X. *Stridulating Organs in* Coleoptera. By Charles J. Gahan, M.A.

[Read March 7th, 1900.]

Plate VII.

In the course of my work on the Coleoptera I have had occasion from time to time to note the occurrence of stridulating organs in these insects. Some of my observations appeared to be new, but instead of offering these as a separate contribution, I thought it might be more useful to include them in a general account of the subject. This I have endeavoured to give in the present paper. The stridulating organs of beetles, so far as they were known at the time, have been very adequately dealt with by Darwin in his "Descent of Man," and the account which he has there given of them still remains one of the most complete. Landois also, to whose researches we owe a great part of our knowledge of these organs, has given a very full and detailed history of them in his "Thierstimmen," published at Freiburg in 1874. But it was not until that same year that the first account appeared of the remarkably well developed stridulating organs which Schiodte discovered in the larvæ of several genera of beetles; and this, together with the further observations which have been made by others since that date, have somewhat considerably increased our knowledge of the subject, and have added fresh interest to it. Had Schiodte's discovery been known to Darwin it might, perhaps, have led him to modify his view that stridulation in beetles serves as a sexual call, and that the organs by which it is produced have reached their present state of development by a process of sexual selection. If adult beetles alone had to be considered there would be little ground for objecting to this view. But it is quite evident that the stridulating organs must serve some other purpose in the larvæ, and that sexual selection could have had nothing to do with their development; and if this be true of the larvæ there is no reason why it should not be true also in regard to some at least of the adult forms.

I believe, however, that Darwin's view does on the whole remain true in its application to the perfect insects, although I am unable to adduce any important fresh facts in support of it. One objection to it was the fact that the stridulating organs when present, were found to be, as a rule, present alike in both sexes, showing no appreciable difference in structure or position according to the sex. On his own hypothesis, Darwin expected that the exceptions to this rule would prove to be very numerous, but those that he could find were remarkably few. Many more such exceptions have, however, since been brought to light, going some way towards realising Darwin's expectation, and so far lending support to his view.

The stridulating organs of beetles are, as a rule, very simple in structure, showing no great amount of variety in this respect; but they are, as Darwin has remarked, "wonderfully diversified in position," much more so even than he supposed them to be. Wherever any part of the external surface of the body is subjected to the friction of an adjoining part by the movements of the insect, there, in some species or another, these organs are almost sure to be found. They do not remain constant in position even among the different genera of the same family, yet they sometimes appear unexpectedly having almost identically the same position and structure in one genus that they have in a genus of some totally different family. A Cicindelid, for example, may in this respect be exactly like a Tenebrionid, while two Tenebrionids may be quite unlike one another. Owing to this inconstancy in their position, the stridulating organs of beetles are less important for general purposes of classification than the corresponding structures met with in the Orthoptera; and for this reason among others, I have thought it best to take them according to their position on the body of the insect, instead of in the order of the families in which they are found to occur.

1. *Stridulating organs on the head.*

The presence of stridulating areas on the head, though of fairly common occurrence in beetles, was evidently unknown to Darwin and Landois, neither of whom has mentioned any instance of the kind. It was first, I believe, pointed out by Crotch, who in characterising certain genera of *Languriinæ*, noticed that there was a

single stridulating file on the crown of the head in the genus *Goniolanguria*, and that there were two such files in the genus *Teretilanguria*. Dr. D. Sharp has since detected the presence of a stridulating area in the same position in the genus *Ips* and allied forms of the family *Nitidulidæ*, and Mr. Gorham has discovered it in two species of *Endomychidæ*—*Encymon ruficollis*, Kirsch, and *Phæomychus rufipennis*, Motsch., as well as in some additional genera and species of *Languriinæ*.

In the *Endomychidæ*, stridulating organs are much more generally present than Mr. Gorham seems to have suspected, and it is owing, perhaps, to the somewhat exceptional character of the striated area in *Encymon ruficollis*, that his observations in reference to this species are not altogether accurate. "The true characters are," he says, "sexual and very interesting. The male in this species has the head furnished with a stridulating file on the crown formed of fine transverse striæ, the front edge of the thorax in this sex having a small fossa corresponding to an internal projection for the purpose of rasping the file. This apparatus does not exist in either of the allied species; although the fossa is feebly present in some specimens, there are no corresponding striæ."

I have, as I believe, correctly determined the sexes of *E. ruficollis*, and I find the stridulating area present and having the same appearance in both sexes. It consists of two portions differing in the character of the striation. The more coarsely striated part lies in front, and is generally exposed to view, while the more finely striated posterior area is usually hidden under the pronotum. In his examination of the species, Mr. Gorham seems to have seen only the anterior more coarsely striated area, and to have overlooked the other portion, which, in position and in the fineness of its striæ, corresponds almost exactly with the stridulating area present in all other species of the genus *Encymon*, and in those of several other genera of *Endomychidæ*.

Certain authors appear to set very little or no value whatsoever on the stridulating organs as affording characters to be used in the classification of Coleoptera. There can be no doubt that these organs have arisen independently in the same position and with an almost exact identity of structure in different families of beetles, so that it would be wrong to assume from any close

similarity in position and structure of the stridulating organs in certain families, that these families were therefore closely related to each other.

But the case seems to be different when we come to consider genera and other minor groups within the family, and if certain species of a genus, or certain genera of a family agree in possessing stridulating organs, in the same position, and with the same kind of structure, it is safe to infer that such species or such genera, as the case may be, have derived this character from a common source, and are more closely related to each other than to those species or genera which do not offer the same character.

These remarks may be illustrated by a further reference to the family *Endomychidæ*. In all the species I have so far examined belonging to the "groupes" *Eumorphites*, *Corynomalites* and *Lycoperdites*—the three groups which come first in Chapuis' arrangement of the family—a stridulating area has been found present on the head in both sexes. It appears to be absent in the other "groupes," or if present, to be present in a most rudimentary condition. The first three "groupes" might therefore be associated in one large group distinguished by the possession of stridulating organs, and such a group would, I think, be admitted as a natural one.

Stridulating organs occupying the same position on the head, and very similar in all points of structure to those of the *Endomychidæ* are very generally present in the *Hispidæ*, but it has never been suggested that these two families are in any way closely related to each other.

In the *Hispidæ*, as in the *Endomychidæ*, the stridulating organs have as a rule the same characters in both sexes, the only exception so far met with, occurring in the genus *Spilispa*, Baly.

In *Spilispa imperialis*, Baly, there is no true stridulating organ in the female, whereas in the male the stridulating area on the crown of the head is well-defined, though somewhat exceptional in structure, the series of ridges of which it is formed being slightly arcuate, less closely approximated than usual, and marked with short longitudinal furrows (Pl. VII, figs. 2 and 2*a*). The male of this species is further distinguished by the presence of a small triangular flap, thin and semi-membranous, projecting from the front margin of the pronotum (figs. 2 and 2*b*). What part this flap takes in stridulation does not

seem clear; it can scarcely act as a scraper, an inwardly projecting rim at its base where it joins the pronotum appearing to serve for that purpose. It may possibly be set in vibration, and serve to augment or modulate the sound produced by the scraping of the file on the head. A somewhat similar but less conspicuous modification of the anterior edge of the pronotum occurs in both sexes of *Estigmena* and other genera of *Hispidæ* and in nearly all of the stridulating species of *Endomychidæ*, appearing in most in the form of a small pit or depression such as is described by Mr. Gorham in his reference to the stridulating organ of *Encymon ruficollis*, Kirsch.

The stridulating area in *Estigmena chinensis* is divided into two parts by a short depressed interval, the anterior being much more finely striated than the posterior part, thus by its structure seeming capable of producing a very much higher note when rubbed by the edge of the pronotum. In *Hispopria foveicollis*, Baly, the stridulating area is still more complex, consisting of three parts (Pl. VII, figs. 3 and 3*a*); the part in front, forming the apex of a triangular area, is very finely striated, and is followed behind without any break by an area in which the striæ are much coarser and less approximate to one another; this area is succeeded by a pit-like depression, behind which there is a short space presenting a fairly regular transverse striation somewhat intermediate in character between the other two. Equally complex is the condition existing in *Anisodera scutellata*, Baly, the striated area on the head being similar to that of *Hispopria* with this difference only, that the three parts of the area are divided from one another by shallow transverse depressions.

From the structure of their stridulating apparatus it is to be inferred that these beetles can and do produce sounds of at least two different degrees of pitch (and probably of three), one being about an octave higher than the other, while further the possibility has to be admitted that by the requisite movement of the head, the beetles might be able to vary the order or succession of the notes in such a way as to give rise to several simple musical airs.

Unfortunately no observations have yet been recorded in reference to the nature of the sounds made by the living insects, and although it is very unlikely that such observations will prove the sounds to be so varied as the

theoretical possibilities of the case would seem to allow, they will probably show them to be a good deal removed from the ordinary monotonous squeak produced by the majority of stridulating Coleoptera.

In addition to the genera mentioned above, stridulating areas on the upperside of the head are found to be present in species belonging to the following genera of *Hispidæ*: *Wallacea*, *Botryonopa*, *Oxycephala*, *Cephalodonta*, *Prosopodonta* and *Hispa*. They are absent in *Arescus*, *Alurnus* and a few other genera, but taking the family as a whole, they will probably be found to occur in a majority of the species, and as they seem to offer a sufficient amount of variety in the details of their structure they will probably prove to be useful as aids in the diagnoses of species and sub-genera, if not of genera.

In several genera of Coleoptera the striated area is situated not on the upperside, but in a corresponding position on the underside of the head, sound being produced by the friction of this area against a small, inwardly projecting ridge at the anterior edge of the prosternum. A well-defined triangular or lenticular area marked with very regular transverse striæ is to be seen on the gula in the Tenebrionid genus *Praogena* and in the allied genera *Nesogena*, *Dysgena* and *Lamprobothris*. Its presence in the first-named genus was pointed out by me a few years ago, but since then I have found that the gular stridulating area is equally well-developed in many other *Tenebrionidæ*, being in some cases characteristic of genera, in others of small groups of genera. It occurs in all the species I have examined belonging to the genera *Gonopus*, *Anomalipus*, *Hopatrinus*, *Selinus*, *Trigonopus*, *Pseudoblaps*, *Platynotus* and *Eurynotus*, and is to be found in several, but not all of the species of *Helops*.

Its presence in *Selinus* affords a further means of distinguishing the species of that genus from those of *Dendarus*, to which they have sometimes a very close resemblance.

It occurs also in the genus *Stenerula*, Fairm., of the family *Cistelidæ*, and outside of the Heteromera, is met with again under a slightly different form in the genera *Priobium* and *Dryophilus* of the family *Ptinidæ*, and *Scolytus* of the family *Scolytidæ*. Its presence in *Priobium* was scarcely to be expected, and is very interesting, in view of the fact that some of the allied species of *Anobiinæ*—

the so-called "death-watches"—have such a different means of producing sound.

On the hinder part of the underside of the head of *Priobium castaneum*, Fab., a comparatively large sub-circular area is to be seen, bounded at the sides by sutural lines. This area is slightly convex, and is traversed towards each side by a regular series of very fine, parallel transverse ridges. The ridges are not continued across the median part of the circular space, so that there are in reality two separate striated areas, each somewhat elliptical in outline.

In *Dryophilus pusillus*, Gyll, the position of the stridulating organ is the same as in *Priobium*, but in this case the striæ appear to run right across the whole of the circumscribed space forming but a single stridulating area.

In the genus *Anobium* proper, the gula is less extensive than in *Priobium*, and has no trace of a stridulating area, but in many of the species there is a curious series of ridges on the underside of each elytron close to its outer and apical margin, suggesting that the elytra may in these cases be used for purposes of stridulation. These ridges are not present in *Priobium*, and are wanting also in *Xestobium tessellatum*,—one of the species which are known to make a noise by tapping their head against the wood on which they stand.

The stridulation of *Scolytidæ* was first noticed by Dr. T. A. Chapman, who, in a very instructive article on the habits of these insects,* relates among other facts, that "*Scolytus destructor, intricatus* and *pruni* squeak audibly, by a rapid movement of the abdomen against the elytra, *intricatus* making the loudest sound."

This statement was accepted by Darwin and others, and apparently has never since been disputed. For my own part, being curious to examine the stridulating organs in these insects, and not doubting the accuracy of so keen and critical an observer as Dr. Chapman, my search was for a long time confined to the elytra and abdomen, but with negative results, forcing me to the conclusion that Dr. Chapman's statement must have been based solely on his observation of the movements of the insects and not on any actual examination of the structures concerned in stridulation. This was fully confirmed when later I found

* "Ent. Mo. Mag." VI, p. 130 (1869).

that the stridulating area in these insects is situated on the underside of the head.

In *S. destructor*, *ratzeburgi*, *pruni* and *multistriatus*, it is a narrow elongated, very slightly elevated space, running along the middle, up to the hind margin of the head, and crossed by a series of very fine parallel ridges, the shape of the area being almost exactly the same in all of these species (Pl. VII, figs. 9 and 9*a*).

In *S. intricatus* the stridulating area is shorter and broader, and appeared to me (but of this I cannot speak with certainty, not having made exact measurements) to be somewhat less finely striated (Pl. VII, figs. 10 and 10*a*).

Scolytus rugulosus appears to be without a true stridulating area, the gula in this species being marked along the middle with a depressed line or groove from which coarse ridges run transversely towards the sides of the head. Ridges of a similar character, often continued right across the underside, and sometimes all round the head, are met with in other *Scolytidæ*, and occur frequently among the *Curculionidæ*. They are in some cases so regular and parallel as to make it doubtful whether they do not serve for stridulation, but certain species in which they occur are not known to stridulate, and as I have found them present in species which possess a true stridulating area on the elytra, I am inclined to think they are never used for that purpose.

Stridulating organs situated on the mandibles and maxillæ have been described by Schiodte as occurring in the larvæ of certain genera of *Dynastidæ*, *Cetoniidæ*, *Rutelidæ*, *Sericidæ*, *Melolonthidæ* and *Copridæ*. They consist of (1) a series of teeth on the upper face of the maxillary stem (stipes), and (2) special granulations variously placed and grouped on the lower face of the mandibles, the parts being so disposed that the teeth on the maxillæ reach and rasp the granulations on the mandibles when the maxillæ are moved backwards and forwards. In *Dynastidæ* and *Cetoniidæ* the granulations are arranged to form rather strong transverse ridges, which occupy a somewhat elliptical and completely circumscribed area near the base of each mandible. In the *Rutelidæ* they differ only in that the ridges formed by them are much finer, more numerous, and placed closer together; but in the larvæ of the other groups the granulations do not form ridges. Dr. Sharp believes that these structures are little

adapted for the production of sound, but judging from the excellent figures which Schiodte has given of them ("Naturhistorisk Tidsskrift," Ser. 3, Vol. IX, 1874), and from what little I have seen of them in one or two species, I should consider them very well adapted for the purpose; and such is, I believe, their true function.

2. *Stridulating organs on the prothorax and front legs.*

These are found only in a relatively small number of genera and species, but some of them are very interesting as being amongst the most perfect of their kind. The stridulating apparatus met with in several species of the Carabid genus *Siagona* has recently been figured and described by MM. Bedel and Francois in the "Bulletin de la Soc. Ent. de France" for 1897. It consists of a transversely striated or ridged carina running along under each side of the prothorax, and of a very small striated area on the outer face of each of the front femora, this area being so placed as to come in contact with the ridge on the prothorax, when the femur is rubbed along the side of the latter. An arrangement somewhat similar to this occurs in the Bostrychid genus *Phonapate,* Lesne (see Pl. VII, figs. 7 and 7*a*), and has been described by M. Lesne as one of the distinctive characters of his genus. In the females of *Phonapate* each of the anterior femora has a well-defined longitudinally striated area on its outer face close to the apex, and when the femur is rubbed along the side of the prothorax, this area is made to scrape against a series of six or seven short oblique ridges placed near the hind angle of the thorax. The whole apparatus is one of the most perfectly developed met with amongst the Coleoptera, but what makes it especially remarkable is the fact that it occurs only in the females, the males, so far as is known, being without stridulating organs of any kind. This is the only instance known to me, in which the stridulating organ of insects is confined to the female sex. (The bed-bug may prove to be another exception, the complicated apparatus discovered by Dr. Ribaga in the female of this insect being conjectured by him to be a stridulating apparatus.)

In *Omaloplia brunnea* the stridulating area is situated on the prosternum. Westring has long since pointed out that the dorsal or inner face of the intercoxal part of the prosternum is transversely striated, and that stridulation

results from the rubbing of this face against a process of the metasternum, which projects into a hollow space lying above it.

It is a well-attested fact that *Cychrus rostratus*, and one or two other species of the same genus of *Carabidæ* stridulate loudly, and the late Mr. Frederick Smith went so far as to declare that *Cychrus rostratus* stridulates more loudly than any other beetle found in England. One would naturally expect therefore that the stridulating apparatus is well-developed in this species and easily to be seen; but, so far as I can find, nothing that can satisfactorily be regarded as the stridulating apparatus has up to the present time been described.

The stridulation of *C. rostratus* is noticed in Kirby and Spence's "Entomology," and is there stated to be produced by the friction of the prothorax against the base of the elytra. On the other hand Mr. T. Marshall, in the "Entomological Magazine" for 1833, attributes it to the friction of the lateral edges of the abdomen against a very fine file lying in the epipleural groove along the side of each elytron. Darwin examined the species, but was unable to detect the presence of any rasp or file. Even if such a file as Marshall has indicated did exist, it would, I think, be impossible for it to operate on the edges of the abdomen in such a way as to produce an appreciable sound. As far as I could make out, the elytra play no part in stridulation, and the only structures I could discover at all likely to answer the purpose are situated on the epimeral lobes of the prothorax. These lobes are somewhat larger and more prominent in *Cychrus* than is usual in *Carabidæ*, and the inner (hidden) face of each is traversed by a series of rather coarse but fairly regular ridges, running approximately parallel to one another in a direction almost at right angles to the longer axis of the lobe. When the prothorax is bent up and down these ridges rub over the sides of the mesosternum, which in their outer part are slightly rugose, and the friction results in the production of sound. By rubbing these parts together in dead specimens I did not succeed in producing more than a feeble sound. But Mr. Bernard Penny, a young entomologist interested in the stridulation of beetles, wrote in answer to an inquiry from my colleague Mr. Arrow, that "the noise [of *Cychrus rostratus*] seems to me to be produced by the friction of the lower part of the base of the

thorax against a small plate on or about the episternum, in fact, as far as I can judge,—sternum against episternum. The sound is shrill and clearer than that of *Aromia moschata.* When held between the finger and thumb, the beetle moved the head downwards and up again, but the sound was only produced on the downward motion. The thorax did not move much." These observations of Mr. Penny go far to show that the structures I have described constitute the true stridulating apparatus of *Cychrus.* At the same time I am obliged to admit that the ridges on the epimera are much coarser and less regular, and the lateral edge of the mesosternum appears less efficient as a scraper, than the corresponding structures concerned in the stridulation of other beetles; and I have difficulty in understanding why the sound produced by their action should be shriller and clearer than that made by the Longicorn beetles.

Hydrophilus piceus makes a clearly audible sound, described to me by Mr. H. Donisthorpe and Mr. F. Terry, both of whom have kept the living insects under observation for a long time, as being a distinct stridulation like that of the Longicorns. During the process of stridulation the abdomen was observed to move rapidly, from which it was inferred that the sound was produced by the friction of the abdomen against the elytra. I had previously seen it stated that *Hydrophilus* makes a kind of rustling noise in that way. But having carefully examined the abdomen and elytra I could find no structures that seemed at all capable of giving rise by their action to a distinct stridulation. The most likely structures of the kind are very similar in character to the epimeral ridges of *Cychrus,* and only slightly different in position, the ridges in *Hydrophilus* being placed transversely in a small area on each side of the under surface of the pronotum just where the latter fits over the outer edge of the mesosternum.

3. *Stridulating organs on the mesothorax and middle legs.*

A stridulating area situated on the mesonotum, median in position and usually undivided, occurs in most of the Longicorn beetles, excepting the *Prionidæ,* in which it is present in the genus *Philus* only. But in certain genera and groups of genera both among the *Cerambycidæ* and *Lamiidæ* it is entirely wanting. The ridges are as a

rule of the same character throughout the whole of the stridulating area, and show no appreciable difference according to sex, though varying in number and the degree of fineness in different species and genera. The only exceptions to this rule, so far as I know at present, are met with in the Madagascar genera *Ranova*, *Leucographis* and *Lasiocercis*. In these the ridges are much coarser in the male than in the female, and in both sexes become distinctly coarser and less approximate to one another in passing from the hind to the front end of the stridulating area.

Stridulating organs similar in character and position to those of the Longicorns are found in the Phytophagous beetles of the family *Megalopidæ*. They were first noticed by Lacordaire, whose observations in reference to them seem to have been entirely overlooked by subsequent writers. They appear to be present in both sexes throughout the whole family.

Stridulation in beetles of the family *Clythridæ* is noted by Darwin in his "Descent of Man." He attributes the discovery to Crotch, and states, erroneously, that the stridulating area is situated on the pygidium. The stridulating areas—two in number—are on the mesonotum, lying close alongside its lateral edges. I have found them present in most of the species which I have examined, but they appear to be altogether absent in a few genera, and are wanting also in certain species of *Clythra* which differ in other respects from the remaining species of that genus. Stridulation can be easily produced in cabinet specimens of some of the larger species, by forcibly moving the prothorax backwards and forwards over the mesonotum.

The most interesting, perhaps, of all the stridulating organs of Coleoptera are those discovered by Schiodte in the larvæ of *Lucanidæ*, *Passalidæ* and *Geotrupidæ*, and figured and fully described by him in the "Naturhistorisk Tidsskrift," Ser. 3, Vol. IX (1874). In these larvæ the sound-producing organs are situated entirely on the legs, a series of ridges or tubercles on the coxæ of the middle legs constituting the rasps or files, and structures adapted for the purpose on the hind-legs acting as the scrapers. In the larvæ of the common stag-beetle, a ridge along the anterior face of each of the hind-legs is made up of a series of short transverse tubercles, and stridulation is produced by drawing this ridge along the hard, serrate or

crenulate, edge of a plate forming part of the middle coxa, the action being much the same as when the edge of one file is drawn obliquely across the edge of another. The larvæ of *Passalidæ* practically have but two pairs of legs; for the hind-legs, though present, are as legs almost absolutely functionless, and seem to be used only for the purpose of producing sound. These legs are very greatly reduced in size, being only just sufficiently long to reach forward as far as the coxæ of the middle legs and scrape the transversely ribbed areas which are specially situated there. In the forms described by Schiodte each of the hind-legs is narrowed towards the apex, and furnished there, as well as on its anterior face, with special rasping teeth; but in other forms, one of which has been figured and described by Dr. Sharp in the "Cambridge Natural History," each of these legs resembles a paw, the rasping teeth being spread out in a row at the apex.

The profound modification which the hind-legs have undergone, apparently in order to become more efficient as sound-producing organs, suggests that stridulation has some important bearing in the life of these larvæ. But as the larvæ live concealed in burrows made by eating through the decaying wood of old stumps or trunks of trees, it seems unlikely that stridulation can be of much, if any, use in protecting them from their enemies. Then what is its use? My colleague, Mr. Waterhouse, has suggested to me that, with a number of larvæ living close together in the way described, it would be an advantage to each to be left in undisturbed possession of its burrow, and to eat its way in such a direction that it would not cross the path of another. Stridulation as a means of effecting this becomes useful to the larvæ. Acting as a sort of declaration of each individual's rights, it would tend to promote general harmony. This suggestion as to the use of the stridulating organs will, however, scarcely apply to the larvæ of the *Geotrupidæ*, since these larvæ, which live at some depth underground, are not, so far as I know, usually met with living in close proximity to one another. But every other suggestion I have heard seems to offer as great or even greater difficulties, and I fear that the precise use and meaning of these organs will for some time longer remain a mystery. Judging from what I have seen of them in the larvæ of *Lucanus cervus*, the stridulating organs seem to be developed at a very early stage,

and to be retained throughout the whole life of the larva.

It has been stated by Leconte that some of the adult *Passalidæ* stridulate by rubbing the inner surface of the sides of the elytra over the sides of the abdomen; but I have not been able to find any true stridulating area in the position indicated by him. The adult *Lucanidæ* are without stridulating organs; and the species of *Geotrupes* while capable of stridulating loudly do so in a manner different to the larvæ. The stridulating organs appear therefore to have arisen quite independently in the larvæ of these families.

Stridulating structures are not known to occur on the middle legs of adult beetles except in those remarkable Longicorns from the Sandwich Islands belonging to the genus *Plagithmysus*. These beetles not only stridulate in the ordinary manner of Longicorns by moving the edge of the prothorax over a striated area on the mesonotum, but have in addition a stridulating file along the lateral edge of each elytron against which they rub the hind femora; while there is present also on each of the middle and hind coxæ a series of ridges which in some species are very regular and parallel, and are considered by Dr. Sharp, who discovered them, to be true stridulating structures.

4. *Stridulating organs on the hind-legs, elytra and abdomen.*

In the species of *Geotrupes* and *Typhoeus*, an oblique ridge on each of the hind coxæ is transversely striated, forming a file which scrapes against a ridge in the coxal cavity when the coxa is turned.

In *Heliocopris* the posterior surface of each of the hind coxæ exhibits a short transverse elevation marked with a few transverse striæ; but the stridulating area proper is on the inflexed part of the first abdominal segment which helps to form the coxal cavity, while the striated ridge on the coxa seems to act chiefly as the scraper. I am indebted to Mr. H. E. Andrewes for calling my attention to the stridulation of this genus. He says that some of the large Indian species stridulate very loudly, the stridulation being produced by the motion of the hind coxæ in their sockets. I have found it easy to produce a tolerably loud sound in dead specimens by turning the

coxæ backwards and forwards in their sockets. Stridulating organs are present in all the species of *Heliocopris* which I have had an opportunity of examining; but I was unable to find them in any species of *Catharsius*, a genus so closely allied to *Heliocopris* that some authors refuse to consider it distinct. Both genera were formerly included in *Copris*, and though some species of *Copris* proper have the power of stridulating, the method is not the same as in *Heliocopris*. According to Darwin, *Copris lunaris* stridulates by rubbing the abdomen against a very narrow striated ridge situated on the underside of each elytron close to its sutural margin.

Stridulation in the Rutelid genus *Macraspis* has been noticed by Dr. Ohaus, who, in ascribing it to the friction of the hind femora against a number of oblique ridges on the side of the abdomen, appears to have overlooked the fact that the arcuate ridge, situated on the outer part of the upper face of each femur, which rubs against the abdomen is itself transversely and very regularly striated, and constitutes the true stridulating file, the widely separated ridges on the abdomen merely serving to act as so many scrapers. The whole apparatus as it occurs in this genus has recently been correctly described by my colleague Mr. G. J. Arrow, who assisted me in examining it.

Dr. Sharp ("Ent. Mo. Mag." XI, 1874) has fully described the somewhat similar means by which stridulation is produced in certain species of the Cetoniid genus *Lomaptera*, since associated together by Dr. Gestro in a separate genus to which he has given the name of *Ischiopsopha*. Here the ridges on the abdomen are situated towards the sides, on the second and third segments, a few on the fourth; they are more regular and very much closer together than in *Macraspis*, and form the true stridulating areas, the upper surface of the femora which rubs against them being furnished with a number of rather widely separated scraping ridges.

The little beetles of the family *Heterocerídæ* also stridulate by rubbing the hind femora against the fore part of the abdomen. A well-marked ridge lying in the form of a segment of a circle on each side of the first ventral plate acts as the file, being very finely striated in its inner and posterior part, less finely in its outer and anterior part; while a single very narrow ridge on the upper face of each femur performs the part of a scraper. Schiodte has

accurately described these structures, but Erichson was the first to call attention to them.

Stridulating files situated on the elytra are to be found in *Oxycheila*, a genus of *Cicindelidæ*, in *Blethisa* and *Elaphrus* (family *Carabidæ*), in *Pelobius* (*Dytiscidæ*), in *Trox*, *Copris* and *Ligyrus* (*Scarabæidæ*), in *Cacicus* (*Tenebrionidæ*), in several genera of *Curculionidæ*, and in a few *Prionidæ*.

In *Oxycheila* a narrow ridge running along the edge of each elytron just above the epipleural fold is very finely and regularly striated in a transverse direction. The stridulation, as Lacordaire has noticed, is produced by rubbing the hind femora along these ridges, but he apparently failed to observe that the part of each femur which rubs along the edge of the elytron is also very regularly striated, the striated area forming a narrow strip with the striæ running in a longitudinal direction. In the Heteromerous genus *Cacicus*, represented by a single species, *C. americanus*, Sol., the stridulating apparatus is remarkably like that of *Oxycheila*, each of the hind femora being striated in the same way. But in this genus (see Pl. VII, fig. 8) the elytral file is placed much higher up on the side and takes a sinuous course. The little transverse ridges of which it is formed are sufficiently strong to be plainly visible to the naked eye, and it is interesting to note that instead of being exactly parallel with one another, they are so set on the different parts of the file that they always correspond in direction with the striæ on the femur as the latter rotates when rubbing along the side of the elytron. Lacordaire, who heard the stridulation in this species, has described the method by which it is produced, although failing to notice in this case also that the hind femora are longitudinally striate and thus specially adapted for the part they play in the process. From the structure of the parts concerned, one would expect that the stridulation of this species would be particularly loud, but Lacordaire does not appear to have noticed anything specially remarkable in this respect.

A stridulating file runs along the edge of each elytron in some species of *Prionidæ* (it is best developed in those of the genus *Ctenoscelis*) as well as in some of the Cerambycid genus *Plagithmysus*, but in these Longicorn beetles, the hind femora, except in the presence of granules or spines, are not specially adapted to act as scrapers.

In the stridulation of the Carabid genera *Blethisa* and

Elaphrus, the elytra and abdomen are the parts concerned. The structures by which it is effected have been on the whole correctly described, especially by Landois in his "Thierstimmen." They consist of (1) a series of very short ridges on the abdomen placed in a slightly arcuate row on each side of the posterior part of the penultimate dorsal segment (see Pl. VII, fig. 1); and (2) a series of longitudinal striæ lying on the posterior expanded part of the epipleural ridge which runs along the underside of each elytron (Pl. VII, fig. 1*a*). Darwin, in referring to the stridulation of *Blethisa*, says: "the transverse ridges on the furrowed border of the abdominal segment do not come into play, as far as I could judge, in scraping the rasps on the elytra," and Landois, quoting this remark, fails to explain exactly how stridulation is effected. In other beetles which stridulate by rubbing the abdomen against the elytra, the movement of the abdomen is a backward and forward one, but in the present case, judging from the direction of the ridges and striæ, these parts can only come into play, when the abdomen is moved from side to side, and such, I conclude, is the actual way in which the stridulation is brought about. This method of stridulating would account also for the fact that the ridges on the abdomen form an arc instead of being placed in a straight transverse row, the actual arrangement being the one best adapted in order that each ridge should act most effectively in scraping the striæ on the elytra.

In *Pelobius* and *Trox* the stridulating file is situated on the underside of each elytron close alongside its sutural margin, a transverse ridge at the border of one of the posterior abdominal segments acting as the scraper. Dr. Sharp has given a full account ("Ent. Mo. Mag." 1897) of the position and structure of the organs in the genus *Trox*, correcting the misstatements that had previously appeared in reference to them. In *Ligyrus* the stridulating file is imperfectly developed, consisting of a number of feeble ridges crossing the central part of the under surface of each elytron. A similar structure is met with in a few other genera of *Scarabæidæ*.

It has long been known that certain of the weevils are capable of stridulating, the sound produced being remarkably loud considering the size of the species. The position of the stridulating area in these beetles was, however, never accurately ascertained until Landois investigated the matter,

though Wollaston previously professed to have discovered it in a rather large granulated or shagreened area of triangular shape placed close to the apex on the underside of each elytron. The true stridulating area, as Landois has correctly observed, lies close to the suture, and is covered with very regular and parallel transverse ridges, giving it an appearance quite distinct from the reticulated or granulated surface on the outer part of the triangular area. The male only of *Cryptorhynchus lapathi* possesses this elytral file, the female being without stridulating organs of any kind. The same sexual difference was apparently met with in all the species examined by Landois, who has too hastily generalised in stating that stridulating organs are present in the male sex only of *Curculionidæ*. In *Plinthus*, *Acalles*, *Mononychus* and other genera which I have investigated, stridulating files were found to be present on the elytra in both sexes; while in many forms the stridulating files are present in both sexes, but occupy a different position in each sex, being placed on the elytra in the males and on the pygidium in the females. The latter condition occurs in *Cryptorhynchus lirinus*, Boh., *C. lemniscatus*, Boh., and other (probably several) species of *Cryptorhynchus*, in the species of the genus *Camptorhinus*, in *Gasterocercus propugnator*, Sch., *Ectatorhina wallacei*, Lac., and in other genera. The form and position of the pygidial files in the female of *C. lirinus*, figs. 12 and 12*b*, and of *Camptorhinus* sp., figs. 13 and 13*b*, are shown on Pl. VII; in both cases, as in others of the same kind, each of the two files lies along the inner side of a conspicuous triangular area, the outer part of which is usually covered with a fine silky pubescence. A strongly-marked ridge which crosses the underside of the elytron obliquely a little in front of the apex acts as the scraper, the inner part of the ridge (that next the suture) being almost directly transverse and somewhat sharper than the rest (see Pl. VII, figs. 12*a* and 13*a*). A similar ridge present in the males of the stridulating species, stops short as a rule before reaching the suture, allowing the elytral file to extend forwards a short way in front of it (see fig. 5*a*). This condition occurs also in those females in which the files are situated on the elytra.

The scraping of the elytral files is usually effected by means of a series of little granules or tubercles placed at intervals along the pygidium in the females, and along the

pro-pygidium in the males. The species I have selected to be figured (see Pl. VII, figs. 5 and 6) in order to show these structures best are *Cryptorhynchinæ* of a genus to which Jekel gave the MS. name of *Eupterus*. In the males the scraping tubercles are of such a kind as is usually met with in the other stridulating *Curculionidæ*, but are somewhat more numerous. Those of the female are exceptional in character, they are few in number, of relatively large size, and each is crossed by a series of small ridges (Pl. VII, fig. 6*b*), appearing to be the commencement of what would in time develop into complete pygidial files like those present in the females of other forms.

The stridulating organs of the *Curculionidæ* are on the whole very interesting. They appear to be confined chiefly to the *Cryptorhynchinæ* and a few allied groups, and a more detailed study of them with a view to their use in classification would, I believe, well repay any student working at those groups.

Stridulating areas are situated on the dorsal side of the abdomen in the genus *Necrophorus*, in *Oryctes* and other genera of *Dynastidæ*, in the genera *Lema* and *Crioceris* of the family *Crioceridæ*, and in the males of the Tenebrionid genus *Heliopathes*.

In *Necrophorus* they are narrow and strongly raised, forming two very distinct and conspicuous files on the back of the fifth segment. A short transverse ridge on the underside of each elytron just in front of its apex acts as a scraper. In the *Dyanastidæ* they are usually on the pro-pygidium, and as a rule single; while in *Lema*, *Crioceris* and *Heliopathes* they are double, and placed on the pygidium. There are no special scraping ridges on the elytra in *Lema* and *Crioceris*, but in the males of some species of *Heliopathes*, as Darwin has already noticed, each elytron is furnished near the apex with a special series of short ridges. Sexual differences in the structure of the stridulating areas have been noticed in the *Dynastidæ*, Darwin finding in three or four species of *Oryctes*, that the striæ are coarser and more regular in the male than in the female. The same kind of difference, but even more pronounced, is met with in *Camelonotus*, another genus of that family.

In the water-beetles of the genus *Colymbetes*, there is a series of short longitudinal or oblique ridges, placed close to the hind border, on each side of the second ventral

segment of the abdomen. These ridges have been referred to by different authors, as a stridulating apparatus, but I think they can only be doubtfully regarded as such. I am not aware that these beetles have ever been heard to stridulate.

As these pages were passing through the press, Mr. Distant called my attention to some remarks in reference to stridulation which appear in a work entitled "On the Indian Hills," by Edwin Lester Arnold (vol. ii. p. 313). Mr. Arnold, struck by the loud noise made by a large Longicorn beetle, *Batocera rubus*, was desirous to find out how the sound was produced, so he "took him home and investigated"; and with what result, he goes on to tell us: "He squeaked most strangely all the time, moving his head backward and forwards and waving his antennæ. This gave me a clue, and I dipped a small feather in oil and passed it lightly round the junction of the head and thorax, and in a moment all sounds ceased though the insect still continued his movements, and it was plain the sound had been caused by friction of his head and neck."

Now as it is well known that *Batocera* squeaks like other Longicorns by rubbing the prothorax over the stridulating area on the mesonotum, which is very large and conspicuous in this genus, I am at a loss to explain why all sounds ceased when oil was passed between the head and prothorax. The inference drawn by Mr. Arnold was of course wrong, but it serves to show how easily mistakes of the kind may be made, even by painstaking investigators.

Explanation of Plate VII.

[*See explanation facing the* Plate.]

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