring, which upon examination proves to be only slightly convex where the points are at work, showing here also that the drill moves from side to side and around in its work.

A *Tremex* bores a hole almost the extreme length of its ovipositor, lays an egg therein, withdraws, and flies away. This egg hatches a tiny grub that at once begins its work as a wood borer, hibernating within its burrow, and reaching its full development the following season. As is well known, a *Thalessa*, ascertaining the position of the *Tremex* larval boring by a subtle sense that we cannot comprehend, proceeds to drill through the hard wood, and unerringly reaches the retreat of the *Tremex* larva and lays an egg therein. This hatches a larva that searches out the *Tremex*, fastens upon it, sucks its juices, and eventually kills it, the *Thalessa* thereupon passing through its transformation in the boring of the *Tremex* and emerging the following summer, at about the time that a *Tremex*, if unmolested, would have done. When a *Thalessa* drills its boring, the *Tremex* larva has perhaps reached a considerable depth in the wood, hence the necessity for the very long drill of a *Thalessa* as compared to the shorter one of a *Tremex*. If a *Tremex* possessed a drill like the *Thalessa* and its larva could begin its boring at such a depth, then the drill of the *Thalessa* would need to be, perhaps, double in length. The ovipositor drill of a *Thalessa* is three or four inches long, and that of a *Tremex* less than an inch.

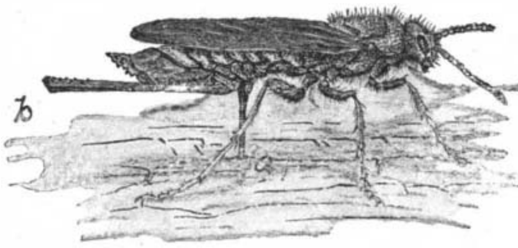
Considering the delicacy of the *Thalessa* drill, the comparatively slight power behind it, and the hardness of the wood into which it is often thrust, nothing in the mechanism of Nature is more truly wonderful. Possibly it is only surpassed by the ability of the insect to ascertain the exact position of its victim at such a depth in the solid wood.

Luminous Projectiles.

It is proposed to substitute for searchlights on warships guns firing projectiles which will emit intense light, either during their flight through the air or on striking the water. The short duration of the flight, however, appears to make the first method impracticable. For the production of light on striking the water calcium carbide is the most suitable substance, as, on contact with water, it generates acetylene gas which, when ignited, produces a very intense light. The latest form of acetylene or carbide bomb comprises two cylindrical wooden shells, which telescope together. The inner shell is filled with calcium carbide, calcium phosphide, and gunpowder, not mixed together. It has an iron head and, at its opposite end, an orifice for the escape of gas.

The two wooden cylinders separate immediately on leaving the muzzle of the gun and the inner cylinder continues its flight alone. On striking the water the projectile, after the first plunge, rises to the surface. Water enters the shell and evolves acetylene from the carbide, and hydrogen phosphide or phosphureted hydrogen from the calcium phosphide. The hydrogen phosphide ignites spontaneously on contact with the air and sets fire to the acetylene. The flame is not extinguished, but rather brightened, by contact with water, so that an intense light is produced even in a high sea. An intensity of 2,000 candles and a life of three hours are claimed for these acetylene bombs, and they can be projected to distances of two miles or more. Yet they form very incomplete substitutes for searchlights. They are of little use in the search for hostile torpedo boats because they are useful only when the position of the object to be illuminated is already approximately known. Even in such a case a torpedo boat could easily escape from the area illuminated by the bomb before it could be hit by the enemy's guns.—Prometheus.

At the recent *soirée* of the British Royal Society, Mr. J. Franklin Adams, F.R.A.S., exhibited the ingenious machine he has evolved in order to complete his extensive star-counting task and preparation of the star chart of the heavens. After securing photographs of every section of the northern heavens at various points, this astronomer in 1895 went to Cape Town and secured negatives of the southern heavens. In all 260 successful negatives were obtained, upon which are recorded something like 23,000,000 stars. The task of counting this huge aggregation has almost been completed, but it has occupied nearly seventeen years. By means of his special machine precession



The pigeon horntail (Tremex columba) boring in wood.

a. Ovipositor drill forced in vertically; length, ⅞ inch. *b.* Sheath attached to body horizontally. Sheath not used to strengthen the drill as in Thalessa.

lines are drawn upon his plates, which are 15 inches square, the latter lines 0.01 millimeter apart giving star places at the 1855, 1875, 1900, and 1925 epochs both in right ascension and declination. This machine works with such minute accuracy that regions adjacent to the selected areas can be subsequently added without overlapping or omission.