INSECTS AND WAR:

XII.—THE MOSQUITO (*Anopheles maculipennis*).

BY

A. E. SHIPLEY, Sc.D., F.R.S.,

MASTER OF CHRIST'S COLLEGE, CAMBRIDGE.

(Continued from p. 285.)

The tiny trumpeting gnat can break our dream when sweetest.—TENNYSON.

It is now pretty well accepted that the auditory organs of the mosquito are situated in the antennae. Sixty years ago Johnston of Baltimore was investigating the hearing apparatus of a gnat, and came to the conclusion that "the animal may judge of the intensity or distance of the source of sound by the quantity of the impression; of the pitch, or quality, by the consonance of particular whorls

Fig. 1.—A, *Anopheles maculipennis*, male, showing large, feathered antennae. B, Head of female, showing antennae, little developed.

of stiff hairs, according to their lengths; and of the direction in which the modulations travel, by the manner in which they strike upon the antennae, or may be made to meet either antenna, in consequence of an opposite movement of that part. That the male should be endowed with superior acuteness of the sense of hearing appears from the fact that he must seek the female for sexual union either in the dim twilight or in the dark night, when nothing save her sharp humming noise can serve him as a guide." Johnston also notes that the male mosquito is the more difficult to catch. The bushy, complicated antennae of the male shows that of the two sexes with the mosquito, as with man, the male is primarily the hearer or the listener.

Another American, Mayer, twenty years later made some interesting experiments confirming the views held by Johnston. He managed to cement with shellac a species of *Culex* on to a glass slide, and, placing it beneath a low-powered microscope, watched the response of the antennae to tuning-forks of varying strengths. He found that under the influence of a fork producing 512 vibrations per second certain hairs of the antennae vigorously vibrated, whilst others were left unmoved. He measured the amplitudes of the vibrations of these hairs under the influence of the sound emitted by various tuning-forks. Different hairs were seen to vibrate to different notes. Mayer also observed that when the sound came from a

direction in line with the long axis of the antennary hair vibrations ceased altogether. Hence he argued that the antennae could register the direction whence the sound came. Observing the antennae under the microscope, he confirmed the view that the vibrations ceased when the hairs pointed towards the source of sound, and on drawing a line in the direction in which the hair pointed, he found that it always cut within 5° of the position of the source of sound. He concludes:

"The song of the female vibrates the fibrillae of one of the antennae more forcibly than those of the other. The insect spreads the angle between his antennae, and thus, as I have observed, brings the fibrillae, situated within the angle formed by the antennae, in a direction approximately parallel to the axis of the body. The mosquito now turns his body in the direction of that antenna whose fibrils are most affected, and thus gives greater intensity to the vibrations of the fibrils of the other antenna. When he has thus brought the vibrations of the antennae to equality of intensity he has placed his body in the direction of the radiation of the sound, and he directs his flight accordingly, and from my experiments it would appear that he can thus guide himself to within 5° of the direction of the female."

There has always been some divergence of opinion as to how the buzzing sound to which the male so readily reacts is produced. Howard once thought that it was due to vibrations of certain chitinous processes in the large tracheae. Our experiments showed, however, that when the wing was cut off closer and closer to its origin the

Fig. 2.—A, Right half of thorax of *Anopheles maculipennis*, Meig., with base of right wing and right halter, magnified about 90-100. B, The same magnified about 15 to show the area which bears the stridulator. C, The teeth which rasp on the ridges borne by d. d, Distal chitinous sclerite bearing a claw which works in. kn, Papillae on knob. h, Distal end of halter. sel, Chitinous thickenings.

sound decreased in volume but the note progressively rose. The males at all times gave a higher pitched note than the female, and in both sexes the note rose after feeding. "The greater the meal the higher the note." This is, however, by no means confined to mosquitos. It is a matter any one must have noticed when assisting at a public dinner or when dining in a College Hall.

Three unfed females gave a note of from 240 to 270 vibrations. One unfed female gave an abnormally low note of about 175 vibrations. Four other females which were arranged in the order of the distension of the abdomen after food gave notes corresponding to 264-281-297-317 vibrations; whereas three unfed males all gave exactly the same note corresponding to 880 vibrations. The explanation of the higher note of the males is probably that their wings are markedly narrower and shorter than those of the females.

Whilst working at *Anopheles* Mr. Edwin Wilson, the artist who was drawing our plates, observed at the base of the wing a structure which may possibly account for the tone which is so characteristic a feature of the buzzing. The articulation of the wing with the body is extremely complex. There seem to be a series of structures like a

series of minute knuckle bones articulated with one another, and at the outer end of the series are two ribbed rods which may play some part in the production of the over-tones. One is a chitinous bar with some fourteen or fifteen well-marked teeth. In certain circumstances we consider that this rod can rasp across the ridges of the bar below it. As the wing is raised and lowered it seems probable that the slightly movable rod A would be drawn across the ridged bar B. (See Fig. 2.)

We have mentioned above that the mosquito's note increased in pitch as the wings were shortened until a very short stump was left. But as long as these stumps were left a note was heard, and these stumps would undoubtedly include the apparatus just described, for it is next and highest the insertion of the wing into the body. But Dr. Nuttall found that when even this short stump was removed all perceptible sound ceased, which is certainly an argument in favour of these rods and bars playing some part in the production of the buzzing, and in opposition to the view of Howard and others that the buzzing is caused by certain chitinous structures in the tracheae.

M. J. Perez¹ has carefully gone into the question of the production of sound in the Diptera. He claims to have shown experimentally that the stigmata take no part in the production of sound. "Les causes du bourdonnement résident certainement dans les ailes." He, too, points out that if the wings are cut short the note becomes more acute, until the *timbre* resembles that of certain interruptors which break and make an electric conductor. This sound we should attribute to the stridulator described above. M. Perez definitely states that both in the Diptera and in the Hymenoptera the buzzing is due to two causes, "l'une, les vibrations dont l'articulation de l'aile est le siège et qui constituent le vrai bourdonnement; l'autre, le frottement des ailes contre l'air, effet qui modifie plus ou moins le premier." The apparatus we have described is, we believe, the mechanism by means of which the first vibrations are produced.

In the same periodical M. Jousset de Bellesme² confirms the statement that both Dipterous and Hymenopterous insects emit two sounds, one deep and one acute, and states that the latter is usually the octave of the former. It is this double note which gives rise to the peculiar buzzing associated with these two orders of insects. M. de Bellesme, like M. Perez, discards the view that acute sounds are due to any action of the issuing air in the stigmata, and attributes it to the vibrations of the pieces of the thorax which support the wing, and which are moved by the muscles of flight. It is usually stated that these muscles are not inserted into the wing, but into the sides of the thorax, to which the wing is so attached that when the lateral walls of this part of the body are deformed by the action of the muscles the wings move up and down. But whether this be the case or not, it is clear that the vibrations of the sides of the thorax caused by the muscles of flight—and causing the vibrations of the wing—will synchronize in number with these wing vibrations, and will give forth the same note. The existence of the higher note—"usually the octave" of the one produced by the wing vibrations—is unexplained by this view. It is, however, easily explicable if such a stridulating organ as we have described at the base of the wing in *Anopheles maculipennis* be found in other Diptera and in Hymenopterous insects.

In our paper Mr. Wilson and I thought it well to figure the upper surface of the halter as seen under a high magnification. The drawing showed the hinge on which the halter quivers—the certain basal papillae, as Weinland³ calls them. There is little doubt that the main function of the halteres is that of balancing and orientating the insect. They may, however, have a secondary function; in some flies they are known to vibrate with extreme rapidity. It is just possible that in these rapid vibrations the papillae of the concave surface rubbing against those of the convex basal plate may produce a note. As long ago as 1764 von Gleichen-Russworm⁴ observed that when the halteres of the common house-fly are removed the volume of the buzzing diminished. This, however, in all probability is due to the diminished activity of the wings. On the other hand, Professor Stanley J. Gardiner informs us that he has noticed that mosquitos still continue to give forth a faint note even when their wings are quite at rest, and this note may possibly be caused by the halteres.

The part which sound plays in the life of the mosquito

has not been very fully recognized. Grassi says that people who are talking are more liable to be bitten by *Anopheles* than people who are silent—and quite properly, we think; people are apt to talk too much, especially in trains. Joly observes in Madagascar that mosquitos are attracted by music. When he played a stringed instrument the quiescent mosquitos in his room began to fly about, and if the windows were open mosquitos were attracted from the outside into his room, and he notes that mosquitos are attracted by musicians when at work.

Two curious instances, one recorded by Howard and the other recorded in a letter to the *Times*, of the attraction that electric buzzings have on these insects should be given. Mr. A. de P. Weaver, an electrical engineer, of Jackson, Miss., U.S.A., records that, when engaged in some experiments in harmonic telegraphy, he observed that when the note was raised to a certain number of vibrations per second, all the mosquitos, not only in the room, but from the outside, would congregate near the apparatus, and were, in fact, precipitated from the air with a quite extraordinary force, hurling their frail bodies against the buzzing machinery. This machinery formed, in conjunction with sticky fly-paper, an excellent means of capturing them. Mr. Weaver then devised a means of electrocuting the pests. He used a section of unpainted wire screen mounted on a board with pins driven through the meshes, the heads of the pins being flush with the surface of the screen. The bodies of the pins were then electrically connected together, and the whole forming one electrode of the secondary coil of an induction coil, whilst the wire screen formed the other electrode. An alternating current of high potential was passed, and when the note was sounded the insects precipitated themselves to their doom, being electrocuted the moment they touched the apparatus.

A somewhat similar story is told by Sir Hiram Maxim in the *Times* of October 29th, 1901. One of the lamps in an installation which was put up in Saratoga Springs, New York, hummed in an agreeable manner, and he noticed that night after night this lamp was covered with small insects. On closer examination he found that they were all mosquitos, and all males.

REFERENCES.

- ¹ *Compt. Rend. Acad. Paris*, lxxxvii. 1878, p. 378. ² *Ibid.*, p. 535.
³ *Zeit. f. wissensch. Zool.*, li, 1891, p. 55. ⁴ *Geschichte der gemeinen Stuberrfliege*, Nuremberg, 1764.

THE VALUE OF SALICYLIC ACID IN THE TREATMENT OF WOUNDS AND TYPHOID FEVER.

By ALBERT WILSON, M.D.,
LONDON.

I WAS so impressed by the value of dry salicylic acid powder in the treatment of the wounded soldiers in France that I recently formulated the following series of experiments *in vitro*. I am indebted to Mr. J. Gilbert Hare, now Bacteriologist to the Hospital of the Alliance, Yvetot, for affording me the use of his laboratory and giving personal supervision; and also to Mr. Dudley-Ward for the accurate carrying out of the technique.

Some have attributed to this drug a saponifying action, but this is surely a term limited to alkaline hydrates in the presence of fats. It has, however, a liquefying action, but of what nature I cannot explain. I was repeatedly struck with its effect in causing dense, often fibrous, sloughs to disappear quickly. The bright red granulating surfaces which followed negative any suggestion of caustic action. The offensive odours would disappear in perhaps twenty-four hours. It caused neither pain nor irritation, however freely applied to wounds. This important fact should be noted by any who may hesitate to use it on account of its well-known solvent action on horny material—corns, etc. It may even be introduced into the abdomen in septic cases.

In former years, when I had a number of cases of typhoid fever to treat, I obtained a large measure of success by the use of salicylic acid as an intestinal antiseptic; and the same in diphtheria (dissolved in glycerine). In typhoid fever I gave it in water, which is rather difficult, as the drug must be rubbed down in a mortar; or mixed with bismuth and mucilage as a vehicle. It had a distinct