CHAPTER X.

SECONDARY SEXUAL CHARACTERS OF INSECTS.

IN the immense class of insects the sexes sometimes differ in their locomotive-organs, and often in their sense-organs, as in the pectinated and beautifully plumose antennae of the males of many species. In Chloeon, one of the Ephemerae, the male has great pillared eyes, of which the female is entirely destitute.* The ocelli are absent in the females of certain insects, as in the Multillidae; and here the females are likewise wingless. But we are chiefly concerned with structures by which one male is enabled to conquer another, either in battle or courtship, through his strength, pugnacity, ornaments, or music. The innumerable contrivances, therefore, by which the male is able to seize the female, may be briefly passed over. Besides the complex structures at the apex of the abdomen, which ought perhaps to be ranked as primary organs,*(2) "it is astonishing," as Mr. B. D. Walsh*(3) has remarked, "how many different organs are worked in by nature for the seemingly insignificant object of enabling the male to grasp the female firmly." The mandibles or jaws are sometimes used for this purpose; thus the male Corydalis cornutus (a neuropterous insect in some degree allied to the dragon flies, &c.) has immense curved jaws, many times longer than those of the female; and they are smooth instead of being toothed, so that he is thus enabled to seize her without injury.*(4) One of the stag-beetles of North America (Lucanus elaphus) uses his jaws, which are much larger than those of the female, for the same purpose, but probably likewise for fighting. In one of the sand-wasps (Ammophila) the jaws in the two sexes are closely alike, but are used for widely different purposes: the males, as Professor Westwood observes, "are exceedingly ardent, seizing their partners round the neck with their sickle-shaped jaws";*(5) whilst the females use these organs for burrowing in sand-banks and making their nests.

* Sir J. Lubbock, Transact. Linnean Soc., vol. xxv, 1866, p. 484. With respect to the Mutillidae, see Westwood, Modern Class. of Insects, vol. ii., p. 213.

*(2) These organs in the male often differ in closely-allied species, and afford excellent specific characters. But their importance, from a functional point of view, as Mr. R. MacLachlan has remarked to me, has probably been overrated. It has been suggested, that slight differences in these organs would suffice to prevent the intercrossing of well-marked varieties or incipient species, and would thus aid in their development. That this can hardly be the case, we may infer from the many recorded cases (see, for instance, Bronn, Geschichte der Natur, B. ii., 1843, s. 164; and Westwood, Transact. Ent. Soc., vol. iii., 1842, p. 195) of distinct species having been observed in union. Mr. MacLachlan informs me (vide Stett. Ent. Zeitung, 1867, s. 155) that when several species of Phryganidae, which present strongly-pronounced differences of this kind, were confined together by Dr. Aug. Meyer, they coupled, and one pair produced fertile ova.

*(3) The Practical Entomologist, Philadelphia, vol. ii., May, 1867, p 88.

*(4) Mr. Walsh, ibid., p. 107.

*(5) Modern Classification of Insects, vol. ii., 1840, pp. 205, 206. Mr. Walsh, who called my attention to the double use of the jaws, says that he has repeatedly observed this fact.

The tarsi of the front-legs are dilated in many male beetles, or are furnished with broad cushions of hairs; and in many genera of water-beetles they are armed with a round flat sucker, so that the male may adhere to the slippery body of the female. It is a much more unusual circumstance that the females of some water-beetles

(Dytiscus) have their elytra deeply grooved, and in Acilius sulcatus thickly set with hairs, as an aid to the male. The females of some other water-beetles (Hydroporus) have their elytra punctured for the same purpose.* In the male of Crabrocribrarius (see fig. 9), it is the tibia which is dilated into a broad horny plate, with minute membraneous dots, giving to it a singular appearance like that of a riddle.*(2) In the male of Penthe (a genus of beetles) a few of the middle joints of the antennae are dilated and furnished on the inferior surface with cushions of hair, exactly like those on the tarsi of the Carabidae, "and obviously for the same end." In male dragon-flies, "the appendages at the tip of the tail are modified in an almost infinite variety of curious patterns to enable them to embrace the neck of the female." Lastly, in the males of many insects, the legs are furnished with peculiar spines, knobs or spurs; or the whole leg is bowed or thickened, but this is by no means invariably a sexual character; or one pair, or all three pairs are elongated, sometimes to an extravagant length.*(3)

* We have here a curious and inexplicable case of dimorphism, for some of the females of four European species of Dysticus, and of certain species of Hydroporus, have their elytra smooth; and no intermediate gradations between the sulcated or punctured, and the quite smooth elytra have been observed. See Dr. H. Schaum, as quoted in the Zoologist, vols. v.-vi., 1847-48, p. 1896. Also Kirby and Spence, Introduction to Entomology, vol. iii., 1826, p. 305.

*(2) Westwood, Modern Class., vol. ii., p. 193. The following statement about Penthe, and others in inverted commas, are taken from Mr. Walsh, Practical Entomologist, Philadelphia, vol. iii., p. 88.

*(3) Kirby and Spence, Introduct. &c., vol. iii., pp. 332-336.

The sexes of many species in all the orders present differences, of which the meaning is not understood. One curious case is that of a beetle (see fig. 10), the male of which has left mandible much enlarged; so that the mouth is greatly distorted. In another carabidous beetle, Eurygnathus,* we have the case, unique as far as known to Mr. Wollaston, of the head of the female being much broader and larger, though in a variable degree, than that of the male. Any number of such cases could be given. They abound in the Lepidoptera: one of the most extraordinary is that certain male butterflies have their fore-legs more or less atrophied, with the tibiae and tarsi reduced to mere rudimentary knobs. The wings, also, in the two sexes often differ in neuration,*(2) and sometimes considerably in outline, as in the Aricoris epitus, which was shewn to me in the British Museum by Mr. A. Butler. The males of certain South American butterflies have tufts of hair on the margins of the wings, and horny excrescences on the discs of the posterior pair.*(3) In several British butterflies, as shewn by Mr. Wonfor, the males alone are in parts clothed with peculiar scales.

* Insecta Maderensia, 1854, page 20.

*(2) E. Doubleday, Annals and Mag. of Nat. Hist., vol. i., 1848, p. 379. I may add that the wings in certain Hymenoptera (see Shuckard, Fossorial Hymenoptera, 1837, pp. 39-43) differ in neuration according to sex.

*(3) H. W. Bates, in Journal of Proc. Linn. Soc., vol. vi., 1862, p. 74. Mr. Wonfor's observations are quoted in Popular Science Review, 1868, p. 343.

The use of the bright light of the female glow-worm has been subject to much discussion. The male is feebly luminous, as are the larvae and even the eggs. It has been supposed by some authors that the light serves to frighten away enemies, and by others to guide the male to the female. At last, Mr. Belt* appears to have solved the difficulty: he finds that all the Lampyridae which he has tried are

highly distasteful to insectivorous mammals and birds. Hence it is in accordance with Mr. Bates' view, hereafter to be explained, that many insects mimic the Lampyridae closely, in order to be mistaken for them, and thus to escape destruction. He further believes that the luminous species profit by being at once recognised as unpalatable. It is probable that the same explanation may be extended to the elaters, both sexes of which are highly luminous. It is not known why the wings of the female glow-worm have not been developed; but in her present state she closely resembles a larva, and as larvae are so largely preyed on by many animals, we can understand why she has been rendered so much more luminous and conspicuous than the male; and why the larvae themselves are likewise luminous.

* The Naturalist in Nicaragua, 1874, pp. 316-320. On the phosphorescence of the eggs, see Annals and Magazine of Natural History, Nov., 1871, p. 372.

Difference in Size between the Sexes.- With insects of all kinds the males are commonly smaller than the females; and this difference can often be detected even in the larval state. So considerable is the difference between the male and female cocoons of the silk-moth (Bombyx mori), that in France they are separated by a particular mode of weighing.* In the lower classes of the animal kingdom, the greater size of the females seems generally to depend on their developing an enormous number of ova; and this may to a certain extent hold good with insects. But Dr. Wallace has suggested a much more probable explanation. He finds, after carefully attending to the development of the caterpillars of Bombyx cynthia and yamamai, and especially to that of some dwarfed caterpillars reared from a second brood on unnatural food, "that in proportion as the individual moth is finer, so is the time required for its metamorphosis longer; and for this reason the female, which is the larger and heavier insect, from having to carry her numerous eggs, will be preceded by the male, which is smaller and has less to mature."*(2) Now as most insects are short-lived, and as they are exposed to many dangers, it would manifestly be advantageous to the female to be impregnated as soon as possible. This end would be gained by the males being first matured in large numbers ready for the advent of the females; and this again would naturally follow, as Mr. A. R. Wallace has remarked,*(3) through natural selection; for the smaller males would be first matured, and thus would procreate a large number of offspring which would inherit the reduced size of their male parents, whilst the larger males from being matured later would leave fewer offspring.

* Robinet, Vers a Soie, 1848, p. 207.
*(2) Transact. Ent. Soc., 3rd series, vol. v., p. 486.
*(3) Journal of Proc. Ent. Soc., Feb. 4, 1867, p. lxxi.

There are, however, exceptions to the rule of male insects being smaller than the females: and some of these exceptions are intelligible. Size and strength would be an advantage to the males, which fight for the possession of the females; and in these cases, as with the stagbeetle (Lucanus), the males are larger than the females. There are, however, other beetles which are not known to fight together, of which the males exceed the females in size; and the meaning of this fact is not known; but in some of these cases, as with the huge Dynastes and Megasoma, we can at least see that there would be no necessity for the males to be smaller than the females, in order to be matured before them, for these beetles are not short-lived, and there would be ample time for the pairing of the sexes. So again, male dragon-flies (Libellulidae) are sometimes sensibly larger, and never smaller, than the females;* and as Mr. MacLachlan believes, they do not generally pair with the females until a week or fortnight has elapsed, and until they have assumed their proper masculine colours. But the most curious case, shewing on what

complex and easily-overlooked relations, so trifling a character as difference in size between the sexes may depend, is that of the aculeate Hymenoptera; for Mr. F. Smith informs me that throughout nearly the whole of this large group, the males, in accordance with the general rule, are smaller than the females, and emerge about a week before them; but amongst the bees, the males of Apis mellifica, Anthidium manicatum, and Anthophora acervorum, and amongst the fosseres, the males of the Methoca ichneumonides, are larger than the females. The explanation of this anomaly is that a marriage flight is absolutely necessary with these species, and the male requires great strength and size in order to carry the female through the air. Increased size has here been acquired in opposition to the usual relation between size and the period of development, for the males, though larger, emerge before the smaller females.

* For this and other statements on the size of the sexes, see Kirby and Spence, ibid., vol. iii., p. 300; on the duration of life in insects, see p. 344.

We will now review the several Orders, selecting such facts as more particularly concern us. The Lepidoptera (butterflies and moths) will be retained for a separate chapter.

Order: THYSANURA.- The members of this lowly organised order are wingless, dull-coloured, minute insects, with ugly, almost mis-shapen heads and bodies. Their sexes do not differ, but they are interesting as shewing us that the males pay sedulous court to the females even low down in the animal scale. Sir J. Lubbock* says: "It is very amusing to see these little creatures (Smynthurus luteus) coquetting together. The male, which is much smaller than the female, runs round her, and they butt one another, standing face to face and moving backward and forward like two playful lambs. Then the female pretends to run away and the male runs after her with a queer appearance of anger, gets in front and stands facing her again; then she turns coyly round, but he, quicker and more active, scuttles round too, and seems to whip her with his antennae; then for a bit they stand face to face, play with their antennae, and seem to be all in all to one another."

* Transact. Linnean Soc., vol. xxvi., 1868, p. 296.

Order: DIPTERA (Flies).- The sexes differ little in colour. The greatest difference, known to Mr. F. Walker, is in the genus Bibio, in which the males are blackish or quite black, and the females obscure brownish-orange. The genus Elaphomyia, discovered by Mr. Wallace* in New Guinea, is highly remarkable, as the males are furnished with horns, of which the females are quite destitute. The horns spring from beneath the eyes, and curiously resemble those of a stag, being either branched or palmated. In one of the species, they equal the whole body in length. They might be thought to be adapted for fighting, but as in one species they are of a beautiful pink colour, edged with black, with a pale central stripe, and as these insects have altogether a very elegant appearance, it is perhaps more probable that they serve as ornaments. That the males of some Diptera fight together is certain; Prof. Westwood*(2) has several times seen this with the Tipulae. The males of other Diptera apparently try to win the females by their music: H. Muller*(3) watched for some time two males of an Eristalis courting a female; they hovered above her, and flew from side to side, making a high humming noise at the same time. Gnats and mosquitoes (Culicidae) also seem to attract each other by humming; and Prof. Mayer has recently ascertained that the hairs on the antennae of the male vibrate in unison with the notes of a tuning-fork, within the range of the sounds emitted by the female. The longer hairs vibrate sympathetically with the graver notes, and the shorter hairs with the higher ones. Landois also asserts that he has

repeatedly drawn down a whole swarm of gnats by uttering a particular note. It may be added that the mental faculties of the Diptera are probably higher than in most other insects, in accordance with their highly-developed nervous System.*(4)

* The Malay Archipelago, vol. ii., 1869, p. 313.
*(2) Modern Classification of Insects, vol. ii., 1840, p. 526.
*(3) "Anwendung," &c., Verh. d. n. V. Jahrg. xxix. p. 80. Mayer, in American Naturalist, 1874, p. 236.
*(4) See Mr. B. T. Lowne's interesting work, On the Anatomy of the Blowfly, Musca vomitoria, 1870, p. 14. He remarks (p. 33) that, "the captured flies utter a peculiar plaintive note, and that this sound causes other flies to disappear."

Order: HEMIPTERA (Field-Bugs).- Mr. J. W. Douglas, who has particularly attended to the British species, has kindly given me an account of their sexual differences. The males of some species are furnished with wings, whilst the females are wingless; the sexes differ in the form of their bodies, elytra, antennae and tarsi; but as the signification of these differences is unknown, they may be here passed over. The females are generally larger and more robust than the males. With British, and, as far as Mr. Douglas knows, with exotic species, the sexes do not commonly differ much in colour; but in about six British species the male is considerably darker than the female, and in about four other species the female is darker than the male. Both sexes of some species are beautifully coloured; and as these insects emit an extremely nauseous odour, their conspicuous colours may serve as a signal that they are unpalatable to insectivorous animals. In some few cases their colours appear to be directly protective: thus Prof. Hoffmann informs me that he could hardly distinguish a small pink and green species from the buds on the trunks of lime-trees, which this insect frequents.

Some species of Reduvidae make a stridulating noise; and, in the case of Pirates stridulus, this is said* to be effected by the movement of the neck within the prothoracic cavity. According to Westring, Reduvius personatus also stridulates. But I have no reason to suppose that this is a sexual character, excepting that with non-social insects there seems to be no use for sound-producing organs, unless it be as a sexual call.

* Westwood, Modern Classification of Insects, vol. ii., p. 473.

Order: HOMOPTERA.- Every one who has wandered in a tropical forest must have been astonished at the din made by the male Cicadae. The females are mute; as the Grecian poet Xenarchus says, "Happy the cicadas live, since they all have voiceless wives." The noise thus made could be plainly heard on board the Beagle, when anchored at a quarter of a mile from the shore of Brazil; and Captain Hancock says it can be heard at the distance of a mile. The Greeks formerly kept, and the Chinese now keep these insects in cages for the sake of their song, so that it must be pleasing to the ears of some men.* The Cicadidae usually sing during the day, whilst the Fulgoridae appear to be night-songsters. The sound, according to Landois,*(2) is produced by the vibration of the lips of the spiracles, which are set into motion by a current of air emitted from the tracheae; but this view has lately been disputed. Dr. Powell appears to have proved*(3) that it is produced by the vibration of a membrane, set into action by a special muscle. In the living insect, whilst stridulating, this membrane can be seen to vibrate; and in the dead insect the proper sound is heard, if the muscle, when a little dried and hardened, is pulled with the point of a pin. In the female the whole complex musical apparatus is present, but is much less developed than in the male, and is never used for producing sound.

* These particulars are taken from Westwood's Modern

Classification of Insects, vol. ii., 1840, p. 422. See, also, on the Fulgoridae, Kirby and Spence, Introduct., vol. ii., p. 401.

*(2) Zeitschrift fur wissenschaft Zoolog., B. xvii., 1867, ss. 152-158.

*(3) Transactions of the New Zealand Institute, vol. v., 1873, p. 286.

With respect to the object of the music. Dr. Hartman, in speaking of the Cicada septemdecim of the United States, says,* "The drums are now (June 6th and 7th, 1851) heard in all directions. This I believe to be the martial summons from the males. Standing in thick chestnut sprouts about as high as my head, where hundreds were around me, I observed the females coming around the drumming males." He adds, "This season (Aug. 1868) a dwarf pear tree in my garden produced about fifty larvae of C. pruinosa; and I several times noticed the females to alight near a male while he was uttering his clanging notes." Fritz Muller writes to me from S. Brazil that he has often listened to a musical contest between two or three males of a species with a particularly loud voice, seated at a considerable distance from each other: as soon as one had finished his song, another immediately begun, and then another. As there is so much rivalry between the males, it is probable that the females not only find them by their sounds, but that, like female birds, they are excited or allured by the male with the most attractive voice.

* I am indebted to Mr. Walsh for having sent me this extract from A Journal of the Doings of Cicada septemdecim, by Dr. Hartman.

I have not heard of any well-marked cases of ornamental differences between the sexes of the Homoptera. Mr. Douglas informs me that there are three British species, in which the male is black or marked with black bands, whilst the females are pale-coloured or obscure.

Order: ORTHOPTERA (Crickets and Grasshoppers).- The males in the three saltatorial families in this Order are remarkable for their musical powers, namely the Achetidae or crickets, the Locustidae for which there is no equivalent English name, and the Acridiidae or grasshoppers. The stridulation produced by some of the Locustidae is so loud that it can be heard during the night at the distance of a mile;* and that made by certain species is not unmusical even to the human ear, so that the Indians on the Amazons keep them in wicker cages. All observers agree that the sounds serve either to call or excite the mute females. With respect to the migratory locusts of Russia, Korte has given*(2) an interesting case of selection by the female of a male. The males of this species (Pachytylus migratorius) whilst coupled with the female stridulate from anger or jealousy, if approached by other males. The house-cricket when surprised at night uses its voice to warn its fellows.*(3) In North America the katydid (Platyphyllum concavum, one of the Locustidae) is described*(4) as mounting on the upper branches of a tree, and in the evening beginning "his noisy babble, while rival notes issue from the neighbouring trees, and the graves resound with the call of Katy-did-she-did the live-long night." Mr. Bates, in speaking of the European field-cricket (one of the Achetidae), says "the male has been observed to place himself in the evening at the entrance of his burrow, and stridulate until a female approaches, when the louder notes are succeeded by a more subdued tone, whilst the successful musician caresses with his antennae the mate he has won."*(5) Dr. Scudder was able to excite one of these insects to answer him, by rubbing on a file with a quill.*(6) In both sexes a remarkable auditory apparatus has been discovered by von Siebold, situated in the front legs.*(7)

* L. Guilding, Transactions of the Linnean Society, vol. xv., p. 154.

*(2) I state this on the authority of Koppen, "Uber die Heuschrecken in Sudrussland," 1866, p. 32, for I have in vain endeavoured to procure Korte's work.

*(3) Gilbert White, Natural History of Selborne, vol. ii., 1825, p. 262.

*(4) Harris, Insects of New England, 1842, p. 128.

*(5) The Naturalist on the Amazons, vol. i., 1863, p. 252. Mr. Bates gives a very interesting discussion on the gradations in the musical apparatus of the three families. See also Westwood, Modern Classification of Insects, vol. ii., pp. 445 and 453.

*(6) Proceedings of the Boston Society of Natural History, vol. xi., April, 1868.

*(7) Nouveau Manuel d'Anat. Comp., French translat., tom. 1, 1850, p. 567.

In the three families the sounds are differently produced. In the males of the Achetidae both wing-covers have the same apparatus; and this in the field cricket (see Gryllus campestris, fig. 11) consists, as described by Landois,* of from 131 to 138 sharp, transverse ridges or teeth (st) on the under side of one of the nervures of the wing-cover. This toothed nervure is rapidly scraped across a projecting, smooth, hard nervure (r) on the upper surface of the opposite wing. First one wing is rubbed over the other, and then the movement is reversed. Both wings are raised a little at the same time, so as to increase the resonance. In some species the wing-covers of the males are furnished at the base with a talc-like plate.*(2) I here give a drawing (see fig. 12) of the teeth on the under side of the nervure of another species of Gryllus, viz., G. domesticus. With respect to the formation of these teeth, Dr. Gruber has shown*(3) that they have been developed by the aid of selection, from the minute scales and hairs with which the wings and body are covered, and I came to the same conclusion with respect to those of the Coleoptera. But Dr. Gruber further shews that their development is in part directly due to the stimulus from the friction of one wing over the other.

* Zeitschrift fur wissenschaft. Zoolog., B. xvii., 1867, s. 117.

*(2) Westwood, Modern Classification of Insects, vol. i., p. 440.

*(3) "Uber der Tonapparat der Locustiden, ein Beitrage zum Darwinismus," Zeitschrift fur wissenschaft. Zoolog., B. xxii., 1872, p. 100.

In the Locustidae the opposite wing-covers differ from each other in structure (see fig. 13), and the action cannot, as in the last family, be reversed. The left wing, which acts as the bow, lies over the right wing which serves as the fiddle. One of the nervures (a) on the under surface of the former is finely serrated, and is scraped across the prominent nervures on the upper surface of the opposite or right wing. In our British Phasgonura viridissima it appeared to me that the serrated nervure is rubbed against the rounded hind-corner of the opposite wing, the edge of which is thickened, coloured brown, and very sharp. In the right wing, but not in the left, there is a little plate, as transparent as talc, surrounded by nervures, and called the speculum. In Ephippiger vitium, a member of this same family, we have a curious subordinate modification; for the wing-covers are greatly reduced in size, but "the posterior part of the pro-thrax is elevated into a kind of dome over the wing-covers, and which has probably the effect of increasing the sound."*

* Westwood Modern Classification of Insects, vol. i., p. 453.

We thus see that the musical apparatus is more differentiated or specialised in the Locustidae (which include, I believe, the most powerful performers in the Order), than in the Achetidae, in which both wing-covers have the same structure and the same function.*

Landois, however, detected in one of the Locustidae, namely in Decticus, a short and narrow row of small teeth, mere rudiments, on the inferior surface of the right wing-cover, which underlies the other and is never used as the bow. I observed the same rudimentary structure on the under side of the right wing-cover in Phasgonura viridissima. Hence we may infer with confidence that the Locustidae are descended from a form, in which, as in the existing Achetidae, both wing-covers had serrated nervures on the under surface, and could be indifferently used as the bow; but that in the Locustidae the two wing-covers gradually became differentiated and perfected, on the principle of the division of labour, the one to act exclusively as the bow, and the other as the fiddle. Dr. Gruber takes the same view, and has shewn that rudimentary teeth are commonly found on the inferior surface of the right wing. By what steps the more simple apparatus in the Achetidae originated, we do not know, but it is probable that the basal portions of the wing-covers originally overlapped each other as they do at present; and that the friction of the nervures produced a grating sound, as is now the case with the wing-covers of the females.*(2) A grating sound thus occasionally and accidentally made by the males, if it served them ever so little as a love-call to the females, might readily have been intensified through sexual selection, by variations in the roughness of the nervures having been continually preserved.

* Landois, Zeitschrift fur wissenschaft. Zoolog., B. xvii., 1867, ss. 121, 122.

*(2) Mr. Walsh also informs me that he has noticed that the female of the Platyphyllum concavum, "when captured makes a feeble grating noise by shuffling her wing-covers together."

In the last and third family, namely the Acridiidae or grasshoppers, the stridulation is produced in a very different manner, and according to Dr. Scudder, is not so shrill as in the preceding families. The inner surface of the femur (see fig. 14, r) is furnished with a longitudinal row of minute, elegant, lancet-shaped, elastic teeth, from 85 to 93 in number;* and these are scraped across the sharp, projecting nervures on the wing-covers, which are thus made to vibrate and resound. Harris*(2) says that when one of the males begins to play, he first "bends the shank of the hind-leg beneath the thigh, where it is lodged in a furrow designed to receive it, and then draws the leg briskly up and down. He does not play both fiddles together, but alternately, first upon one and then on the other." In many species, the base of the abdomen is hollowed out into a great cavity which is believed to act as a resounding board. In Pneumora (see fig. 15), a S. African genus belonging to the same family, we meet with a new and remarkable modification; in the males a small notched ridge projects obliquely from each side of the abdomen, against which the hind femora are rubbed.*(3) As the male is furnished with wings (the female being wingless), it is remarkable that the thighs are not rubbed in the usual manner against the wing-covers; but this may perhaps be accounted for by the unusually small size of the hind-legs. I have not been able to examine the inner surface of the thighs, which, judging from analogy, would be finely serrated. The species of Pneumora have been more profoundly modified for the sake of stridulation than any other orthopterous insect; for in the male the whole body has been converted into a musical instrument, being distended with air, like a great pellucid bladder, so as to increase the resonance. Mr. Trimen informs me that at the Cape of Good Hope these insects make a wonderful noise during the night.

* Landois, ibid., s. 113.

*(2) Insects of New England, 1842, p. 133.

*(3) Westwood, Modern Classification, vol i., p. 462.

In the three foregoing families, the females are almost always

destitute of an efficient musical apparatus. But there are a few exceptions to this rule, for Dr. Gruber has shewn that both sexes of Ephippiger vitium are thus provided; though the organs differ in the male and female to a certain extent. Hence we cannot suppose that they have been transferred from the male to the female, as appears to have been the case with the secondary sexual characters of many other animals. They must have been independently developed in the two sexes, which no doubt mutually call to each other during the season of love. In most other Locustidae (but not, according to Landois, in Decticus) the females have rudiments of the stridulatory organs proper to the male; from whom it is probable that these have been transferred. Landois also found such rudiments on the under surface of the wing-covers of the female Achetidae, and on the femora of the female Acridiidae. In the Homoptera, also, the females have the proper musical apparatus in a functionless state; and we shall hereafter meet in other divisions of the animal kingdom with many instances of structures proper to the male being present in a rudimentary condition of the female.

Landois has observed another important fact, namely, that in the females of the Acridiidae, the stridulating teeth on the femora remain throughout life in the same condition in which they first appear during the larval state in both sexes. In the males, on the other hand, they become further developed, and acquire their perfect structure at the last moult, when the insect is mature and ready to breed.

From the facts now given, we see that the means by which the males of the Orthoptera produce their sounds are extremely diversified, and are altogether different from those employed by the Homoptera.* But throughout the animal kingdom we often find the same object gained by the most diversified means; this seems due to the whole organisation having undergone multifarious changes in the course of ages, and as part after part varied different variations were taken advantage of for the same general purpose. The diversity of means for producing sound in the three families of the Orthoptera and in the Homoptera, impresses the mind with the high importance of these structures to the males, for the sake of calling or alluring the females. We need feel no surprise at the amount of modification which the Orthoptera have undergone in this respect, as we now know, from Dr. Scudder's remarkable discovery,*(2) that there has been more than ample time. This naturalist has lately found a fossil insect in the Devonian formation of New Brunswick, which is furnished with "the well-known tympanum or stridulating apparatus of the male Locustidae." The insect, though in most respects related to the Neuroptera, appears, as is so often the case with very ancient forms, to connect the two related Orders of the Neuroptera and Orthoptera.

* Landois has recently found in certain Orthoptera rudimentary structures closely similar to the sound-producing organs in the Homoptera; and this is a surprising fact. See Zeitschrift fur wissenschaft. Zoolog., B. xxii., Heft 3, 1871, p. 348.

*(2) Transactions, Entomological Society, 3rd series, vol. ii. (Journal of Proceedings, p. 117).

I have but little more to say on the Orthoptera. Some of the species are very pugnacious: when two male field-crickets (Gryllus campestris) are confined together, they fight till one kills the other; and the species of mantis are described as manoeuvring with their swordlike front-limbs, like hussars with their sabres. The Chinese keep these insects in little bamboo cages, and match them like game-cocks.* With respect to colour, some exotic locusts are beautifully ornamented; the posterior wings being marked with red, blue, and black; but as throughout the Order the sexes rarely differ much in colour, it is not probable that they owe their bright tints to sexual selection. Conspicuous colours may be of use to these

insects, by giving notice that they are unpalatable. Thus it has been observed*(2) that a bright-coloured Indian locust was invariably rejected when offered to birds and lizards. Some cases, however, are known of sexual differences in colour in this Order. The male of an American cricket*(3) is described as being as white as ivory, whilst the female varies from almost white to greenish-yellow or dusky. Mr. Walsh informs me that the adult male of Spectrum femoratum (one of the Phasmidae) "is of a shining brownish-yellow colour; the adult female being of a dull, opaque, cinereous brown; the young of both sexes being green." Lastly, I may mention that the male of one curious kind of cricket*(4) is furnished with "a long membranous appendage, which falls over the face like a veil"; but what its use may be, is not known.

* Westwood, Modern Classification of Insects, vol. i., p. 427; for crickets, p. 445.

*(2) Mr. Ch. Horne, in Proceedings of the Entomological Society, May 3, 1869, p. xii.

*(3) "The Oecanthus nivalis," Harris, Insects of New England, 1842, p. 124. The two sexes of OE. pellucidus of Europe differ, as I hear from Victor Carus, in nearly the same manner.

*(4) Platyblemnus: Westwood, Modern Classification, vol. i., p. 447.

Order: NEUROPTERA.- Little need here be said, except as to colour. In the Ephemeridae the sexes often differ slightly in their obscure tints;* but it is not probable that the males are thus rendered attractive to the females. The Libellulidae, or dragon-flies, are ornamented with splendid green, blue, yellow, and vermilion metallic tints; and the sexes often differ. Thus, as Prof. Westwood remarks,*(2) the males of some of the Agrionidae, "are of a rich blue with black wings, whilst the females are fine green with colourless wings." But in Agrion ramburii these colours are exactly reversed in the two sexes.*(3) In the extensive N. American genus of Hetaerina, the males alone have a beautiful carmine spot at the base of each wing. In Anax junius the basal part of the abdomen in the male is a vivid ultramarine blue, and in the female grass-green. In the allied genus Gomphus, on the other hand, and in some other genera, the sexes differ but little in colour. In closely-allied forms throughout the animal kingdom, similar cases of the sexes differing greatly, or very little, or not at all, are of frequent occurrence. Although there is so wide a difference in colour between the sexes of many Libellulidae, it is often difficult to say which is the more brilliant; and the ordinary coloration of the two sexes is reversed, as we have just seen, in one species of Agrion. It is not probable that their colours in any case have been gained as a protection. Mr. MacLachlan, who has closely attended to this family, writes to me that dragon-flies- the tyrants of the insect-world- are the least liable of any insect to be attacked by birds or other enemies, and he believes that their bright colours serve as a sexual attraction. Certain dragon-flies apparently are attracted by particular colours: Mr. Patterson observed*(4) that the Agrionidae, of which the males are blue, settled in numbers on the blue float of a fishing line; whilst two other species were attracted by shining white colours.

* B. D. Walsh, the "Pseudo-neuroptera of Illinois," in Proceedings of the Entomological Society of Philadelphia, 1862, p. 361.

*(2) Modern Classification, vol. ii., p. 37.

*(3) Walsh, ibid., p. 381. I am indebted to this naturalist for the following facts on Hetaerina, Anax, and Gomphus.

*(4) Transactions, Ent. Soc., vol. i., 1836, p. lxxxi.

It is an interesting fact, first noticed by Schelver, that, in several genera belonging to two sub-families, the males on first emergence from the pupal state, are coloured exactly like the females; but that their bodies in a short time assume a conspicuous

milky-blue tint, owing to the exudation of a kind of oil, soluble in ether and alcohol. Mr. MacLachlan believes that in the male of Libellula depressa this change of colour does not occur until nearly a fortnight after the metamorphosis, when the sexes are ready to pair.

Certain species of Neurothemis present, according to Brauer,* a curious case of dimorphism, some of the females having ordinary wings, whilst others have them "very richly netted, as in the males of the same species." Brauer "explains the phenomenon on Darwinian principles by the supposition that the close netting of the veins is a secondary sexual character in the males, which has been abruptly transferred to some of the females, instead of, as generally occurs, to all of them." Mr. MacLachlan informs me of another instance of dimorphism in several species of Agrion, in which some individuals are of an orange colour, and these are invariably females. This is probably a case of reversion; for in the true Libellulae, when the sexes differ in colour, the females are orange or yellow; so that supposing Agrion to be descended from some primordial form which resembled the typical Libellulae in its sexual characters, it would not be surprising that a tendency to vary in this manner should occur in the females alone.

* See abstract in the Zoological Record for 1867, p. 450.

Although many dragon-flies are large, powerful, and fierce insects, the males have not been observed by Mr. MacLachlan to fight together, excepting, as he believes, in some of the smaller species of Agrion. In another group in this Order, namely, the termites or white ants, both sexes at the time of swarming may be seen running about, "the male after the female, sometimes two chasing one female, and contending with great eagerness who shall win the prize."* The Atropos pulsatorius is said to make a noise with its jaws, which is answered by other individuals.*(2)

* Kirby and Spence, Introduction to Entomology, vol. ii., 1818, p. 35.

*(2) Houzeau, Etudes sur Les Facultes Mentales des Animaux, tom. i., p. 104.

Order: HYMENOPTERA.- That inimitable observer, M. Fabre,* in describing the habits of Cerceris, a wasp-like insect, remarks that "fights frequently ensue between the males for the possession of some particular female, who sits, an apparently unconcerned beholder of the struggle for supremacy, and when the victory is decided, quietly flies away in company with the conqueror." Westwood*(2) says that the males of one of the saw-flies (Tenthredinae) "have been found fighting together, with their mandibles locked." As M. Fabre speaks of the males of Cerceris striving to obtain a particular female, it may be well to bear in mind that insects belonging to this Order have the power of recognising each other after long intervals of time, and are deeply attached. For instance, Pierre Huber, whose accuracy no one doubts, separated some ants, and when, after an interval of four months, they met others which had formerly belonged to the same community, they recognised and caressed one another with their antennae. Had they been strangers they would have fought together. Again, when two communities engage in a battle, the ants on the same side sometimes attack each other in the general confusion, but they soon perceive their mistake, and the one ant soothes the other.*(3)

* See an interesting article, "The Writings of Fabre," in Nat. Hist. Review, April, 1862, p. 122.

*(2) Journal of Proceedings of Entomological Society, Sept. 7, 1863, p. 169.

*(3) P. Huber, Recherches sur les Moeurs des Fourmis, 1810, pp. 150,165.

In this Order slight differences in colour, according to sex, are common, but conspicuous differences are rare except in the family of bees; yet both sexes of certain groups are so brilliantly coloured- for instance in Chrysis, in which vermilion and metallic greens prevail- that we are tempted to attribute the result to sexual selection. In the Ichneumonidae, according to Mr. Walsh,* the males are almost universally lighter-coloured than the females. On the other hand, in the Tenthredinidae the males are generally darker than the females. In the Siricidae the sexes frequently differ; thus the male of Sirex juvencus is banded with orange, whilst the female is dark purple; but it is difficult to say which sex is the more ornamented. In Tremex columboe the female is much brighter coloured than the male. I am informed by Mr. F. Smith, that the male ants of several species are black, the females being testaceous.

* Proceedings of the Entomological Society of Philadelphia, 1866, pp. 238, 239.

In the family of bees, especially in the solitary species, as I hear from the same entomologist, the sexes often differ in colour. The males are generally the brighter, and in Bombus as well as in Apathus, much more variable in colour than the females. In Anthophora retusa the male is of a rich fulvous-brown, whilst the female is quite black: so are the females of several species of Xylocopa, the males being bright yellow. On the other hand the females of some species, as of Andraena fulva, are much brighter coloured than the males. Such differences in colour can hardly be accounted for by the males being defenceless and thus requiring protection, whilst the females are well defended by their stings. H. Muller,* who has particularly attended to the habits of bees, attributes these differences in colour in chief part to sexual selection. That bees have a keen perception of colour is certain. He says that the males search eagerly and fight for the possession of the females; and he accounts through such contests for the mandibles of the males being in certain species larger than those of the females. In some cases the males are far more numerous than the females, either early in the season, or at all times and places, or locally; whereas the females in other cases are apparently in excess. In some species the more beautiful males appear to have been selected by the females; and in others the more beautiful females by the males. Consequently in certain genera (Muller, p. 42), the males of the several species differ much in appearance, whilst the females are almost indistinguishable; in other genera the reverse occurs. H. Muller believes (p. 82) that the colours gained by one sex through sexual selection have often been transferred in a variable degree to the other sex, just as the pollen-collecting apparatus of the female has often been transferred to the male, to whom it is absolutely useless.*(2)

* "Anwendung der Darwinschen Lehre auf Bienen," Verh. d. n. V. Jahrg., xxix.

*(2) M. Perrier, in his article, "La Selection sexuelle d'apres Darwin" (Revue Scientifique, Feb., 1873, p. 868), without apparently having reflected much on the subject, objects that as the males of social bees are known to be produced from unfertilised ova, they could not transmit new characters to their male offspring. This is an extraordinary objection. A female bee fertilised by a male, which presented some character facilitating the union of the sexes, or rendering him more attractive to the female, would lay eggs which would produce only females; but these young females would next year produce males; and will it be pretended that such males would not inherit the characters of their male grandfathers? To take a case with ordinary animals as nearly parallel as possible: if a female of any white quadruped or bird were crossed by a male of a black breed, and the male and female offspring were paired together, will it be pretended that the grandchildren would not inherit a tendency to

blackness from their male grandfather? The acquirement of new characters by the sterile worker-bees is a much more difficult case, but I have endeavoured to show in my Origin of Species, how these sterile beings are subjected to the power of natural selection.

Mutilla Europaea makes a stridulating noise; and according to Goureau* both sexes have this power. He attributes the sound to the friction of the third and preceding abdominal segments, and I find that these surfaces are marked with very fine concentric ridges; but so is the projecting thoracic collar into which the head articulates, and this collar, when scratched with the point of a needle, emits the proper sound. It is rather surprising that both sexes should have the power of stridulating, as the male is winged and the female wingless. It is notorious that bees express certain emotions, as of anger, by the tone of their humming; and according to H. Muller (p. 80), the males of some species make a peculiar singing noise whilst pursuing the females.

* Quoted by Westwood, Modern Classification of Insects, vol. ii., p. 214.

Order: COLEOPTERA (Beetles).- Many beetles are coloured so as to resemble the surfaces which they habitually frequent, and they thus escape detection by their enemies. Other species, for instance diamond-beetles, are ornamented with splendid colours, which are often arranged in stripes, spots, crosses, and other elegant patterns. Such colours can hardly serve directly as a protection, except in the case of certain flower-feeding species; but they may serve as a warning or means of recognition, on the same principle as the phosphorescence of the glow-worm. As with beetles the colours of the two sexes are generally alike, we have no evidence that they have been gained through sexual selection; but this is at least possible, for they have been developed in one sex and then transferred to the other; and this view is even in some degree probable in those groups which possess other well-marked secondary sexual characters. Blind beetles, which cannot of course behold each other's beauty, never, as I hear from Mr. Waterhouse, jr., exhibit bright colours, though they often have polished coats; but the explanation of their obscurity may be that they generally inhabit caves and other obscure stations.

Some longicorns, especially certain Prionidae, offer an exception to the rule that the sexes of beetles do not differ in colour. Most of these insects are large and splendidly coloured. The males in the genus Pyrodes,* which I saw in Mr. Bates's collection, are generally redder but rather duller than the females, the latter being coloured of a more or less splendid golden-green. On the other hand, in one species the male is golden-green, the female being richly tinted with red and purple. In the genus Esmeralda the sexes differ so greatly in colour that they have been ranked as distinct species; in one species both are of a beautiful shining green, but the male has a red thorax. On the whole, as far as I could judge, the females of those Prionidae, in which the sexes differ, are coloured more richly than the males, and this does not accord with the common rule in regard to colour, when acquired through sexual selection.

* Pyrodes pulcherrimus, in which the sexes differ conspicuously, has been described by Mr. Bates in Transact. Ent. Soc., 1869, p. 50. I will specify the few other cases in which I have heard of a difference in colour between the sexes of beetles. Kirby and Spence (Introduct. to Entomology, vol. iii., p. 301) mention a Cantharis, Meloe, Rhagium, and the Leptura testacea; the male of the latter being testaceous, with a black thorax, and the female of a dull red all over. These two latter beetles belong to the family of longicorns. Messrs. R. Trimen and Waterhouse, jr., inform me of two lamellicorns, viz., a Peritrichia and Trichius, the male of the latter being more obscurely coloured than the female. In Tillus elongatus the male is

black, and the female always, as it is believed, of a dark blue colour, with a red thorax. The male, also, of Orsodacna atra, as I hear from Mr. Walsh, is black, the female (the so-called O. ruficollis) having a rufous thorax.

A most remarkable distinction between the sexes of many beetles is presented by the great horns which rise from the head, thorax, and clypeus of the males; and in some few cases from the under surface of the body. These horns, in the great family of the lamellicorns, resemble those of various quadrupeds, such as stags, rhinoceroses, &c., and are wonderful both from their size and diversified shapes.

Instead of describing them, I have given figures of the males and females of some of the more remarkable forms. (See Figs. 16 to 20.) The females generally exhibit rudiments of the horns in the form of small knobs or ridges; but some are destitute of even the slightest rudiment. On the other hand, the horns are nearly as well developed in the female as in the male Phanaeus lancifer; and only a little less well developed in the females of some other species of this genus and of Copris. I am informed by Mr. Bates that the horns do not differ in any manner corresponding with the more important characteristic differences between the several subdivisions of the family: thus within the same section of the genus Onthophagus, there are species which have a single horn, and others which have two.

In almost all cases, the horns are remarkable for their excessive variability; so that a graduated series can be formed, from the most highly developed males to others so degenerate that they can barely be distinguished from the females. Mr. Walsh* found that in Phanaeus carnifex the horns were thrice as long in some males as in others. Mr. Bates, after examining above a hundred males of Onthophagus rangifer (see fig. 20), thought that he had at last discovered a species in which the horns did not vary; but further research proved the contrary.

* Proceedings of the Entomological Society of Philadephia, 1864, p. 228.

The extraordinary size of the horns, and their widely different structure in closely-allied forms, indicate that they have been formed for some purpose; but their excessive variability in the males of the same species leads to the inference that this purpose cannot be of a definite nature. The horns do not show marks of friction, as if used for any ordinary work. Some authors suppose* that as the males wander about much more than the females, they require horns as a defence against their enemies; but as the horns are often blunt, they do not seem well adapted for defence. The most obvious conjecture is that they are used by the males for fighting together; but the males have never been observed to fight; nor could Mr. Bates, after a careful examination of numerous species, find any sufficient evidence, in their mutilated or broken condition, of their having been thus used. If the males had been habitual fighters, the size of their bodies would probably have been increased through sexual selection, so as to have exceeded that of the females; but Mr. Bates, after comparing the two sexes in above a hundred species of the Copridae, did not find any marked difference in this respect amongst well-developed individuals. In Lethrus, moreover, a beetle belonging to the same great division of the lamellicorns, the males are known to fight, but are not provided with horns, though their mandibles are much larger than those of the female.

* Kirby and Spence, Introduction to Entomology, vol. iii., P. 300.

The conclusion that the horns have been acquired as ornaments is that which best agrees with the fact of their having been so immensely, yet not fixedly, developed,- as shewn by their extreme variability in the same species, and by their extreme diversity in

closely-allied species. This view will at first appear extremely improbable; but we shall hereafter find with many animals standing much higher in the scale, namely fishes, amphibians, reptiles and birds, that various kinds of crests, knobs, horns and combs have been developed apparently for this sole purpose.

The males of Onitis furcifer (see fig. 21), and of some other species of the genus, are furnished with singular projections on their anterior femora, and with a great fork or pair of horns on the lower surface of the thorax. Judging from other insects, these may aid the male in clinging to the female. Although the males have not even a trace of a horn on the upper surface of the body, yet the females plainly exhibit a rudiment of a single horn on the head (see fig. 22, a), and of a crest (b) on the thorax. That the slight thoracic crest in the female is a rudiment of a projection proper to the male, though entirely absent in the male of this particular species, is clear: for the female of Bubas bison (a genus which comes next to Onitis) has a similar slight crest on the thorax, and the male bears a great projection in the same situation. So, again, there can hardly be a doubt that the little point (a) on the head of the female Onitis furcifer, as well as on the head of the females of two or three allied species, is a rudimentary representative of the cephalic horn, which is common to the males of so many lamellicorn beetles, as in Phanaeus (see fig. 18).

The old belief that rudiments have been created to complete the scheme of nature is here so far from holding good, that we have a complete inversion of the ordinary state of things in the family. We may reasonably suspect that the males originally bore horns and transferred them to the females in a rudimentary condition, as in so many other lamellicorns. Why the males subsequently lost their horns, we know not; but this may have been caused through the principle of compensation, owing to the development of the large horns and projections on the lower surface; and as these are confined to the males, the rudiments of the upper horns on the females would not have been thus obliterated.

The cases hitherto given refer to the lamellicorns, but the males of some few other beetles, belonging to two widely distinct groups, namely, the Curculionidae and Staphylinidae, are furnished with horns - in the former on the lower surface of the body,* in the latter on the upper surface of the head and thorax. In the Staphylinidae, the horns of the males are extraordinarily variable in the same species, just as we have seen with the lamellicorns. In Siagonium we have a case of dimorphism, for the males can be divided into two sets, differing greatly in the size of their bodies and in the development of their horns, without intermediate gradations. In a species of Bledius (see fig. 23), also belonging to the Staphylinidae, Professor Westwood states that, "male specimens can be found in the same locality in which the central horn of the thorax is very large, but the horns of the head quite rudimental; and others, in which the thoracic horn is much shorter, whilst the protuberances on the head are long."*(2) Here we apparently have a case of compensation, which throws light on that just given, of the supposed loss of the upper horns by the males of Onitis.

* Kirby and Spence, Introduction to Entomology, vol. iii., p. 329.

*(2) Modern Classification of Insects, vol. i., p. 172: Siagonium, p. 172. In the British Museum I noticed one male specimen of Siagonium in an intermediate condition, so that the dimorphism is not strict.

Law of Battle.- Some male beetles, which seem ill-fitted for fighting, nevertheless engage in conflicts for the possession of the females. Mr. Wallace* saw two males of Leptorhynchus angustatus, a linear beetle with a much elongated rostrum, "fighting for a female, who stood close by busy at her boring. They pushed at each other with their rostra, and clawed and thumped, apparently in the greatest rage." The smaller male, however, "soon ran away,

acknowledging himself vanquished." In some few cases male beetles are well adapted for fighting, by possessing great toothed mandibles, much larger than those of the females. This is the case with the common stag-beetle (Lucanus cervus), the males of which emerge from the pupal state about a week before the other sex, so that several may often be seen pursuing the same female. At this season they engage in fierce conflicts. When Mr. A. H. Davis*(2) enclosed two males with one female in a box, the larger male severely pinched the smaller one, until he resigned his pretensions. A friend informs me that when a boy he often put the males together to see them fight, and he noticed that they were much bolder and fiercer than the females, as with the higher animals. The males would seize hold of his finger, if held in front of them, but not so the females, although they have stronger jaws. The males of many of the Lucanidae as well as of the above-mentioned Leptorhynchus, are larger and more powerful insects than the females. The two sexes of Lethrus cephalotes (one of the lamellicorns) inhabit the same burrow; and the male has larger mandibles than the female. If, during the breeding-season, a strange male attempts to enter the burrow, he is attacked; the female does not remain passive, but closes the mouth of the burrow, and encourages her mate by continually pushing him on from behind; and the battle lasts until the aggressor is killed or runs away.*(3) The two sexes of another lamellicorn beetle, the Ateuchus cicatricosus, live in pairs, and seem much attached to each other; the male excites the females to roll the balls of dung in which the ova are deposited; and if she is removed, he becomes much agitated. If the male is removed the female ceases all work, and as M. Brulerie*(4) believes, would remain on the same spot until she died.

* The Malay Archipelago, vol. ii., 1869, p. 276. Riley, Sixth Report on Insects of Missouri, 1874, p. 115.

*(2) Entomological Magazine, vol. i., 1833, p. 82. See also on the conflicts of this species, Kirby and Spence, ibid., vol. iii., p. 314; and Westwood, ibid., vol. i., p. 187.

*(3) Quoted from Fischer, in Dict. Class. d'Hist. Nat., tom. x., p. 324.

*(4) Ann. Soc. Entomolog. France, 1866, as quoted in Journal of Travel, by A. Murray, 1868, p. 135.

The great mandibles of the male Lucanidae are extremely variable both in size and structure, and in this respect resemble the horns on the head and thorax of many male lamellicorns and Staphylinidae. A perfect series can be formed from the best-provided to the worst-provided or degenerate males. Although the mandibles of the common stag-beetle, and probably of many other species, are used as efficient weapons for fighting, it is doubtful whether their great size can thus be accounted for. We have seen that they are used by the Lucanus elaphus of N. America for seizing the female. As they are so conspicuous and so elegantly branched, and as owing to their great length they are not well adapted for pinching, the suspicion has crossed my mind that they may in addition serve as an ornament, like the horns on the head and thorax of the various species above described. The male Chiasognathus grantii of S. Chile- a splendid beetle belonging to the same family- has enormously developed mandibles (see fig. 24); he is bold and pugnacious; when threatened he faces round, opens his great jaws, and at the same time stridulates loudly. But the mandibles were not strong enough to pinch my finger so as to cause actual pain.

Sexual selection, which implies the possession of considerable perceptive powers and of strong passions, seems to have been more effective with the lamellicorns than with any other family of beetles. With some species the males are provided with weapons for fighting; some live in pairs and show mutual affection; many have the power of stridulating when excited; many are furnished with the most extraordinary horns, apparently for the sake of ornament; and some,

which are diurnal in their habits, are gorgeously coloured. Lastly, several of the largest beetles in the world belong to this family, which was placed by Linnaeus and Fabricius as the head of the Order.*

* Westwood, Modern Classification, vol. i., p. 184.

Stridulating organs.- Beetles belonging to many and widely distinct families possess these organs. The sound thus produced can sometimes be heard at the distance of several feet or even yards,* but it is not comparable with that made by the Orthoptera. The rasp generally consists of a narrow, slightly-raised surface, crossed by very fine, parallel ribs, sometimes so fine as to cause iridescent colours, and having a very elegant appearance under the microscope. In some cases, as with Typhoeus, minute, bristly or scale-like prominences, with which the whole surrounding surface is covered in approximately parallel lines, could be traced passing into the ribs of the rasp. The transition takes place by their becoming confluent and straight, and at the same time more prominent and smooth. A hard ridge on an adjoining part of the body serves as the scraper for the rasp, but this scraper in some cases has been specially modified for the purpose. It is rapidly moved across the rasp, or conversely the rasp across the scraper.

* Wollaston, "On Certain Musical Curculionidae," Annals and Mag. of Nat. Hist., vol. vi., 1860, p. 14.

These organs are situated in widely different positions. In the carrion-beetles (Necrophorus) two parallel rasps (see r, fig. 25) stand on the dorsal surface of the fifth abdominal segment, each rasp* consisting of 126 to 140 fine ribs. These ribs are scraped against the posterior margins of the elytra, a small portion of which projects beyond the general outline. In many Crioceridae, and in Clythra 4-punctata (one of the Chrysomelidae), and in some Tenebrionidae, &c.,*(2) the rasp is seated on the dorsal apex of the abdomen, on the pygidium or propygidium, and is scraped in the same manner by the elytra. In Heterocerus, which belongs to another family, the rasps are placed on the sides of the first abdominal segment, and are scraped by ridges on the femora.*(3) In certain Curculionidae and Carabidae,*(4) the parts are completely reversed in position, for the rasps are seated on the inferior surface of the elytra, near their apices, or along their outer margins, and the edges of the abdominal segments serve as the scrapers. In Pelobius Hermanni (one of Dytiscidae or water-beetles) a strong ridge runs parallel and near to the sutural margin of the elytra, and is crossed by ribs, coarse in the middle part, but becoming gradually finer at both ends, especially at the upper end; when this insect is held under water or in the air, a stridulating noise is produced by the extreme horny margin of the abdomen being scraped against the rasps. In a great number of longhorned beetles (Longicornia) the organs are situated quite otherwise, the rasp being on the meso-thorax, which is rubbed against the pro-thorax; Landois counted 238 very fine ribs on the rasp of Cerambyx heros.

* Landois, Zeitschrift fur wissenschaft. Zoolog., B. xvii., 1867, s. 127.

*(2) I am greatly indebted to Mr. G. B. Crotch for having sent me many prepared specimens of various beetles belonging to these three families and to others, as well as for valuable information. He believes that the power of stridulation in the Clythra has not been previously observed. I am also much indebted to Mr. E. W. Janson, for information and specimens. I may add that my son, Mr. F. Darwin, finds that Dermestes murinus stridulates, but he searched in vain for the apparatus. Scolytus has lately been described by Dr. Chapman as a stridulator, in the Entomologist's Monthly Magazine, vol. vi., p. 130.

*(3) Schiodte, translated, in Annals and Magazine of Natural History, vol. xx., 1867, p. 37.

*(4) Westring has described (Kroyer, Naturhist. Tidskrift, B. ii., 1848-49, p. 334) the stridulating organs in these two, as well as in other families. In the Carabidae I have examined Ealphrus uliginosus and Blethisa multipunctata, sent to me by Mr. Crotch. In Blethisa the transverse ridges on the furrowed border of the abdominal segment do not, as far as I could judge, come into play in scraping the rasps on the elytra.

Many lamellicorns have the power of stridulating, and the organs differ greatly in position. Some species stridulate very loudly, so that when Mr. F. Smith caught a Trox sabulosus, a gamekeeper, who stood by, thought he had caught a mouse; but I failed to discover the proper organs in this beetle. In Geotrupes and Typhaeus, a narrow ridge runs obliquely across (see r, fig. 26) the coxa of each hindleg (having in G. stercorarius 84 ribs), which is scraped by a specially projecting part of one of the abdominal segments. In the nearly allied Copris lunaris, an excessively narrow fine rasp runs along the sutural margin of the elytra, with another short rasp near the basal outer margin; but in some other Coprini the rasp is seated, according to Leconte, on the dorsal surface of the abdomen. In Oryctes it is seated on the propygidium; and, according to the same entomologist, in some other Dynastini, on the under surface of the elytra. Lastly, Westring states that in Omaloplia brunnea the rasp is placed on the pro-sternum, and the scraper on the meta-sternum, the parts thus occupying the under surface of the body, instead of the upper surface as in the Longicorns.

* I am indebted to Mr. Walsh, of Illinois, for having sent me extracts from Leconte's Introduction to Entomology, pp. 101, 143.

We thus see that in the different coleopterous families the stridulating organs are wonderfully diversified in position, but not much in structure. Within the same family some species are provided with these organs, and others are destitute of them. This diversity is intelligible, if we suppose that originally various beetles made a shuffling or hissing noise by the rubbing together of any hard and rough parts of their bodies, which happened to be in contact; and that from the noise thus produced being in some way useful, the rough surfaces were gradually developed into regular stridulating organs. Some beetles as they move, now produce, either intentionally or unintentionally, a shuffling noise, without possessing any proper organs for the purpose. Mr. Wallace informs me that the Euchirus longimanus (a lamellicorn, with the anterior legs wonderfully elongated in the male) "makes, whilst moving, a low hissing sound by the protrusion and contraction of the abdomen; and when seized it produces a grating sound by rubbing its hind-legs against the edges of the elytra." The hissing sound is clearly due to a narrow rasp running along the sutural margin of each elytron; and I could likewise make the grating sound by rubbing the shagreened surface of the femur against the granulated margin of the corresponding elytron; but I could not here detect any proper rasp; nor is it likely that I could have overlooked it in so large an insect. After examining Cychrus, and reading what Westring has written about this beetle, it seems very doubtful whether it possesses any true rasp, though it has the power of emitting a sound.

From the analogy of the Orthoptera and Homoptera, I expected to find the stridulating organs in the Coleoptera differing according to sex; but Landois, who has carefully examined several species, observed no such difference; nor did Westring; nor did Mr. G. R. Crotch in preparing the many specimens which he had the kindness to send me. Any difference in these organs, if slight, would, however, be difficult to detect, on account of their great variability. Thus, in the first pair of specimens of Necrophorus humator and of Pelobius which I

examined, the rasp was considerably larger in the male than in the female; but not so with succeeding specimens. In Geotrupes stercorarius the rasp appeared to me thicker, opaquer, and more prominent in three males than in the same number of females; in order, therefore, to discover whether the sexes differed in their power of stridulating, my son, Mr. F. Darwin, collected fifty-seven living specimens, which he separated into two lots, according as they made a greater or less noise, when held in the same manner. He then examined all these specimens, and found that the males were very nearly in the same proportion to the females in both the lots. Mr. F. Smith has kept alive numerous specimens of Monoynchus pseudacori (Curculionidae), and is convinced that both sexes stridulate, and apparently in an equal degree.

Nevertheless, the power of stridulating is certainly a sexual character in some few Coleoptera. Mr. Crotch discovered that the males alone of two species of Heliopathes (Tenebrionidae) possess stridulating organs. I examined five males of H. gibbus, and in all these there was a well-developed rasp, partially divided into two, on the dorsal surface of the terminal abdominal segment; whilst in the same number of females there was not even a rudiment of the rasp, the membrane of this segment being transparent, and much thinner than in the male. In H. cribratostriatus the male has a similar rasp, excepting that it is not partially divided into two portions, and the female is completely destitute of this organ; the male in addition has on the apical margins of the elytra, on each side of the suture, three or four short longitudinal ridges, which are crossed by extremely fine ribs, parallel to and resembling those on the abdominal rasp; whether these ridges serve as an independent rasp, or as a scraper for the abdominal rasp, I could not decide: the female exhibits no trace of this latter structure.

Again, in three species of the lamellicorn genus Oryctes, we have a nearly parallel case. In the females of O. gryphus and nasicornis the ribs on the rasp of the pro-pygidium are less continuous and less distinct than in the males; but the chief difference is that the whole upper surface of this segment, when held in the proper light, is seen to be clothed with hairs, which are absent or are represented by excessively fine down in the males. It should be noticed that in all Coleoptera the effective part of the rasp is destitute of hairs. In O. senegalensis the difference between the sexes is more strongly marked, and this is best seen when the proper abdominal segment is cleaned and viewed as a transparent object. In the female the whole surface is covered with little separate crests, bearing spines; whilst in the male these crests in proceeding towards the apex, become more and more confluent, regular, and naked; so that three-fourths of the segment is covered with extremely fine parallel ribs, which are quite absent in the female. In the females, however, of all three species of Oryctes, a slight grating or stridulating sound is produced, when the abdomen of a softened specimen is pushed backwards and forwards.

In the case of the Heliopathes and Oryctes there can hardly be a doubt that the males stridulate in order to call or to excite the females; but with most beetles the stridulation apparently serves both sexes as a mutual call. Beetles stridulate under various emotions, in the same manner as birds use their voices for many purposes besides singing to their mates. The great Chiasognathus stridulates in anger or defiance; many species do the same from distress or fear, if held so that they cannot escape; by striking the hollow stems of trees in the Canary Islands, Messrs. Wollaston and Crotch were able to discover the presence of beetles belonging to the genus Acalles by their stridulation. Lastly, the male Ateuchus stridulates to encourage the female in her work, and from distress when she is removed.* Some naturalists believe that beetles make this noise to frighten away their enemies; but I cannot think that a quadruped or bird, able to devour a large beetle, would be frightened by so slight a sound. The belief that the stridulation serves as a sexual call is supported by

the fact that death-ticks (Anobium tessellatum) are well known to answer each other's ticking, and, as I have myself observed, a tapping noise artificially made. Mr. Doubleday also informs me that he has sometimes observed a female ticking,*(2) and in an hour or two afterwards has found her united with a male, and on one occasion surrounded by several males. Finally, it is probable that the two sexes of many kinds of beetles were at first enabled to find each other by the slight shuffling noise produced by the rubbing together of the adjoining hard parts of their bodies; and that as those males or females which made the greatest noise succeeded best in finding partners, rugosities on various parts of their bodies were gradually developed by means of sexual selection into true stridulating organs.

* M. P. de la Brulerie, as quoted in Journal of Travel, A. Murray, vol. i., 1868, p. 135.

*(2) According to Mr. Doubleday, "the noise is produced by the insect raising itself on its legs as high as it can, and then striking its thorax five or six times, in rapid succession, against the substance upon which it is sitting." For references on this subject see Landois, Zeitschrift fur wissen. Zoolog., B. xvii., s. 181. Olivier says (as quoted by Kirby and Spence, Introduction to Entomology, vol. ii., p. 395) that the female of Pimelia striata produces a rather loud sound by striking her abdomen against any hard substance, "and that the male, obedient to this call, soon attends her, and they pair."