No. 13. — *On some Crustacean Deformities.* By Walter Faxon.

In November, 1879, the Museum bought of K. D. Atwood, a fish-dealer of Portland, Me., a collection of nearly two hundred deformed lobster claws. The malformations range from slight deformities resulting from incomplete restoration of lost parts, abnormal curvature of the fingers, etc., to such as may, from the enormous development of abnormal outgrowths or the duplication of parts, be truly called monstrosities. Some of the most remarkable of these specimens are here described and figured. One (Plate I. fig. 16) from the collection of the Peabody Academy of Science, Salem, Mass., for which I am indebted to Prof. E. S. Morse, a deformed claw of *Callinectes hastatus* from Chesapeake Bay (Plate II. fig. 5) kindly communicated by Dr. S. F. Clarke, of Johns Hopkins University, and an abnormal lateral spine of the carapace of the same species (Plate II. fig. 8) in the Museum of Comparative Zoölogy, are also figured. Most of these irregularities have clearly resulted, as Rösel long ago remarked of similar malformations in the European crayfish, from injuries received after moulting, before the new cuticle had become calcified.

Plate I. Fig. 1 (right chela).* — In this claw the dactylus (*a*) is curved strongly outwards towards the index, and thrust upwards from its normal plane so that it does not meet, but crosses, the index when closed. The prehensile power of the claw is thus destroyed. From the inner border of the dactylus there is developed an enormous flattened process, which divides at the tip into two prongs (*b*, *c*), which are toothed on their opposed edges. Near the middle of the process is a deep scar (*d*), visible on both sides.

There is a specimen quite similar to this, for a drawing of which I am indebted to Prof. S. I. Smith, in the Museum of Yale College, New Haven, Conn.

Plate I. Fig. 2 (left chela). — In this specimen the dactylus is curved and bent from its true plane as in the last specimen. From the inner edge of the dactylus (*a*) arise two diverging horns (*b*, *c*), which are furnished with teeth upon their opposed edges, and simulate very closely the dactylus and index of a normal claw. The dentition of the proximal

* All the figures on Plate I. are *Homarus Americanus*, one half natural size.

horn (*b*) resembles that of the index (*a*), while the teeth of the distal horn (*c*) mark it as the analogue of the index. There is no trace of articulation at the base of either horn.

There are several specimens similar to this in the collection of the Peabody Academy of Science, Salem, and two or three in the collection of the Boston Society of Natural History.

Plate I. Fig. 3 (right chela). — Dactylus (*a*) slightly flexed from the plane of the index and broken off about an inch from the tip. From the inner side of the dactylus, near the fracture (*d*), arise two toothed processes (*b*, *c*), directed forwards, which repeat in form the lost tip of the dactylus and the tip of the index. A short, blunt process, directed upward and forward, projects from the inner margin of the dactylus, at a point a little beyond the middle.

Plate I. Fig. 4 (right chela). — Here the dactylus (*a*), a short distance from its articulation with the hand, is bent at a right angle with its normal trend, and thrown out from the plane of the hand so that it crosses the index when closed. The tip is broken off. From the untoothed margin of the dactylus, near the proximal end, proceed two processes (*b*, *c*) at an angle of about 45° to one another, the distal one (*c*) taking the normal direction of the index. Both of these processes are toothed on their opposed margins, but it is noteworthy that the teeth of the two processes are not directed exactly toward each other, but are inclined a little downward, as if by attraction to the teeth of the thumb. It is curious to observe that the toothed margins of the index and thumb are beset with an uncommonly large number of stiff setæ, and that this character is repeated in the toothed edges of the monstrous processes *b*, *c*.

Plate I. Fig. 5 (left chela). — Similar to Fig. 2, but the processes *b* and *c*, instead of diverging from one another, cross one another near their tips like the index finger and thumb of the claw when closed.

Plate I. Fig. 6 (right chela). — In this claw, unlike what we have seen in those before noticed, the prehensile power has not been lost, the dactylus closing accurately upon the index. Just beyond the middle of the dactylus springs a simple branch directed forwards at an angle of 45° with the long axis of the dactylus. This branch shows no tendency to form teeth.

Plate I. Fig. 7 (left chela). Here the dactylus (*a*) is bent near the middle, at almost a right angle with its normal direction, away from the index, but is thrown very little, if any, from its true plane of motion. It has acquired an abnormal length, and developed two processes from its toothed margin. One of these (*b*) seems to be developed in order to recover the prehensile power which was lost by the distortion of the dactylus. The other (*c*) is broken off near its tip, but corresponds to the process *c* described in the next figure.

There is another dactylus in the collection quite similar to this.

Plate I. Fig. 8 (right chela). — This deformity belongs to the same category as the one represented by the last figure. The dactylus (*a*) is curved strongly away from the index, and lengthened. At *d* is the scar resulting from the wound that probably caused the curvature of the dactylus. An outgrowth (*b*) provided with teeth, and meeting the thumb when the claw is closed, replaces functionally the distorted extremity of the dactylus. In addition to this a second process (*c*) projects at a right angle with the deflected part of the dactylus. This process presents a line of teeth opposite to those on *a*. My reason for considering *a* rather than *b* to be the end of the original dactylus, and *b* and *c* to be secondary outgrowths, comes from the arrangement of the punctures and the striæ on the cuticle of these parts, which seem clearly to show that *b* and *c* are the newer portions.

Plate I. Fig. 9 (right chela). — The index here is split into two parts. The outer (*a*) is toothed on its inner border. The inner (*b*, *c*) is toothed on both margins, and shows a tendency to divide at the end. The lines on the cuticle show that *a* is the original index, and *b*, *c*, a secondary process developed from it. The dactylus does not meet the index when closed.

Plate. I. Fig. 10 (right chela). — The dactylus is abnormally short and curved, and its proximal half produced into a large roundish plate, toothed on its margin, only the basal part of which closes against the index.

Plate I. Fig. 11 (left chela). — A large triangular crest, directed outward and forward from the middle of the outer margin of the penultimate segment. This crest-like process has a strong curve downward.

There are several claws similar to this in the collection.

Plate I. Fig. 12 (right chela). — The inner border of the hand is distorted by a wound (*d*) which has resulted in the outgrowth of a simple, blunt, movably-jointed segment (*a'*), which evidently represents an abortive supernumerary dactylus. On its upper side (the figure shows the lower surface), near the articulation with the hand, is the small spine characteristic of the normal dactylus. The abnormal finger moves in a plane at right angles to the plane of motion of the normal dactylus.

There is another specimen in the collection similar to this, — a left chela with a supernumerary dactylus articulated with the lower face of the hand. The dactylus is lost.

Plate I. Fig. 13 (right chela). — This specimen, like the last, is didactyle. The two dactyli (a, a') are here articulated with the hand side by side; both are thrust to one side, so that they do not close against the index finger. The index itself shows a tendency to duplication; first, by a slight bifurcation at the end; secondly, in the alteration of the tooth-bearing edge into a flat surface, bearing a row of teeth on each margin, directed toward the dactyli, but not met by them on closure.

One can easily believe that this is a congenital monstrosity, while most if not all the others on the plate are more naturally explained as malformations arising from injuries received after moulting.

Plate I. Fig. 14 (right chela). — A severe injury to the hand has resulted in the growth of a process (c) from near the base of the index, which duplicates the index. It is curved downward and inward, under the lower face of the primary index, and furnished with sharp teeth on its inner border. At the base of the toothed margin of the secondary index springs a very small process (b), which shows a line of very minute teeth on its inner border, and seems to be a rudimentary third index. The dactylus does not meet the primary index when the claw is shut.

Plate I. Fig. 15 (left chela). — The dactylus is here bent upward and outward at a right angle, at a point midway between the base and the tip. Two finger-like processes (b, b') arise near one another from the bend of the dactylus. Of these the proximal (b) is a little longer than the distal (b'). Both lie in the normal trend of the dactylus, and present a row of teeth directed towards the teeth of the distal end of the index. When the dactylus is closed, however, the teeth of neither of these processes exactly meet the teeth of the index, but fall on each side.

Plate I. Fig. 16 (left chela). This specimen resembles Fig. 12 of the same plate. From the inner and lower part of the hand arises a process (x) which is not articulated with the main portion of the hand. On its upper surface (turned away from the observer in the figure) is a prominent spine, like those developed along the inner margin of the normal hand. Articulated with the distal extremity of this process is a long, curved, pointed, toothless segment (a'), which is an imperfectly developed duplication of the dactylus (a). On the upper face of this supernumerary dactylus, close to its articulation with the process x, is the short spine characteristic of that point in the normal dactylus. The secondary dactylus almost equals in length the primary one, and, as in the example represented by Fig. 12 of the same plate, swings in a plane nearly at right angles with the plane of motion of the normal dactylus (*a*). Here, then, in addition to the duplication of the dactylus seen in Fig. 12 (*a'* indicating homologous parts in the two figures), one sees an imperfect attempt to duplicate the propodite in the process *x*.

Plate I. Fig. 17 (left chela). — This monstrous claw is similar to the one described and figured by Lucas (*Homarus vulgaris*, in No. 7 of the Bibliography). The dactylus (*a*) does not close upon the index. From the base of the index there arises from the upper side a very large unjointed appendage, which shows a strong tendency to divide into two branches (*b*, *c*), each furnished with a row of teeth. The teeth of the branch *b* point toward the teeth of the index, while those of the branch *c* are directed toward the row of teeth on the dactylus when the latter is opened. The tendency seems to be to duplicate the dactylus in *b*, the index in *c*. As there is no articulation at the base of the monstrous appendage, the teeth on the branch *b* are useless, and as the branch *c* is not in the plane of motion of the dactylus its teeth are likewise functionless. Thus, although these two extra lines of teeth are developed, there are no two in the claw which can be applied to one another.

Plate II. Fig. 1 (*Homarus Americanus*, dactylus of right chela).* — Beyond the middle, this dactylus is bent downward at nearly a right angle. From the upper side are developed two processes (*b*, *b'*), which are forked at their ends and furnished with two rows of teeth within. The propodite is lost. Resembles the dactylus of the claw figured on Plate I. fig. 15, but differs in the fission of the processes *b* and *b'*.

Plate II. Fig. 2 (*Homarus Americanus*, one of the small chelipeds). — This leg is provided with two chelæ. One of them has the ordinary form and structure, but is bent at a strong angle with the long axis of the leg. The second claw appears to have budded off from an amputated surface of the propodite. It consists of two fingers, which have the form of the normal dactylus and index, but neither is articulated with the other at the base. The two fingers together seem to be morphologically equivalent to a single segment, and represent a two-branched supernumerary dactylus.

Plate II. Fig. 3 (*Homarus Americanus*, left chela). — In this small chela the index is curved sharply upward and deeply channelled on its lower face. Unlike all those previously noticed in this paper, this is a simple malformation through distortion, without any development of accessory parts.

Plate II. Fig. 4 (*Homarus Americanus*, dactylus of right chela). —

* All the figures on Plate II. are of natural size.

Near the base the dactylus divides into two branches, a long one (*a*), which appears to be the distal part of the original dactylus bent so as to make almost a right angle with its proximal portion, and a shorter one which forks at the end (*b*, *c*), and presents a row of teeth on both the inner and outer borders. This shorter branch has the normal direction of the dactylus, and is probably a secondary outgrowth from the primitive dactylus. This malformation resembles that seen in Plate I. figs. 7 and 8. The propodite is lost.

Plate II. Fig. 5 (*Callinectes hastatus*, left chela). — The dactylus is divided longitudinally, nearly to its base, and furthermore the lower of the two branches thus produced forks at a point midway between the base and the tip. One of the prongs of the fork (*c*) inclines toward the upper branch of the dactylus (*b*), the other prong (*a*) is curved downward toward the index finger. The dactylus thus becomes tridactyle instead of monodactyle. The superior branch (*b*) is toothed along its lower edge, the inferior branch along both its upper and lower edges, the teeth of the upper edge being continued along the upper margin of the upper prong (*c*), while the teeth of the lower edge are continued along the lower margin of the lower prong (*a*). All the branches are much shorter than the index finger. The teeth on *a* do not strike against those on the index when the claw is shut. Even the coloration of *a*, *b*, and *c* is like that of the normal fingers.

This monstrosity is like that described and figured by Lucas (*Carcinus mœnas*, in No. 7 of the Bibliography). I differ from Lucas in the interpretation of the finger-like parts of the tridactyle segment. He considers *b* to be the normal dactylus, and *a* and *c* to be supernumerary fingers, *a* being the analogue of the dactylus (*b*), and *c* the analogue of the index. From the analogy of this deformity with those represented on Plate I. figs. 1–5, I conceive *a* to represent the original dactylus, and *b* and *c* to be the supernumerary parts, representing the dactylus (*a*) and the index respectively.

Plate II. Fig. 6 (*Homarus Americanus*, right cheliped). — The first segment (coxa) is wanting. The second and third segments, instead of having their normal flattened form, are subcylindrical. The third segment (meros) further shows a tendency to divide, a deep groove running across the distal end. The upper half of this segment repeats antitropically, or in a reverse manner, the lower half: thus the spine *sp* on the anterior border is symmetrically repeated in *sp′*, and the articulating process *z* has its homotype in *z′*. The symmetry of the segment is not complete, however, inasmuch as the two or three short spines on the internal border of the segment (turned away from the reader in the figure) are not duplicated on the homologous margin of the upper half of the segment. Articulated with the distal end of this segment are two carpi (4, 4′). The supernumerary carpus (4′) does not have the exact form of the normal carpus (4), but is slenderer, subcylindrical, and much more spiny. The normal carpus is followed by a propodus and dactylus (5, 6) of the regular form. The supernumerary carpus bears at its distal extremity an abortive propodus (5′) in the shape of a small stump-like segment, bifurcated at the end and armed with a blunt spinous tubercle (y') on its inner margin. This tubercle is homologous with the tubercle y at the proximal end of the external border of the normal propodus. Curiously, the supernumerary carpus is set upon the meros in a position almost the reverse of that of the normal carpus, so that the surface of the accessory carpus and propodus, which is homologous with the upper surface of the regular carpus and propodus, looks in almost the opposite direction. It is as if the abnormal carpus were rotated upon the meros through nearly 180 to the left. It thus comes about that the articular tubercle x' falls on the same side with its homotype, x, instead of on the opposite side, as one would expect from the reversed symmetry of the two carpi. If the two propodal segments (5, 5′) were flexed at the same time, they would move in nearly opposite directions. This distortion seems to me very singular, and I think nothing like it has been observed among the many cases of double legs in insects.

In this specimen we have the nearest approach to complete duplication of a limb yet observed among Crustacea. It reminds one of the monstrosities among insects, frequently described by entomologists, in which the duplication of a leg may involve all the joints down to the trochanter. Whether this monstrosity be congenital, or the result of injuries received later in life, I cannot tell.

Plate II. Fig. 7 (*Homarus Americanus*, left chela). — In this small chela only a rudiment of the index is present, and the dactylus is curled underneath it in the form of a semicircle.

Plate II. Fig. 8 (*Callinectes hastatus*, left latèral portion of the carapace). — The lateral horn, instead of being simple, as in normal specimens, has three spines, one directed forward, outward, and downward, one backward, outward, and upward, and one, very small in size, backward, outward, and downward.

Plate II. Fig. 9 (*Homarus Americanus*, right chela). — The whole of the index as well as part of the hand is wanting in this sadly mutilated claw. The amputated part was evidently removed when the shell was soft, and the wound has completely healed. The dactylus has the form of a cylindrical stunted segment, with an imperfectly developed line of teeth on its cutting surface. The character of the shell leads me to believe that the amputation passed through the line indicated by x, and that the part of the hand distal to this, as well as the dactylus, was reproduced by budding after the wound was received.

Although as early as 1671 the fanciful Von Berniz (No. 1) described and figured two misshapen Crustacean claws, the number of deformities among animals of this class recorded by naturalists is small compared with those observed in insects. Of the thirty cases which I find hitherto recorded, fifteen belong to the European crayfish (*Astacus fluviatilis*).* Leaving out of account the claw represented by Fig. 3 on Plate II., in which we have a simple distortion arising from an abnormal curvature of the fingers, it appears that all the deformities just described belong to the two categories of *monstrositates per defectum* and *monstrositates per accessum.* The former (such as Plate II. figs. 7, 9) are without doubt the result of an accidental amputation of certain parts when the animal was soft-shelled, which parts would probably have been restored after subsequent moults if the animal had lived. Such deformities can hardly be termed true monstrosities, and are of minor interest. The latter, — in which category all the other cases figured will be included, — while accompanied in most cases by a distortion of normal structures, and probably for the most part the result of injuries, present irregular, secondary outgrowths, and are of considerable interest. Among these we have, *first,* cases of duplication of joints in a limb (as in Plate I. figs. 12, 13, 16, Plate II. fig. 6), similar to the many cases described among insects; *secondly,* processes budding out from either the propodus (Plate I. figs. 9, 11, 14, 17) or the dactylus (Plate I. figs. 1–8, 15, Plate II. figs. 1, 4, 5) without any articulation. These processes frequently simulate a true claw in a marvellous manner, e. g. Plate I. figs. 1–5, and are worthy of especial attention. A Crustacean claw is, morphologically viewed, a composite structure involving two segments of the series of seven which are found in the typical leg. The ultimate segment of the series develops teeth along its inner border, and when flexed closes against an immovable toothed process from the penultimate segment. But in these fictitious claws (see Plate I. figs. 2, 5, etc.) the two

* It is remarkable that in the vast number of American crayfishes examined by Hagen in the preparation of his *Monograph of the North American Astacidæ,* no deformities, strictly speaking (see p. 269), were observed.

digits *b*, *c*, are simply processes developed from the ultimate segment of the leg without the least mobility. We have here a structure which is neither morphologically nor functionally a claw, but only a counterfeit of one. What force produces the perfect development of teeth on the opposed edges of these immovable digits, where they cannot be of the slightest service? It is to be observed that these spurious chelæ are always found on the dactylus of claws which have lost their function through the displacement of the dactylus. In such cases there seems to be a futile effort to form a new claw in the way indicated. When one sees how perfectly the dactylus *a* (e. g. in Plate I. fig. 5) is repeated in the process *b*, and the index in the process *c*, even to the details of dentition and setæ, he is at once tempted to call upon Darwin's hypothesis of pangenesis † to explain the resemblances. It will be observed (see Plate I. figs. 13, 16, Plate II. fig. 6) that a movable dactylus may be duplicated on the propodal segment, but in no case is an *articulated* segment developed from the dactylus.

It would be extremely interesting to know whether these monstrous developments are perpetuated throughout the life of the individual, or whether they are got rid of by exuviation. The latter seems hardly probable. Huxley ‡ says the deformities persist, but whether this statement be based on observation or not, I do not know.

As the specimens which have come under my observation are dry, and the soft parts removed, I can record nothing concerning the arrangement of the muscles, nerves, and arteries in those deformed claws. What modifications of the soft parts are brought about by the deformities would be a most interesting subject of study for any one who may come into possession of such specimens in a fresh or alcoholic state.

Almost all the malformations of the hard parts of Crustacea which have been described are confined to the big claws. These claws, being the chief weapons of offence and defence, are much more liable to receive wounds than any other part of the body, and, as before pointed out, deformities such as are described in this paper are undoubtedly in most cases the result of injuries. Rösel (No. 4) speaks of deformities of the rostrum of crayfishes; Herklots (Nos. 11, 15) describes and figures a triple dactylus of the second pair of legs in *Lithodes arctica*; A. Milne

* In such specimens as that figured on Plate I. fig. 8, where the chela has its functional power, the spurious claw is formed in a different way, *a* being the original dactylus. See p. 258.

† The Variation of Animals and Plants under Domestication, Vol. II. Ch. XXVII.

‡ The Crayfish. An Introduction to the Study of Zoölogy, p. 39, 1880.

Edwards (No. 12, see p. 268) records a monstrosity affecting the eye-stalk of *Palinurus penicillatus;* and finally Packard (No. 17) has noticed a deformity of the caudal spine of *Limulus Polyphemus.* The last is probably not so rare as Packard supposes, as I have found two specimens of *Limulus* with similarly deformed spines. There is also in the Museum of Comparative Zoölogy a small deformed specimen of *Limulus Polyphemus,* in which the left side of the gill-bearing segment of the body is marked by a deep concavity and absence of the lateral spines. Further, Figs. 2 and 8 on Plate II. of this paper portray deformities of other parts than the great claws. Fig. 2 represents a monstrous condition of one of the small chelipeds of the lobster, and there is another specimen in the Museum in which the index or immovable finger of the chela of either the first or second pair of legs is double. Another lobster presents a deformity of one of the third pair of maxillipeds, the terminal segment being divided into three lobes. Plate II. fig. 8 represents a deformed lateral spine of the carapace of *Callinectes hastatus.*

Reviewing all the deformities which have been described among Arthropods, I would divide them into five categories, as follows.

Deformities : — *a,* of deficiency.
b, of excess.
c, of transformation.
d, of arrested development.
e, of hermaphroditism.

a. In individuals affected with deformities of this class, certain parts normally present are wanting. Among Crustacea such cases are, as far as I am aware, never congenital, but result from accidental amputation of parts commonly restored by new growths, as before observed.

b. Monstra per accessum. Under this head fall the majority of the monstrosities that have been described among Arthropods. Among insects the numerous cases recorded by Asmus,* Mocquerys,† various contributors to the *Annales de la Société Entomologique de France,* and lately by Jayne,‡ etc., etc., for the most part belong here. In these cases it is commonly the antennæ and legs which are the seat of the monstrous developments, which usually take the form of a duplication, or even triplication, of the appendage. In most cases such double or triple appendages are single at the base, the duplication or triplication

* Monstrositates Coleopterorum, 1835.

† Recueil de Coléoptères anormaux, 1859.

‡ Descriptions of some Monstrosities observed in North American Coleoptera, *Trans. Amer. Ent. Soc.,* VIII. p. 155, 1880.

involving only the distal segments. In the leg, for instance, all the segments beyond the coxa may be duplicated, while in other cases one or two of the distal joints of the tarsi alone will be repeated.

Among Crustacea the examples of a real duplication or triplication of segments in an appendage are very rare. The most marked instance of the kind is afforded by the lobster cheliped figured on Plate II. (Fig. 6) of this paper, in which there is a clear tendency to duplication, at least from the coxa onward. Duplication of the dactylus is seen in Plate I. figs. 12, 13, 16, and in Plate II. fig. 2.* Jäger (No. 10, p. 38, figs. 12, 13) has described and figured a claw of *Uca una* with two dactyli, and a similar case in *Eriphia spinifrons* has been published by Herklots (No. 15, figs. 6, 7, 8).

On seeing such a specimen as the *Prionus* figured by Jayne,† in which the tibiæ and tarsi are duplicated in all the legs, and perfectly symmetrical on the two sides of the body, one cannot doubt that in insects at least these monstrosities by duplication may be referred to a *vitium primæ conformationis*, and in examples from Crustacea such as those represented by Fig. 13, Plate I., and Fig. 6, Plate II., of this paper, it is very probable that we are dealing with a monstrosity which is not the result of injury.

Most of the *deformities by excess* among Crustacea, however, do not result from a true duplication of more or fewer segments of an appendage, but from the outgrowth of unarticulated processes of various shapes, often furnished with teeth, and simulating true segments. But in such cases, e. g. where there is a process that has the form of a supernumerary dactylus, we find that it is commonly developed from the normal dactylus, and devoid of any articulation, instead of joining by an articular surface with the propodus as a true supernumerary dactyle would do.

In this category the *Astaci* noticed by Emmanuel Rousseau (No. 8) and Eugène Desmarest (No. 9) will also be included. In these abnormal female specimens an extra pair of vulvæ were present on the basal segment of the fourth pair of legs, the oviduct of each side dividing into two branches after leaving the ovary.

c. Monstrosities of this class result from an organ being replaced wholly or in part by another organ. Such monstrosities are common in plants, but exceedingly rare in animals. A few have been described

* There are two or three lobster claws with two dactyli in the collection of the Peabody Academy of Science, Salem.

† *Op. cit.*, Plate IV. fig. 12.

among Arthropods. I am indebted to Dr. Hagen for references to the following cases among insects : —

1. *Prionus coriarius* with two perfect legs in place of the elytra.*

2. *Cimbex axillaris* with a claw like those of the tarsi, on the end of the left antenna.†

3. *Zygœna filipendulœ* with one of the hind legs replaced by a wing.‡

Among Crustacea the only example of this kind of monstrosity is the *Palinurus penicillatus* described by A. Milne Edwards (No. 12), in which a flagellum like one of those of the antennules is developed from the centre of a rudimentary cornea on the end of the eye-stalk.

Monstrosities of this class are especially interesting on account of their bearing on the morphology of organs. If we admit teratological conditions as evidence of homology, as the botanists do in the case of the metamorphosis of the parts of a flower, we must regard the wings and legs of insects, as well as the eye-stalks and antennæ of Crustacea, as morphological equivalents,§ a view which is not supported by the mode of development of these parts in the embryo.

* Saage, *Preussische Provinzial Blätter*, Vol. XXII. p. 191, 1839; *Stettin. Entomol. Zeitung*, Vol. I. p. 48 (cited from Hagen, On some Insect Deformities, *Mem. Mus. Comp. Zoöl.*, Vol. II. No. 9, p. 22, 1876).

† G. Kraatz, Ueber eine merkwürdige Monstrosität bei *Cimbex axillaris* (Hymenopt.), *Deutsche Ent. Zeits.*, XX. Heft II. p. 377, Taf. I. fig. 8 *a*, *a*, *b*, 1876.

‡ N. M. Richardson, *Nature*, Vol. XVI. p. 361, August 30, 1877. Dr. Hagen tells me that he is sure he has seen another similar case recorded, but he has lost the reference to it.

§ Dr. Hagen (in his lectures) also adduces evidence from comparative anatomy of insects to support the theory of the homology of wings and legs. Most authors (Gegenbaur, Lubbock, Fritz Müller, etc.) who have discussed the question of the morphology of insects' wings consider them to have originated independently of the ventral appendages, as tracheal gills or otherwise. Balfour (Treatise on Comparative Embryology, Vol. I. p. 337, 1880) even doubts whether the antennæ of insects have the same morphological value as the succeeding appendages ! None of these writers take notice of the above-mentioned monstrosities in this connection.

With reference to the homology of eye-stalks and antennæ in Crustacea, A. Milne Edwards (No. 12), Gerstaecker (Bronn's Klassen und Ordnungen des Thier-Reichs, V., 1 Abt., 1 Hälfte, pp. 202, 343, 1868), and Rolleston (Forms of Animal Life, pp. 113, 119, 1870) bring forward the abnormal development of an antennulary flagellum from the eye-stalk in the *Palinurus* mentioned above as proof of the homology of the eye-stalk with the antenna, a view long ago advanced by Savigny and H. Milne Edwards. The embryologists on the other hand, as Claus and Fritz Müller, generally deny the equivalence of the parts in question. E. van Beneden says of the eye-stalk in *Mysis* : " Ce pedicule n'apparait aucunement comme les autres appendices, et paraît avoir une autre valeur morphologique." (*Bull. Acad. Roy. de Belgique*, 2 Ser., *d.* The existence of dimorphism among the males of the genus *Cambarus*, first observed by Agassiz, has been fully discussed by Hagen (No. 16), who conjectures from the resemblance of the "second form" males to young individuals and the small development of the internal organs of generation, that they are sterile. In *Lupa* and some other genera of *Brachyura* dimorphism occurs in the females, many full-grown specimens having a narrow and acute abdomen, instead of the broad, roundish abdomen of the normally developed individuals. Agassiz learned from anatomical examination that the females with a narrow triangular abdomen were sterile.

These sterile forms may be properly classed among abnormal variations caused by arrest of sexual development.*

e. Hermaphroditism.—While numerous cases of hermaphroditic insects have been put on record by entomologists, I can find but two undoubted cases of hermaphroditism among Crustacea outside of those groups in which it is the normal condition, viz. the Cirripeds and parasitic Isopods. The first case is that of a lobster (*Homarus vulgaris*) described and figured by F. Nicholls, in 1730, in the Philosophical Transactions of the Royal Society of London (No. 3 of the bibliographical list appended to this paper). In this specimen the right half of the body was female, the left half male, as regards both internal and external organs. The second case is a similar one of *Eubranchipus vernalis*, lately described by Gissler (No. 18).

E. von Martens (No. 14) has published an account of three specimens of *Cheraps* from Adelaide, with openings in the first segment of the third pair of legs answering to the sexual apertures of the normal female, coexisting with the normal male sexual orifices in the first segment of the fifth pair of legs. An examination of the internal parts showed the coiled *vasa deferentia* of the normal male opening out through the apertures in the fifth pair of legs. No ovary or duct leading to the openings in the third pair of legs was detected. The specimens had lain in alcohol some seven years, however, so that the evidence against the existence of any internal female organs cannot be taken as positive. Similar open-

XXVIII., 1869). Gegenbaur (Grundzüge der vergleichenden Anatomie, 2[te] Aufl., p. 397, 1870) also excludes the eye-stalk from the series of appendages.

* Among insects the *Phalæna heteroclita* [*Bombyx monacha ?*], described by O. F. Müller (an imago with the head of the larva), is probably to be explained as a deformity arising from arrest of development. In other cases recorded of the retention of the larval head by a perfect insect, the head of the imago was probably within the head of the larva, which was not cast off at the time of transformation. See Hagen, On some Insect Deformities, *Mem. Mus. Comp. Zoöl.*, Vol. II. No. 9, 1876.

ings were seen in the third pair of legs of male *Parastacus pilimanus* and *P. Brasiliensis.*

Abnormal cases of hermaphroditism in Decapods acquire a peculiar interest in the light of the recent discovery of hermaphroditism as the normal condition in another group of the higher Crustacea, viz. the parasitic Isopods.* Mayer has even found indications of hermaphroditism in *Cirolaña* and *Conilera*, genera of free Isopods.†

* Bullar, The Generative Organs of the Parasitic Isopoda, *Jour. Anat. and Physiol.*, XI. p. 118, 1876. Id., Hermaphroditism among the Parasitic Isopoda, *Ann. Mag. Nat. Hist.*, 4 Ser., XIX. p. 254, 1877.

Paul Mayer, Ueber den Hermaphrodismus bei einigen Isopoden, *Mittheilungen aus der Zoolog. Station zu Neapel*, I. p. 165, 1878.

† *Op. cit.*, p. 177.

CAMBRIDGE, March, 1881.

BIBLIOGRAPHY.

1. Martinus Bernhardus a Berniz. Chela Astaci marini monstrosa. *Miscellanea Curiosa Medico-Physica Academiæ Naturæ Curiosorum*, Annus secundus, Observatio C., p. 174 (fig.). 1671.

   Chela Astaci marini monstrosa alia. *Op. cit.*, Observatio CI., p. 175 (fig.) The figure is reproduced in Michael Bernhard Valentini's *Museum Museorum*, Zweyter Theil, p. 177. 1714.

   (This "*chela monstrosa et tota petrefacta*" evidently does not belong to a lobster.)

2. J. E. Valentini. Chela Astaci fluviatilis tribus Apicibus prædita. *Acta Acad. Cæs. Leopold. Carol. Naturæ Curiosorum*, Vol. II., Observatio CXXVI., p. 285. 1730.

   (Cited after Herklots in No. 15 of this list.)

3. F. Nicholls. An Account of the Hermaphroditic Lobster presented to the Royal Society by Mr. Fisher, examined and dissected. *Philosophical Transactions of the Royal Society of London*, Vol. XXXVI. No. 413, p. 290. 1730. [*Abridgment*, Vol. VII. Part III. p. 421, Pl. IV. 1734.]

   (Right side *female*, left side *male*. See p. 269.)

4. August Johann Rösel von Rosenhof. Fernere Beschreibung des hiesigen Fluskrebses und seiner merkwürdigen Eigenschafften. *Der monatlich-herausgegebenen Insecten-Belustigung dritter Theil*, p. 344, Tab. LX. fig. 28, 29, Tab. LXI. fig. 30 – 33. 1755. Figures copied in *Encyclopédie Méthodique*, Vol. 191, Pl. 290, fig. 1 – 6, 1830, and by Jäger in No. 10, fig. 4 – 6, 9 – 11.

5. F. Tiedemann. Beschreibung einiger seltenen Thier-Missgeburten. *Deutsches Archiv für die Physiologie*, Vol. V. p. 127, Pl. II. fig. 2. 1819. Figure reproduced by Jäger in No. 10, fig. 8.

6. Georg Jäger. Zwei Beispiele missgebildeter Krebsscheeren. *Archiv für Anatomie und Physiologie*, Jahrgang 1826, p. 95, Tab. II. fig. 3, 4. Figures reproduced by the same author in No. 10, fig. 1, 3.

   (*Astacus fluviatilis*).

7. H. Lucas. Notice sur quelques Monstruosités observées dans des Crustacés appartenant aux Genres *Carcinus*, *Lupa*, *Homarus* et *Astacus*. *Annales de la Société Entomologique de France*, 2e Série, Tome II. p. 41, Pl. I. 1844.

8. Emmanuel Rousseau. *Annales de la Société Entomologique de France*, 2e Série, Tome VI. p. 481. 1848.

   (Female *Astacus fluviatilis* with two pairs of vulvæ on the base of the third *and fourth* pairs of legs.)

9. Eugène Desmarest. Note sur une Disposition anormale des Organes Génitaux observée dans *l'Astacus fluviatilis* Fabricius. *Annales de la Société Entomologique de France*, 2e Série, Tome VI. p. 479, Pl. 13. 1848.
(Female *Astacus fluviatilis* with four vulvæ disposed as in the one described by Rousseau. Two oviducts on each side pass from the genital apertures to unite in a common trunk before reaching the ovary.)

10. G. Jäger. Vergleichende Darstellung der missgebildeten Scheeren des gemeinen Flusskrebses (*Astacus fluviatilis*) und der missgebildeten Scheere einer Krabbe (*Cancer uca Linn. Uca Una Latr.*) aus Surinam. *Jahreshefte des Vereins für vaterländische Naturkunde in Würtemberg*, Jahrhg. VII., p. 33, Pl. I. 1851.

11. J. A. Herklots. Notice Carcinologique. *Bijdragen tot de Dierkunde. Uitgegeven door het Koninklijk Zoologisch Genootschap Natura Artis Magistra*, Amsterdam, Deel I. Afl. 5, p. 37, fig. B. 1852. Figure reproduced by the same author in No. 15.
(Deformed dactylus of the second pair of legs of *Lithodes arctica*.)

12. Alphonse Milne Edwards. Sur un Cas de Transformation du Pédoncule oculaire en une Antenne, observé chez une Langouste. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, Tome LIX. p. 710. 1864.
(Antennulary flagellum developed from the end of the eye-stalk in a *Palinurus penicillatus* from Mauritius.)

13. Sidney I. Smith. A Fiddler-Crab, with two large Hands. *The American Naturalist*, Vol. III. p. 557, 1869.
Notes on Amerian Crustacea. No. I. Ocypodoidea. *Transactions of the Connecticut Academy of Arts and Sciences*, Vol. II. p. 133, 1870.
(Notice of an anomalous specimen of *Gelasimus pugnax* Smith, in which the chelipeds were nearly equal in size and form.)

14. E. von Martens. *Sitzungs-Bericht der Gesellschaft naturforschender Freunde zu Berlin* am 18 Jan., 1870, p. 1.
(Male specimens of *Cheraps plebejus*, *Parastacus pilimanus*, and *Parastacus Brasiliensis*, with openings in the first segment of the third pair of legs representing the genital orifices of the female. See p. 269.)

15. J. A. Herklots. Misvormingen bij Schaaldieren waargenomen. *Tijdschrift voor Entomologie, uitgegeven door de Nederlandsche Entomologische Vereeniging*, XIV. Jaargang, p. 69, Pl. I. 1871.
(Malformation of the claw of *Xantho punctulatus*, *Eriphia spinifrons*, and the deformed dactylus of *Lithodes arctica*, previously published by the same author in No. 11.)

16. Hermann A. Hagen. Monograph of the North American Astacidæ. *Illustrated Catalogue of the Museum of Comparative Zoölogy, at Harvard College* [*Memoirs*, Vol. II.], No. III. p. 21 *et seq.* 1871.
(Variation of form accompanying sterility (?) in *Cambarus*, *Lupa*, etc. See p. 269.)

17. A. S. Packard, Jr. The Development of Limulus Polyphemus. *Memoirs of the Boston Society of Natural History*, Vol. II. p. 201, fig. 36. 1872.

(Forked caudal spine.)

18. C. F. Gissler. Description of a Hermaphroditic Phyllopod Crustacean (Eubranchipus). *The American Naturalist*, Vol. XV. p. 136, fig. 1-3. 1881.

(*Eubranchipus vernalis*, showing lateral hermaphroditism both in the external claspers, etc. and in the internal genital organs. The internal female organs are but poorly represented, — although a single egg was observed in the ovarial string, — while the internal male organs have their normal size and shape.)

EXPLANATION OF THE PLATES.

[NOTE. — A detailed description of the specimens figured in the plates will be found on pp. 257-264. Unless otherwise stated, the specimens are in the Museum of Comparative Zoölogy, and were obtained from K. D. Atwood, Portland, Me. Those figured on Plate I. are reduced one half. Those figured on Plate II. are of the natural size.]

PLATE I.

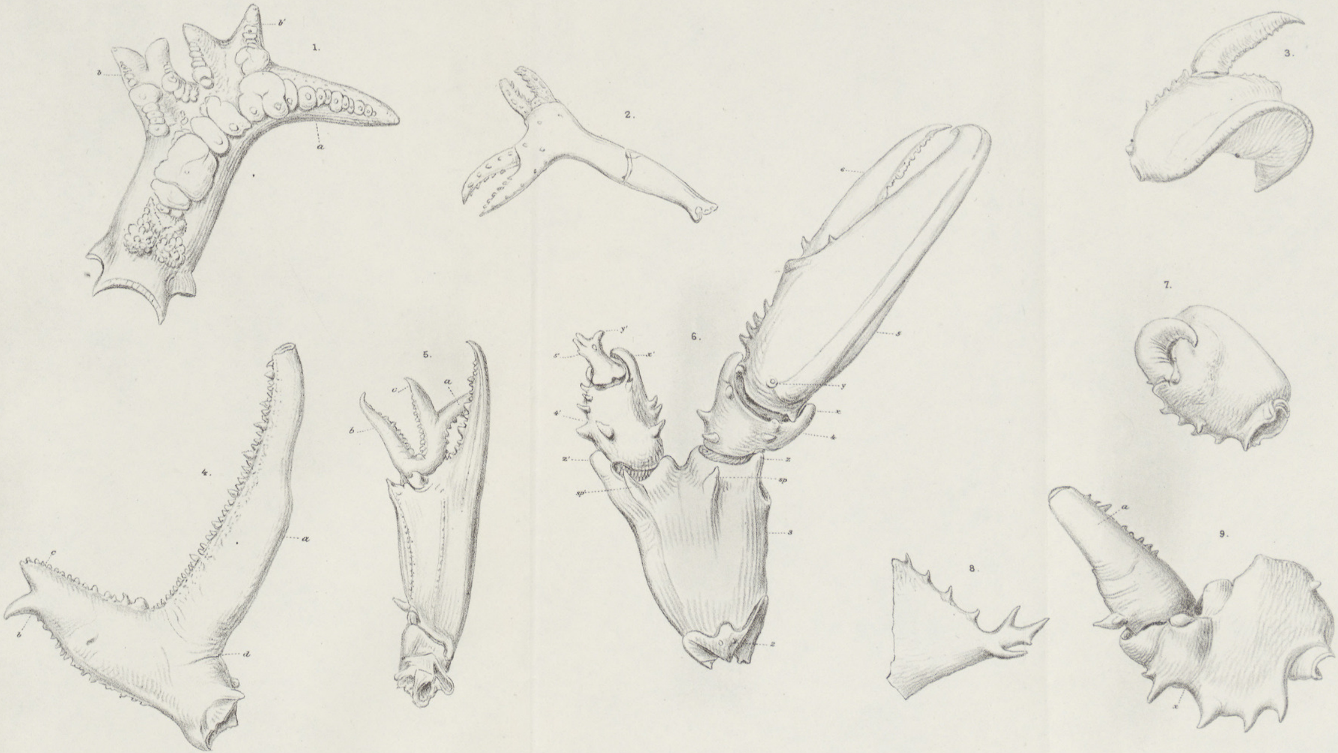
Fig. 1. *Homarus Americanus*, right chela.
" 2. " " left "
" 3. " " right ".
" 4. " " right "
" 5. " " left "
" 6. " " right "
" 7. " " left "
" 8. " " right "
" 9. " " right "
" 10. " " right "
" 11. " " left "
" 12. " " right "
" 13. " " right "
" 14. " " right "
" 15. " " left "
" 16. " " left "
(From Mus. Peabody Acad. Science, Salem, Mass.)
" 17. *Homarus Americanus*, left chela.

PLATE II.

Fig. 1. *Homarus Americanus*, dactylus of right chela.
" 2. " " one of the small chelipeds.
" 3. " " left chela.
" 4. " " dactylus of right chela.
" 5. *Callinectes hastatus*, left chela.
(From Chesapeake Bay; coll. Dr. S. F. Clarke.)
" 6. *Homarus Americanus*, right cheliped.
" 7. " " left chela.
" 8. *Callinectes hastatus*, left lateral part of the carapace with branched spine.
(Coll. M. C. Z.)
" 9. *Homarus Americanus*, right chela.

P. Roetter del.

Print by A. Meisel



P. Roetter del.

Print by A. Meisel