## CHAPTER VIII.

### THE EVIDENCE FROM SECONDARY SEXUAL CHARACTERS.

*The Nature of this Sort of Evidence.*

I HAVE already given many reasons for believing that the male reproductive organ is especially adapted for gathering up the gemmules which are thrown off by the cells of the body; and for transmitting them to the next generation by impregnation, thus giving rise to variation; while the transmission of the gemmules which are formed in the body of the female is not thus provided for.

If this supposition is correct, we should expect to find that a variation which first appears in a male should have more tendency to become hereditary than one which first appears in a female. Any slight change in either the male or the female body will, as we have already seen, cause all the cells which are either directly or indirectly influenced by the change to throw off gemmules. This will happen in a female body as well as in a male body, but the gemmules are, in the latter case, much more likely to be transmitted to descendants, and thus to give rise to more extended modification.

We should also expect to find that an organ which is confined to males is much more likely than one which is confined to females to undergo hereditary changes, for even if the parts of the female body give rise to gemmules as frequently as the parts of the male body, the chance of transmission is much less.

We should also expect to find that parts which are

confined to males are more variable than parts confined to females; for variation in any part is due to inheritance of a gemmule from the corresponding part of one parent or the other, but when the part is found in only one parent the gemmule must come from that parent.

As transmission of gemmules by the mother is more rare than transmission by the father, it is plain that parts which are confined to the male should be expected to vary more than parts found in the female alone.

Finally we should expect the male body as a whole to be more variable than the female body, for the same reason.

In most cases it is impossible to trace any particular variation back to its first appearance. This is almost out of the question with wild animals, and most domesticated races have been formed so slowly that it is impossible to say whether the successive steps appeared in males or in females, nor can we be sure that a variation is new when it first attracts attention. Still it is interesting to note that the sudden variation which resulted in the ancon breed of sheep was first noticed in a male, although it is, of course, impossible to say whether it was due to inheritance of gemmules from the father rather than from the mother. Certain hereditary diseases and montrosities, such as albinism or polydactylism, are fully as often traceable to a male origin as they are to a female origin, but as we know that peculiarities of this kind frequently skip a generation or two, we can never be sure that we have traced them to their origin.

In the secondary sexual characters of animals we have a class of phenomena which are not rare and exceptional, for they are numbered by hundreds of thousands, and they can be observed and studied by every one.

A secondary sexual character is a peculiarity which is not directly concerned in the reproductive process, although it is normally either confined to one sex, or else is much more developed in one sex than it is in the other. The presence of a beard is a secondary sexual character of man; the comb, wattles, spurs and brilliant plumage of the domestic cock, the horns of a stag, the tusks of an elephant, the mane of a lion, or the brilliant plumage of the peacock or of the drake, are all of them examples of this sort of organs, for they are either confined to one sex, or else they are much more conspicuous and important in one sex than they are in the other.

They furnish, like hybrids, a means of disentangling or analyzing to some extent the influence of the two sexes in heredity, and I hope to show in this and the following chapters that they furnish evidence to prove—

1. That in most animals with separate sexes the males of allied species differ more than the females from the ancestral type.

2. That organs which are confined to males or are of more importance or are more perfectly developed in them than in the females, are much more likely to give rise to hereditary modifications than parts which are confined to or are most developed in females.

3. That a part which is confined to or is most developed in males is more likely than a similar female part to vary.

4. That males are, as a rule, more variable than females.

5. That the male leads and the female follows in the evolution of new races.

There are two criteria which are of great use in the attempt to trace the path which a species has followed in its evolution. One of these is by comparison of a

species with its nearest allies. The other is by comparison of the young with the adult.

If most of the species of a genus resemble each other in certain characters, while one species presents a marked deviation, we may in most cases safely conclude that the latter species has undergone recent modification in this respect. Of course this rule does not hold good where the peculiarities of the exceptional species are features of resemblance to other genera of the family, for in this case we must conclude that it has remained comparatively stationary, while all the other species of the genus have been modified.

If in the second place we find that the adults of several related species differ greatly, while the young are much alike, we must attribute the difference in the adults to the fact that they have recently diverged from a common stock.

Now I hope to show that throughout the animal kingdom, wherever the sexes differ from each other, the general law holds good that the males of allied species differ from each other more than the females do, and that the adult male differs more than the adult female from the young. There are many marked exceptions to this law, but the existence of the law has long been recognized by all naturalists. Every one who has worked at the systematic zoology of insects or vertebrates knows how difficult it often is to decide upon the specific identity of an immature or a female specimen, even in cases where the mature males can be recognized and identified without difficulty.

Darwin's interesting essay on "Sexual Selection" is well known. It is almost entirely devoted to the study of secondary sexual characters, and to a masterly discussion of the subject in all its aspects and relations.

Darwin has gone over the whole field so thoroughly and exhaustively that little remains to be said upon the subject, and the reader who is familiar with the essay will discover that almost all the facts in this chapter are borrowed from this source.

Darwin's aim, however, is simply to show the potency of sexual selection, while our present object is to show the frequency of hereditary male modification as compared with female modifications, and I have therefore rearranged the facts, so as to give especial prominence to this aspect of the subject. The critical reader will discover that in many cases I have borrowed the descriptive portion of one of Darwin's paragraphs, but have said nothing about the theoretical portion. As Darwin's conclusions are in many cases opposed to my own, this may convey to some the impression that I have made an unfair use of the weight of his authority, and have quoted him in support of conclusions which he in reality opposes. I will refer such readers to the chapter which follows this, where I have devoted a section to a statement of Darwin's view of the origin of secondary sexual characters, and have given my reasons for believing that it is only a partial explanation of the phenomena in question.

*Examples from Various Groups of the Animal Kingdom to show that in all Groups where the Sexes are Separate the Male is, as a Rule, more Modified than the Female, and that the Adult Males of Allied Species differ more, as a Rule, than the Females or Young.*

Rotifera.—In 1849, Dalrymple (Description of an Infusory Animalcule allied to the Genus Notommata, *Phil. Trans.* 1849) made the interesting and remarkable discovery that, in one species of the Rotifera, *Notom-*

*mata Anglica*, the animals are not hermaphrodites, as earlier writers had supposed, but that the males, which are rarely met with, are very much smaller than the females. The latter sex is furnished with a digestive tract which is quite complicated in structure, and is armed at the mouth with a highly specialized masticating apparatus. The digestive organs of the male, on the other hand, are almost absent. The jaws, the œsophagus and the mouth are wanting, and the stomach and intestine are reduced to a functionless rudiment. The males receive no nourishment after they leave the egg, and they live only a short time. The presence of a digestive tract is characteristic of all groups of animals above the protozoa, so we are compelled to believe that the ancestral form from which the Rotifera are descended had, like the ordinary metazoa, a mouth, a stomach, and an intestine; and no one who is at all familiar with comparative anatomy can doubt that the male, in which it is absent, rather than the female, in which it is present, is the sex which has been modified. The digestive tract is usually one of the first parts to be developed in the embryo, and its disappearance or absence in the adult male rotifer is therefore very different from the absence of the wings in certain female insects. Wings appear very late in life, and the failure of the female to acquire them is simply an arrest short of perfect development, while the absence of digestive organs shows active degeneration. In 1855 Leydig verified Dalrymple's observation (*Zeit. f. Wiss. Zool.* vi. p. 96) in the same species, and also in a second species of the same genus; and as he was able to distinguish the outline of the male inside the egg, while this was still contained within the body of the female, he removed all reason for doubting that the two sexes belong to one

species. In these two species the females were much alike, while the males were not only very different from the females, but also from each other.

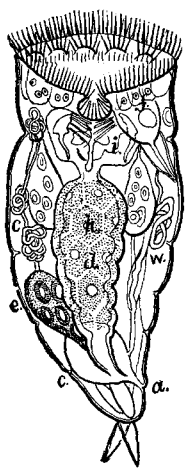


FIG. 1. Young female Rotifer. *Hydatina senta.* *a.* cloaca. *b.* contractile vesicle *c.* water tubes. *d.* stomach. *e.* ovary. *f.* ganglia. *g.* stomach. *i.* mouth-parts.

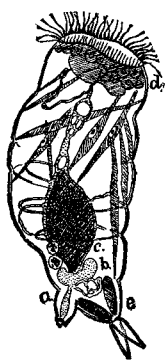


FIG. 2. Male of the same species. *a.* orifice of penis. *b.* contractile vesicle. *c.* testes. *d.* ganglion. *e.* setigerous apparatus.

Since the year 1855 the subject has been studied by many naturalists, and the males have been found in such a number of species that it is probable that the

sexes are separate in all the Rotifera. In some forms the males are even more simplified than in *Notommata*, while in others they are less so, and in a few they are like the females in size and structure, and have the digestive organs perfectly developed.

ANNELIDS.—Among the marine polychætous annelids there is often considerable difference between the sexes, and the points in which the male differs from the female are also points in which the males of various species differ from each other.

ARTHROPODA.—Among the Arthropods, the Insects, Crustacea, etc., the female is often very greatly modified, and in some cases the females of allied species differ from each other much more than the males, and in other cases it is hardly possible to say whether the males or the females of allied species differ most, but, taking the group as a whole, the Anthropods seem to follow the law which prevails in other groups of animals, and male modifications are more numerous than female modifications.

In the Branchiopod Crustacea the males are smaller than the females, and are much less abundant. The male differs from the female in the possession of a number of secondary sexual characters. The second antennæ of the male are more richly supplied with sensory hairs than those of the female, and various appendages of the male may be so modified as to form clasping organs for holding the female. In Branchippus the second antennæ of the male are greatly modified for this purpose. Figure 3 shows the head of a female specimen of *Branchippus Grubei*, figure 4 the head of the male of the same species, and figures 5 and 6 the heads of the males in two closely allied species. These figures show how much the males of the various species

differ from each other in this respect. The shape and structure of the first antennæ and of the abdomen may

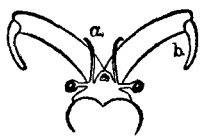


FIG. 3. Head of female specimen of *Branchippus Grubei*, greatly enlarged. *a*. first antennæ. *b*. second antennæ.

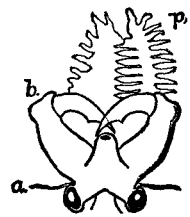


FIG. 4. Head of the male of the same species.

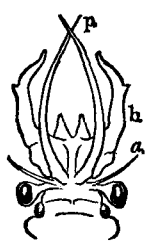


FIG. 5. Head of male *Branchippus stagnalis*.

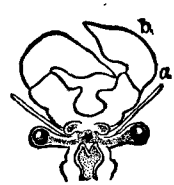


FIG. 6. Head of male *Artemia salina*.

also show considerable modification in the males of various species of Branchiopods.

Among the Cladocera, of which the common *water-flea* of our fresh-water ponds and lakes is an example, the female is provided with a brood pouch, within which the eggs are carried and the young developed. In the male these structures are absent, and the second antennæ are especially modified as organs for discovering and holding the female. They are richly supplied with sensory hairs, and they are often armed at their tips with grappling hooks, which differ in the males of closely allied species.

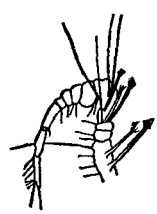

FIG. 7. Antenna of male *Cyclops serrulatus.*

FIG. 8. Antenna of male *Cyclops canthocarpoides.*

The Ostracoda present sexual differences like those in the Cladocera, and in many of them it is certain that the male part deviates, more than the female part, from the typical form.

In the non-parasitic Copepods, of which the fresh-water *Cyclops* (Fig. 9) is an example, there is not very much difference between the sexes, although certain appendages, which are unmodified in the female and retain their typical form, sometimes differ greatly in the males of allied species, and may be specially mod-

ified for discovering or holding the female. The modification of the first antenna of the male for this purpose is quite general, and a comparison of this part in the males of various species of Cyclops (Figs. 7 and 8) with the same part in a female (Fig. 9), shows how much the males of allied species differ in this respect. The second antennæ, the maxillary feet, and the last pair of

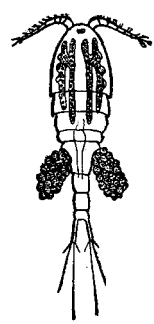

FIG. 9. Female specimen of *Cyclops canthocarpoides.*

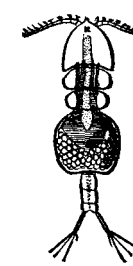

FIG. 10. Female specimen of *Notodelphys Allmani.*

swimming feet, are sometimes modified in the same way in the male. In the male Saphirrina the wonderful display of brilliant colors is due to the presence of peculiar color-producing organs, which are absent in the female.

Among the parasitic Copepods we find a departure from the ordinary typical structure, which is so remark-

able that no one, on first examining one of the more modified parasitic forms, such as the one shown in Fig. 15, would detect any resemblance to the free or non-parasitic members of the group, or would even suspect that the animals are crustaceans.

The females, which are known as "*fish-lice*," are parasites upon fishes and other aquatic animals, while the males are parasites upon the bodies of the females, and are usually of minute size as compared with the females.

The adaptation to a parasitic life has not only produced the most profound changes in the general structure, but it has also brought about an almost unparalleled difference between the sexes. It is true that this is not due to the modification of males alone, for the females as well as the males exhibit the most extreme departures from the organization which is characteristic of typical or non-parasitic crustacea, and it is difficult to decide from structure alone whether the male or the female is most modified. The fact that the male has been adapted to a life as a parasite upon the body of the female, while the female has simply become adapted to a parasitic life on other animals, seem to show that the male organism is somewhat more plastic than the female. Simple parasitism may be brought about by indefinite variability, but parasitism upon a parasite demands definite variation to meet the definite changes which have taken place in the host.

The highly specialized parasitic Copepods are joined to the non-parasitic forms by a long series of intermediate species, in which the parasitic habit is only slightly developed, and I give a few figures to illustrate some of the steps in this most interesting series. The female *Notodelphys* (Fig. 10), which lives in the body cavities

of marine invertebrates, and has very limited powers of locomotion, hardly differs from the non-parasitic Cyclops (Fig. 9), except that two of the body segments are modified to form a chamber in which the eggs undergo their development. The male (Fig. 11) is somewhat

FIG. 11. Male specimen of the same species.

FIG. 12. Female specimen of *Lernentoma corunta.*

smaller than the female, but bears a close resembance to her, and to ordinary copepods.

The female *Lernentoma* (Fig. 12) is very different from the male (Fig. 13), and both depart very greatly from the typical copepod structure, although a slight resemblance can be traced between the female and cyclops. The female is very much larger than the ordi-

nary non-parasitic forms; the segmentation of the body is hardly visible, the power of locomotion is entirely lost, and the appendages are either rudimentary or are changed into hooks for clinging to the animal infested by the parasite. The male, like the female, has no power of locomotion, and is very much smaller than the female, the difference in size being much greater than the two figures would indicate. It is found nowhere except upon the body of the female, to which it clings by its rudimentary feet. The female of another form, *Anchorella,* is shown in Fig. 15, and the male in Fig.

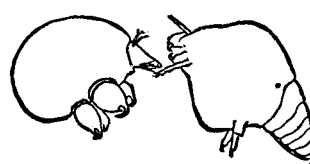

FIG. 13. Male specimen of *Lernentoma corunta.*

FIG. 14. Male specimen of *Anchorella uncinata.*

14. In this species the males are very small as compared with the females, to whose bodies they are firmly fastened by their rudimentary hooked limbs.

We can hardly state with confidence that either sex is more modified than the other in these parasitic copepods, for both have undergone such great changes that they have lost all traces of their crustacean affinity, but in the very similar case of the barnacles, we have sufficient evidence that the males do depart further than the females from the ancestral type.

The barnacles, or acorn-shells (Fig. 16), are crustacea

which are pretty closely related to the copepods, which they resemble somewhat, during the early stages of their development. The young swim freely in the water for a time, but finally attach themselves to foreign bodies, head downwards, by their antennæ, and are sedentary for the rest of their life. In the stalked or pedunculated barnacles, the antennæ of the free larva become replaced in the adult by a long peduncle, at the top of

FIG. 15. Female specimen of *Anchorella uncinata.*

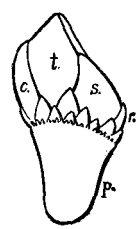


FIG. 16. An hermaphrodite stalked barnacle. *Pollicipes cornucopia.* *c.* carina. *t.* tergum. *s.* scutum. *r.* rostrum. *p.* peduncle.

which there is an irregularly triangular box, the capitulum, made up of a number of calcareous plates. Inside this box the animal is placed, head downwards, and although it is greatly modified to fit it for this protected sedentary life, it still presents unmistakable evidences of its crustacean affinity, such as the mouth-parts, the segmented body and limbs.

One of the most remarkable characteristics of the Barnacles is that, with a few exceptions, they are hermaphrodite. The Arthropoda include a very considerable proportion of all the animals which are known to us, and as all of them, except the Barnacles and a few closely related parasitic forms, have the sexes separated, the fact that these few sedentary forms are hermaphrodite is certainly very remarkable, and we must believe that they are the descendants of crustacea with separate sexes. The stalked barnacles resemble typical crustacea much more closely than do the sessile ones, and we must regard the former as more closely related than the latter to the ancestral form with separated sexes. It is, therefore, interesting to find that a few species of stalked barnacles are male and female, and also that in a few others the ordinary hermaphrodite form is accompanied by a parasitic male, which has been called by its discoverer, Darwin, a complementary male.

The study of the few species with separate sexes and of those with complemental males has brought to light some of the most remarkable phenomena of natural science, and the subject is well worthy of extended notice.

Figure 16 is an ordinary hermaphrodite stalked barnacle, *Pollicipes*. It belongs to a genus in which no true males or true females are ever found.

Figure 17 is a species belonging to a closely related genus, *Scalpellum*, and it will be seen at once that it closely resembles *Pollicipes*, even in the arrangement of the plates of the capitulum. It is an hermaphrodite-like *Pollicipes*, but with a difference, for it carries inside its shell a small parasitic complemental male, which is shown in Fig. 18. This male is very much smaller than the hermaphrodite, and Fig. 18 is considerably magni-

fied, while Fig. 17 is of nearly the natural size; but with this exception the complementary male is essentially like the hermaphrodite, and it has the structure of an ordinary stalked barnacle. There is a distinct peduncle, which carries a triangular capitulum, and although the plates are somewhat reduced in number they agree in form and position with the chief plates of such a species as *Pollicipes*. The animal inside the capitulum is much like an ordinary barnacle, the essential difference being the total absence of female reproductive organs. It is a male and nothing more.

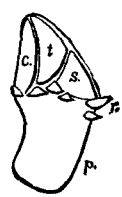


FIG. 17. An hermaphrodite barnacle, *Scalpellum villosum*.


FIG. 18. Complemental male of the same species.

Figure 19 shows the female of another species, *Ibla Cummingi*, which does not differ essentially from the forms shown in Figs. 16 and 17, but the female of *Ibla Cummingi* is a true female instead of an hermaphrodite, and there are no traces of male reproductive organs, but inside her shell, and planted by a long root-like process, there is a minute parasitic male, shown in Fig. 20, magnified thirty-two times, while the figure of the female is magnified only five times. In Fig. 20, *b* is part of the wall of the body of the female, and *a* is the long root by which the parasitic male is planted.

The male has a capitulum, but no calcareous plates, and its antennæ, an., are not completely merged in the peduncle. It also differs from the female in the possession of an ocellus, or eye-spot It has mouth-parts and limbs, and, except for the fact that all its parts are somewhat rudimentary, it does not differ very greatly from other barnacles, except as regards its reproductive organs.

In other species of Scalpellum, however, as in Scal-


Fig. 19. Female specimen of *Ibla Cumingii*.


Fig. 20. Parasitic male of the same species.

pellum Regium, the male is still more rudimentary, and has no mouth or digestive organs.

In two other genera, Alcippe (Fig. 21) and Cryptophyalus, the females, which are true females, with no trace of male reproductive organs, differ very essentially from ordinary barnacles, and they have fastened to the outside of their bodies a number of very small males. In the males of these two species, which are shown greatly magnified at Fig. 22, there are a few faint traces of muscular fibres, but the organs of digestion

are entirely gone, and the inside of the body is entirely filled with a great testis, while the posterior end is prolonged into an enormous penis; and the animal hardly deserves to be called an animal at all, as it is scarcely more than an independent male reproductive organ attached to the body of the female.

This is certainly one of the most remarkable cases of difference between the sexes, and no one who compares Figs. 18 and 22 with Figs. 16, 17 and 19, can doubt that

Fig. 21. Female of *Alcippe lampas*.

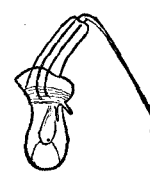

Fig. 22. Male of the same species.

among these barnacles the males differ from each other much more than the females.

Among the higher crustacea we find great numbers of cases where the young male is like the adult female, or the young of both sexes, but at maturity acquires distinctive sexual characters. Any one who is familiar with the crustacea will acknowledge the existence of this phenomenon, and it will only be necessary to give a few illustrations. The adult male Lucifer is distinguished from the adult female by the posses-

sion of a very peculiar clasping organ, figure 23, upon the first swimming appendage of the abdomen. The corresponding appendage, figure 24, of the adult female is like the other abdominal appendages of both sexes, and we must believe that the peculiar form, in the male, is due to recent modification. It is therefore interesting to note that, before the male reaches maturity, the limb in question is exactly like the other abdominal appendages of the adult male or adult female. The male Lucifer differs from the female in the shape of the last segment of the abdomen, and the outline of the

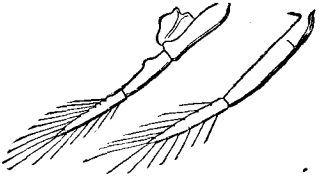

FIG. 23. First abdominal appendage of a male *Lucifer*.

FIG. 24. The corresponding appendage of the female.

exopedite of the tail-fin is peculiar. These differences are very slight, as will be seen by comparing the terminal segments of the male, figure 25, with those of the female, figure 26, and it is hardly possible that they are of any direct service in reproduction. The fact that, in the young of both sexes, these parts are like those of the adult female, and that their peculiarities in the adult male are due to a final change which does not occur in the female, indicates that race-modification has gone a little further in the male Lucifer than it has in the female.

Darwin says that it seems to be a general rule among the crustacea, that the remarkable differences of structure which distinguish the male from the female, do not make their appearance until the male is nearly mature. In proof of this he refers to the fact that the male sand-hopper, does not acquire his large claspers, which are very differently constructed from those of the female, until nearly full grown, while the claspers of the young male resemble those of the female.

The history of the abdomen in crabs seems to show

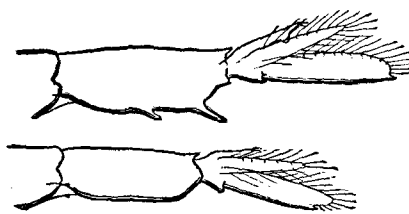

FIG. 25. Tip of abdomen of male *Lucifer*.

FIG. 26. Tip of abdomen of female.

clearly that this difference is due to the fact that the male has deviated further than the female from the ancestral type. The long-tailed crustacea, like the cray-fish, have a long free movable abdomen, ending in an enlarged tail-fin, and composed of a number of segments, each of which carries a pair of appendages. In the female cray-fish the first of these appendages are like those behind, but in the male, the first ones are peculiarly modified and form copulatory organs. We have ample evidence that the true crabs are the modi-

fied descendants of an ancestral form which had, like the cray-fish, a long free tail, which was used in swimming. The fact that the young crab does have such an abdomen, is one of the proofs of the correctness of this view; but as the crab grows up, the abdomen becomes curled forwards under the body; it ceases to be used as a swimming organ; its separate rings become fused together, and its appendages become rudimentary or disappear. This very instructive change goes further in the male than it does in the female, for in the latter, more of the rings remain distinct; a greater number of appendages persist in the adult, and these are much more like those of the young, or of the cray-fish, than are those of the male.

The great modification of the male as compared with the female is well shown, among the crustacea, by the fact that there may be in the same species two different male forms. This *sexual dimorphism*, as it is called, is well shown in a Brazilian amphipod, *Orchestia Darwinii*, in which species there are two male forms which differ from each other in the structure of their large claws. These claws are used for holding the female, but as both forms are now used for this purpose, either shape would certainly have sufficed as well as the other, and this case therefore differs greatly from that of the social insects, where one form performs a certain duty in the community, while another form is adapted to fill a different place and perform a different duty. The two male forms in Orchestia seem to be due simply to the tendency of the male organism to become modified more rapidly than the female, and not to any great advantage which has resulted from the divergent modification. In discussing this case Darwin says that the two male forms have originated by some having varied

in one manner, and some in another: both forms having derived certain special but nearly equal advantages from their differently shaped organs.

Dr. Hagen has called attention to the fact that in certain of our American species of cray-fishes, there are two slightly different male forms, and Fritz Muller, who pointed out the existence of the two male forms of Orchestia, has also described a remarkable dimorphic species of Tanais, in which the male is represented by two distinct forms, never graduating into each other. In the one form the male is furnished with more numerous smelling threads, and in the other form with more powerful and more elongated claws to hold the female. Fritz Muller suggests that these differences between the two male forms of the same species must have originated in certain individuals having varied in the number of their smelling threads, while other individuals varied in the shape and size of their claws, so that of the former those which were best able to find the female, and of the latter those which were best able to hold her when found, have left the greatest number of progeny to inherit their respective advantages.

Whenever a number of species of a genus have any part more developed in the male than it is in the female, this part, as a rule, varies in the males of the different species, and is therefore of great systematic importance, since it furnishes diagnostic characters for distinguishing the species from each other. This rule is of general application, in all groups of animals with separate sexes, and every one who is at all familiar with the systematic zoology of our higher animals knows how difficult it is to identify species without mature male specimens.

The crustacea furnish an abundant supply of illustrations of this law, but we have space for only one.

In the fiddler crabs, one of the claws of the male is enormously developed, so that it compares with the other about as a base-viol does with its bow. In the female both claws are alike, and both small. There are a number of species of fiddler crabs, forming together the genus Gelassimus, and the big claw of the male, in each species, has certain points of difference from all the other species.

The fact that the features which characterize males as distinguished from females, are also the features which distinguish species from each other, certainly indicates that the origin of specific difference is to be sought in some peculiarity of the male organism.

Insects.—Many insects have stridulating organs, by which, as in the house-cricket, they produce their sharp music. In many cases these organs are exclusively confined to the males; in others they are present but rudimentary in the female, while they are perfectly developed in both sexes of certain others. In all cases we find that the organs for this purpose differ greatly in closely related forms, and thus show that they are of comparatively recent acquisition.

In the Cicadas the females are mute, and the sound is produced in the male, by the vibration of the lips of the spiracles, which are set into motion by a current of air discharged from the tracheæ. It is increased by a wonderfully complex resonating apparatus, consisting of two cavities covered by scales. This apparatus is present, very much less developed, in the female, but it is never used for producing sound.

The males of the crickets, grasshoppers, and Locustidae, are all remarkable for their musical powers, which are absent in the females. Although these three groups of insects are pretty closely related to each other,

and although the general character of the sound, and its mechanical cause, are essentially alike in all of them, the position and character of the sound-producing mechanism varies greatly.

In the male cricket the under surface of each wing-cover has a row of sharp transverse ridges or teeth, which is rapidly scraped across a projecting ridge on the outer surface of the opposite wing, thus producing the music. 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 the Locustidæ the opposite wing-covers differ in structure, and their action cannot be reversed, as it is in the crickets. The left wing acts as the bow, and is scraped over the right, which serves as the fiddle. In some forms the posterior part of the pro-thorax is elevated into a sort of resonating dome over the wing-covers. In the grasshoppers the sound is produced in a very different manner. There is usually a long row of nearly a hundred minute teeth on the inner surface of the femur, and this is scraped across the sharp projecting nervures on the wing-covers.

In one South African form the femur is rubbed, not against the wing-cover, but against a notched ridge on the side of the abdomen, and the whole abdomen of the male is distended with air, like a great bladder, to increase the resonance.

The female grasshopper has the stridulating apparatus in a rudimentary condition, and it is interesting to note that the young male is like the adult female in this respect, for Landois states that the teeth on the femora of the female remain throughout life in the condition in which they appear in both sexes during the larval state, but in the male they become fully developed and

acquire their perfect structure at the last moult, when the insect is mature and ready to breed.

Many beetles have rasp-like ridges with fine teeth on certain parts of their bodies, for producing a stridulating noise, by scraping against hard ridges or angles on the adjoining parts. In most stridulating beetles they are equally developed in both sexes: in some they are rudimentary or entirely absent in the female. These organs are situated on widely different parts of the body in different beetles, even when they are very nearly related. In the carrion beetles there are two parallel rasps with fine transverse ribs on the fifth abdominal segment, and they are rubbed against the posterior edge of the wing-cover. In other beetles the rasp is on the dorsal apex of the abdomen. In others it is on the side of the first abdominal segment, and is scraped by ridges on the femur. In others the rasps are on the lower surfaces of the wing-covers, and the edges of the abdominal segments serve as scrapers. In others the horny tip of the abdomen is scraped against a rasp on the wing-covers. In a great number of species of long-horned beetles the rasp is on the meso-thorax, and is rubbed against the pro-thorax. In still other beetles there is a ribbed rasp running obliquely across the coxa of each hind leg, and this is scraped across a specially projecting ridge on one of the abdominal segments. In still others the rasp is on the pro-sternum, and the scraper on the meta-sternum.

In the cases where the stridulating organs are confined to the male, or where they are rudimentary and functionless in the female, we have every reason to believe that the successive variations which have led to their production have originated in males.

In the cases where each sex has inherited them in full perfection, there is, of course, no direct evidence to show

that they have originated in one sex rather than in the other. The organs are essentially alike in structure, whether they are confined to the male or are present in both sexes; and as we have good reason for believing, in the first case, that they have originated in males, and no reason for doubting that they have so originated in the second case, the conclusion that they all have had a male origin certainly has a great probability in its favor.

The great diversity of the males of allied species, as compared with the females, is well shown in those beetles where the males, and not the females, have great horns rising from various parts of the body, as from the head, thorax, clypeus, or the under surface of the body. Darwin gives the following account of these structures: "These horns, in the great family of Lamellicorns, resemble those of various quadrupeds, such as stags, rhinoceroses, etc., and are wonderful both from their size and diversified shapes. The females generally exhibit rudiments of the horns, in the form of small knobs or ridges, but some are destitute of even a rudiment, while in a few others they are almost as well developed in the female as they are in the male. *In almost all cases the horns are remarkable from their excessive variability;* so that a graduated series can be formed, from the most highly developed males to others so degenerate that they can hardly be distinguished from the females. The extraordinary size of the horns, and their widely different structure in closely allied forms, indicate that they have been formed for some important 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. They do not show evidence of friction as they would if used for ordinary work. They are not usually sharp, and do not seem well adapted for defence,

and they are not known to be used by the males in fighting with each other. The conclusion which best agrees with the fact of the horns having been so immensely yet not fixedly developed, as shown by their extreme variability in the same species, and by their extreme diversity in closely allied species, is that they have been acquired as ornaments."

One fact connected with these horn-like projections gives as clear evidence as could be desired, that the male is more liable to modification in this respect than the female. It sometimes happens that the horns are absent in the males of a species, but present in a number of closely related species, and in such cases we must believe that the departure from the general rule is due to the fact that the species in which they are absent has been recently modified. Now, in such forms the female shows her close relationship to the typical, unmodified, or ancestral form by the possession of rudimentary horns.

Darwin says that it is a highly remarkable fact that, although the males of *Onitis furcifer* do not exhibit even a trace of horns on the upper surface of the body, yet in the females a rudiment of a single horn on the head and of a crest on the thorax are plainly visible. The fact that the female of *Bubas bison*, a form which comes next to *Onitis*, has a similar slight crest on the thorax, while the male has, in the same situation, a great projection, indicates, according to Darwin, that the slight thoracic crest in the female *Onitis* is a rudiment of a projection proper to the male, although it is entirely absent in the male of this particular species. The males of the genus *Onitis* give farther evidence of plasticity, as they have not only lost the horns on the upper surface of the body, but have also acquired new and peculiar ones on the anterior pair of legs, and on

the lower surface of the thorax, and these differ greatly in structure and development in the males of the several species of the genus.

Darwin gives the following illustration to show the remarkable nature of this case: "In most ruminants the males have the horns more developed than the females, and they may be quite small or even absent in the latter sex. Now if a new species of deer or sheep were discovered with the horns entirely absent in the male, but represented by rudiments in the female, we we should have a case like that of *Onitis*. Darwin's illustration would be still more appropriate if we suppose that the male in this newly-discovered deer not only lacks all traces of horns on the head, but has a pair of very peculiar ones on his breast.

In this case we should conclude that the new species is the descendant of a form with horns on the head; that the male sex had become modified, and had lost the horns on the head, and had acquired new ones on the breast, while the female had remained without modification, and had adhered to the ancestral type.

In the Staphylinidae there are horns on the head and thorax, and the males of the same species are extraordinarily variable in this respect. In two genera there are species with polymorphic males, which differ greatly in the development of their horns. In a species of Bledius it is said that, in the same locality, males can be found with the central horn of the thorax very large, but the horns on the head quite rudimentary, while in other males the horns on the head are long, and that on the thorax short.

Darwin devotes more than thirty pages to a discussion of the sexual coloration of butterflies and moths, and the two extracts given below will serve to show that his general

conclusion is in accordance with the demands of our hypothesis, although he himself has given a different explanation, which will be discussed in the next chapter. He says:

"No language suffices to describe the splendor of the males of some tropical butterflies. Even within the same genus we often find species presenting an extraordinary difference between the sexes, while others have their sexes closely alike. Thus in the South American genus Epicalia, Mr. Bates, to whom I am much indebted for most of the following facts, and for looking over this whole discussion, informs me that he knows twelve species, the two sexes of which haunt the same stations, and therefore cannot have been differently affected by external conditions.

"In nine of these species the males rank among the most brilliant of all butterflies, and differ so greatly from the comparatively plain females that they were formerly placed in distinct genera. The females of these nine species resemble each other in their general type of coloration, and likewise resemble both sexes in several allied genera, found in various parts of the world. Hence, in accordance with the descent theory, we may infer that these nine species, and probably all the others of the genus, are descended from an ancestral form which was colored in nearly the same manner. In the tenth species the female still retains the same general coloring, but the male resembles her, so that he is colored in a much less gaudy and contrasted manner than the males of the previous species. In the eleventh and twelfth species, the females depart from the type of coloring which is usual with their sex in this genus, for they are gayly decorated in nearly the same manner as the males, but in a somewhat less degree."

This series of forms seems to show that all twelve species are descended from a form with plain males and plain females; that this character has been retained in both sexes by one species, but that the males have been greatly modified in the other eleven, while in two of them the females have inherited, to an imperfect degree, the modification of the males of their own species, and in the other nine the females have remained stationary and have shown no tendency to inherit the modification of their male parents.

In an allied genus, Eubagis, the males of most of the species are decorated with beautiful metallic tints, in a diversified manner, and differ much from the females. The females throughout the genus, on the other hand, retain a uniform style of coloring, so that they commonly resemble each other much more closely than they resemble their own proper males.

Darwin concludes (*Variation*, Vol. I., p. 378) that "when the sexes of butterflies differ, the male, as a general rule, is the most beautiful, and departs most from the usual type of coloring of the group to which the species belongs. Hence in most groups the females of the several species resemble each other much more closely than do the males," . . . "*and this indicates that the males have undergone a greater amount of modification than the females.*" There are many striking exceptions to this law, which is general but not universal. Certain of the most remarkable exceptions, such as the occurrence of polymorphic female butterflies, and of the various female forms among the social insects, will be discussed at the end of the next chapter.

Fishes.—Darwin gives many instances of difference between the sexes in fishes, and his list might be very greatly increased, but one or two examples will be suf-

ficient to show that these animals follow the rule which prevails in so many other groups of the animal kingdom; that the males are more modified than the females; that the males of allied species differ more than the females, and that the mature male differs more than the mature female from the young.

In many species the male alone is ornamented with bright colors, and he is sometimes provided with curious appendages which do not appear to be of any use whatever for the ordinary purposes of life. When the male *Callionymus lyra* is freshly captured the body is colored with various shades of yellow, with stripes and spots of vivid blue on the head; the dorsal fins are pale brown, with dark longitudinal bands, while the other fins are bluish black; the female fish is of a dingy reddish brown, with the dorsal fin brown and the others white. The sexes differ in many other respects, and the dorsal fin of the male is remarkably and excessively elongated. The sexes are so different from each other that they were for a long time regarded as distinct species, and the male is known as the *gorgeous dragonet,* the female as the *sordid dragonet.*

The males of the various species of this genus differ from each other in these sexual characters, and the young males resemble the adult females in structure and color.

The following extract from Darwin shows how greatly the males of closely allied species differ from each other: "In the male of the *Mollienesia petenensis* the dorsal fin is greatly developed and is marked with a row of large, round, ocellated bright-colored spots, while the same fin in the female is smaller, of a different shape and marked only with irregularly curved brown spots. In the male the basal margin of the anal fin is also a little produced and dark colored. In the male of an allied form, the

*Xiphophorus Hellerini*, the inferior margin of the anal fin is developed into a long filament which is striped with bright colors. This filament does not contain any muscles, and apparently cannot be of any direct use to the fish. As in the case of *Callionymus* the males while young resemble in color and structure the adult females."

Darwin discusses the question whether, when the male differs in a marked manner from the female in color or in other ornaments, he alone has been modified with the variations inherited only by his male offspring, or whether the female has been specially modified and rendered inconspicuous for the sake of protection, and he concludes that *with most fishes in which the sexes differ in color or in other ornamental characters, the males originally varied.*

LIZARDS. — Among lizards the sexes often differ greatly in various external characters, and the male sex is in almost every case the one which is peculiar. Among the many examples given by Darwin I quote the following:

"In *Anolis cristatellus* the male is furnished with a crest which runs along the back and tail and can be erected at pleasure, but of this crest the female does not exhibit a trace, although in other species the female does have an imperfect crest, which is much less developed than it is in the male. In the genus *Sitana* the males alone are furnished with a large throat pouch, which can be folded up like a fan, and is colored blue, black and red during the pairing season. The female does not possess even a rudiment of this appendage. The male of *Ceratophora aspera* has a long appendage half as long as his head on the tip of his snout. In a second species of the same genus a terminal scale forms a minute horn on

the summit of this appendage, and in a third species the whole appendage is converted into a horn. In the females of all these species and in the young males the appendage is very minute. The male *Chameleon bifurcus* has two great solid bony projections, covered with scales, in the upper part of the skull. The male *Chameleon Owenii* has three great bony horns on his head. These bony horns are covered with a smooth sheath of integument, so that they are strikingly like those of a bull or a goat. In the females and young of both species these appendages are rudimentary."

BIRDS.—The sexual characteristics of birds are most diversified and conspicuous, and most persons, even those who are not naturalists, know enough of this subject to agree that the males are as a rule much more modified than the females, and it will not be necessary to devote very much space to this group. Darwin has devoted more than two hundred pages to the discussion of the differences between male and female birds, and he has brought together an array of facts all tending to show that male modification is the rule, while female modification is comparatively rare, and although it is true that he gives another explanation of the phenomena, an explanation which will be discussed in the next chapter, yet every reader of his essay must be convinced of the correctness of his conclusion, p. 227, "that weapons for battle, organs for producing sound, ornaments of many kinds, bright and conspicuous colors, *have generally been acquired by the males*, . . . the females and the young being left comparatively but little modified."

This conclusion will be accepted without question by all who are familiar with the subject, and it is hardly necessary to dwell upon it, but the great diversity of the sexual differences in birds demands that in a general

review of the subject they should receive some little notice.

Darwin says: "Male birds sometimes, though rarely, possess special weapons for fighting with each other. They charm the females by vocal and instrumental music of the most various kinds. They are ornamented by all sorts of combs, wattles, protuberances, horns, air-distended sacs, top-knots, naked shafts, plumes and lengthened feathers, gracefully springing from all parts of the body. The beak and naked skin about the head and the feathers are often gorgeously colored. The males sometimes pay their court by dancing, or by fantastic antics, performed either on the ground or in the air. In one instance, at least, the male emits a musky odor, which we may suppose serves to charm or excite the female. The ornaments are wonderfully diversified. The plumes on the front or back of the head consist of variously shaped feathers, sometimes capable of erection or expansion, by which their beautiful colors are fully displayed. Elegant ear-tufts are occasionally present. The head is sometimes covered with velvety down like that of the pheasant, or is naked and vividly colored, or supports fleshy appendages, filaments and solid protuberances. The throat also is sometimes ornamented with a beard, or with wattles or caruncles. Such appendages are generally brightly colored, and no doubt serve as ornaments, though not always ornamental in our eyes: for while the male is in the act of courting the female, they often swell and assume more vivid tints, as in the case of the male turkey. At such times the fleshy appendages about the head of the male Tragopan pheasant swell into a large lappet on the throat and into two horns, one on each side of the splendid top-knot, and these are then colored of the most intense blue which I have ever beheld.

The African hornbill inflates the scarlet bladder-like wattle on its neck, and with its wing drooping and tail expanded makes quite a grand appearance. Even the iris of the eye is sometimes more brightly colored in the male than in the female, and this is frequently the case with the beak, for instance in our common blackbirds. In *Buceros corrugatus*, the whole beak and immense casque are colored more conspicuously in the male than in the female, and the oblique grooves upon the sides of the lower mandible are peculiar to the male sex. The males are often ornamented with elongated feathers or plumes, springing from almost every part of the body. The feathers on the throat and breast are sometimes developed into beautiful ruffs and collars. The tail feathers are frequently increased in length, as we see in the tail of the Argus pheasant. The body of this latter bird is not larger than that of a fowl, yet the length from the end of the beak to the extremity of the tail is no less than five feet three inches. . . . Nor need much be said on the wonderful differences of color between the sexes, or on the extreme beauty of the males of many birds. The common peacock offers a striking instance. Female birds of Paradise are obscurely colored and destitute of all ornaments, while the males are probably the most highly decorated of all birds, and in so many ways that they must be seen to be appreciated. The elongated and golden orange plumes which spring from beneath the wings of the *Paradisea apoda*, when vertically erected and made to vibrate, are described as forming a sort of halo, in the centre of which the head looks like a little emerald sun, with its rays formed by the two plumes. In another most beautiful species the head is bald and of a rich cobalt blue crossed by several lines of black velvety feathers. Male humming birds almost vie with birds

of Paradise in their beauty, as every one will admit who has seen Mr. Gould's splendid volumes in his rich collection. It is very remarkable in how many different ways these birds are ornamented. Almost every part of the plumage has been taken advantage of and modified. . . . When the sexes of birds differ in beauty, in the power of singing, or in producing instrumental music, it is almost invariably the male which excels the female."

This extract is enough to show the wonderful diversity of the characteristics of male birds, and the following examples bring out very prominently the fact that male birds of allied species often differ greatly in their sexual characters, while the females are very much alike. In the South American bell-birds the females of the four species resemble each other very closely, and are of a dusky green color, while the male of one species is pure white; in a second species white with the exception of a large space of naked skin on the throat and round the eyes, which during the breeding season is of a fine green color, while in a third species only the head and neck of the male are white and the rest of the body chestnut-brown. In one species the male alone is provided with three filamentous projections half as long as the body, one rising from the base of the beak and the others from the corners of the mouth, while in another species the male has a spiral tube nearly three inches in length which rises from the base of the beak and is jet black dotted over with minute downy feathers. In the Indian chats, honeysuckers, shrikes, kingfishers, Kallij pheasants, and tree partridges, the males of allied species from distinct countries are quite different from each other, while the females and the young of both sexes are indistinguishable.

In the cases where the females of allied species do differ the difference is rarely so great as between the males. Darwin says: "We see this clearly in the whole family of the Gallinaceæ: the females for instance of the common and Japan pheasant, and especially of the gold and Amherst pheasant, of the silver pheasant and the wild fowl, resemble each other very closely in color, while the males differ to an extraordinary degree. So it is with the *Cotingidae Fringillidae* and many other families. *There can indeed be no doubt that as a general rule the females have been modified to a less extent than the males.*" (*Variation*, Vol. II. p. 184.)

As regards the relation between the young and the adult, the general rule is that when the sexes differ the young of both sexes in their first plumage resemble the adult female as they do in the common fowl or the peacock, or else they resemble her more closely than they do the adult male.

Darwin says that innumerable instances of this law could be given in all orders, but that it will suffice to call to mind the common pheasant, duck, and house sparrow.

There are a few cases in which the young male is like the adult male, and the young female like the adult female, and there are also a few cases where the young of both sexes resemble the adult male, but the difference between the sexes is never, in this case, very great, and instances are so rare that Darwin, who says that he has recorded all he could find, gives only nine. In his summary he says: "We thus see that the cases in which female birds are more conspicuously colored than the males, with the young in their immature plumage resembling the adult males instead of the adult females, *are not numerous*, though they are distributed in various orders. The

amount of difference between the sexes is also *incomparably less* than that which frequently occurs in the last class; *so that the cause of the difference, whatever it may have been, has acted upon the females in the present class either less energetically or less persistently than on the males in the last class.* (*Descent of Man*, II. p. 198.)

MAMMALS.—Among the mammalia the sexes often differ in their weapons of offence and defence, as we see in the deer, when the horns are usually absent in the female; in their voices, as in the case with the cow and bull; in odor, as goats for example, and in the musk deer, where both the musk-producing organ and other organs of a similar character are confined to the male; in color, as in many antelopes, and in the character and distribution of the hair, as we may see by comparing the lion with the lioness, or the human male with the human female.

A little thought will show that among the mammals, as in other groups of the animal kingdom, the males are more modified than the females.

Thus man differs from woman by the possession of a beard, but the boy resembles the girl or the mature female, thus showing that the human race is influenced by the general law of which we have seen the evidence in so many groups of animals, and that the adult female is more like the young of both sexes than the adult male. So, too, the young stag, or the young male goat, resembles the adult female in the absence of horns.

The fact that different human races are characterized by the presence or absence of a beard in the males, and that the horns of different species of deer differ very greatly, shows that the males of allied species of mammals differ more than the females.

Among the mammalia we sometimes find that the

male has been modified by the acquisition of new structures, while in other cases organs common to both sexes and to great groups have become changed in the male, but have remained comparatively unmodified in the female.

The spurs on the leg of the male Ornithorinchus may, *perhaps, be regarded as a case of the first kind, as may* also the horns of the rhinoceros, which are longer and more important in the male than they are in the female, while the great tusks of the boar are organs which must have been present in both sexes of the remote ancestors, although they have recently undergone great change in the male.

No one who will compare the head of the common boar with that of the male Babyrusa, the male wart-hog, and the male river-hog, can doubt that the males of these allied species differ much more than the females.

In some cases certain teeth of the male are so greatly modified that they must be regarded as new organs. This is true of the narwhal, in which one of the teeth is greatly elongated, and forms a long, spirally-twisted spear, nine or ten feet long, while the corresponding tooth in the male, and both teeth in the female, are rudimentary.

The tusks of the male walrus, and those of the male elephant, are greatly modified teeth, but they differ so greatly from ordinary teeth that they are almost as truly new organs as the horns of ruminants.

It is interesting to note how greatly the various races of elephants differ in the development of the tusks. In Ceylon they are never found in the females, and they occur in only about one per cent. of the males. In India they occur in all or nearly all the males, but in the males alone, while in Africa the female usually has small tusks.

The same thing is true of the horns of ruminants. In the hollow-horned species, as in cattle, they are not at all uncommon in the females, although they are usually much less important than they are in the males. Among the antelopes the females of some species have horns like the males; in other species they are somewhat smaller in the female than they are in the male; in others they are large in the male, but rudimentary in the female, while in others they are entirely absent in the female.

In female deer they are usually absent entirely, but in some they are rudimentary, and in the female reindeer they are fully developed. It is interesting to note that in females which normally lack them, they may be developed as the result of injury or disease of the reproductive organs, and that their development in the male may be arrested by castration.