

## ZOOLOGICAL RESEARCHES.

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### MEMOIR 1.

*On the Metamorphoses of the Crustacea, and on Zœca, exposing their singular structure and demonstrating that they are not, as has been supposed, a peculiar Genus, but the Larva of Crustacea !!*

THE transformations which animals undergo in their progress from the egg to a perfect state, have ever been regarded as among the more remarkable traits which their history affords; these, as they affect the *Land* animals offer themselves freely to our observation, and have been ascertained to be strictly confined to the class of true insects: the marine and aquatic animals in general (exclusive of amphibious insects) never emerging from an element which presents numerous obstacles to the investigation of their habitudes, have been considered as undergoing no metamorphosis, with the exception of a few aquatic Reptiles, and some genera of the Linnean Monoculi, viz. *Apus*, *Branchipus*, *Cyclops* and *Argulus*; indeed so decided has been this notion in respect to the more perfect Crustacea, (*Malacostraca*) that the acute and indefatigable Doctor Leach, one of the chief investigators of this tribe of animals, has assigned it as one of their principal characters, *that they undergo no metamorphosis*. ENCY. BRIT. — Art. *Crustacea*.

One of the objects therefore of the present Memoir, will be to show the erroneous nature of this opinion, and to announce the *important discovery*, that the greater number of the Crustacea do actually undergo transformations, of which, in addition to the facts now adduced, further instances will be given in future memoirs.

The circumstance of the Crustacea being supposed to pass through no intermediate form, has been brought forward heretofore as one of the arguments for their separation from Insects; but, although the fallacy of that opinion may diminish the number of the characteristics which distinguish these two tribes of animals as *distinct Classes*, there yet remains those depending on the anatomical structure of their respiratory and circulating systems, which are quite sufficient to render the separation permanent. It may also be observed, that the changes presented to our notice in the Crustacea are quite peculiar, and of a totally different description from those of Insects.

The sea (which is the habitation of the greater part of the Crustacea,) to the casual observer, offers nothing but an immense body of water, here and there presenting a solitary whale, or a vagrant troop of some of the smaller Cetaceous animals; the appearance of a fish of almost any other kind in the track of a vessel over the vast expanse of the open ocean, is regarded even by the mariner, as a kind of phenomenon, and creates an interest not to be appreciated by those who have not engaged in distant voyages. The fathomless parts of the ocean certainly do not offer the same profusion of inhabitants with the shores of Islands and Continents, or those parts where the bottom is within the reach of the sounding line, or where its surface is interspersed with fields of Sargosa (*Fucus natans*;) on due examination however, we shall not fail to find it every where peopled by a considerable variety of animals either of small size, or possessed of such a degree of translucency as to render them invisible, or scarcely

perceptible even when on, or near to, its surface : that it should possess its share of the organized beings which we see spread over every other part of the surface of our globe, is a conclusion we might arrive at indirectly, from the consideration of Oceanic fishes and birds being observed in those parts of the ocean most distant from the land, and the provident care of the Deity which we invariably witness throughout the domain of nature, to furnish food for all the meanest of his creatures ; the more minute and invisible inmates of the sea then, must constitute the food of Oceanic fishes and birds. Few of these marine animals, except some of the larger and more conspicuous, have as yet been observed, so that the investigation of them holds out the promise of a rich harvest to the Naturalist and a vast field of exploration replete with novelty and interest ; \* to accomplish this object however, he must use the greatest diligence, seizing every opportunity when the way of the ship does not exceed three or four miles per hour, to throw out a-stern a small towing net of gauze, bunting, or other tolerably close material, occasionally drawing it up, and turning it inside out into a glass vessel of sea water, to ascertain what captures have been made ; when a ship goes at a greater rate, and in stormy weather, a net of this kind might be appended to the spout of one of the *sea-water* pumps, and examined three or four times a day, or oftener, according to circumstances.

The luminosity or sparkling of the sea by night, is a phenomenon which never fails to attract the attention of voyagers the most incurious, and having been found in the greater number of instances, to be produced by marine animals, first led the author into the use of the towing-net, and discovered to him the variety and profusion in which they occur, both luminous and otherwise, and amongst others, the animals which form the subject of the present memoir.

\* To speak the truth, our own seas have been almost as little explored, although they teem with curious and unknown animals.

The animals of the supposed Genus *Zoea*, have been hitherto little known from their small size, transparency, and the other circumstances above alluded to. Slabber, Bose and Cranch, are the only Naturalists who have had the good fortune to observe them; to these may be added the author, who in towing for luminous animals, during a voyage from the Mauritius in 1816, discovered the species figured in Plate I. fig. 2, and fig. 4, *a. b.* without having it in his power to throw any new light upon their nature or structure: great variety of subjects, and the difficulty of pursuing microscopical dissections of minute animals on so turbulent an element, having prevented this being followed up at the moment, and having subsequently lost these specimens, we might have remained for an indefinite period without the knowledge of their *real* nature, the profusion in which they occur in our own seas, their variety, and the peculiarities of their structure, had not he continued to use the muslin towing net, for the detection of minute marine animals, since his return to Europe; many, and important, have been the results of this simple procedure, but none attended with greater surprise, than the vast profusion of the animals of *Zoea* discovered on our coasts and in our bays and estuaries, the novel and curious history of which, it is intended to give in this and subsequent memoirs.

Slabber in a Dutch Work entitled "Natural Amusements and Microscopical Observations" published at Harlem in 1778, has given us a description and figure of the species which has been since designated *Zoea taurus*, Plate I. fig. 1, *a* (in outline and without adventitious groups of a vorticella) several of these were taken at sea, July 24, 1768. From the observers of that period, any very exact analysis of such an animal was not to be expected, its whole length being but  $1\frac{1}{2}$  line; he describes it as of a greenish colour, the tail paler, the corselet with a long frontal and dorsal spine, the fourth joint of the tail with a projecting spine



behind, and the fifth or terminal joint formed as in all the genuine Zoeas, of a deep fork, the inner sides of which are furnished with three small spines, the feet he erroneously counted as eight, none of them provided with more than four terminal plumose setæ, the antennæ entirely escaped observation, nor does it appear whether there are any lateral spines to the corselet. Upon the whole, we ought to feel grateful to Slabber for the first and most characteristic figure that has been given of these curious animals, and the pains he took to throw light upon their history.

Bosc, one of the most judicious naturalists of the French school, in a voyage which he undertook to America with a view to Natural History, discovered a single individual of the species figured Plate I. fig. 3 in the Atlantic Ocean, 5 or 600 leagues from the coast of France; and justly conceiving it distinct from all the other Genera of the Crustacea, first instituted that of *Zoea* for the reception of these anomalous animals, distinguishing the above species by the title of *pelagica*; it appears to have been one of the smallest size, transparent as glass, and differs from the former, principally, by the addition of a long deflected lateral spine on each side of the corselet; the antennæ did not entirely escape the observation of this able and zealous Naturalist, but he also failed in detecting the peculiar structure of its other members.

Mr. Cranch, in the course of Captain Tuckey's Voyage to the Congo, discovered the curious and singular species Plate I. fig. 5. in N. Lat.  $1^{\circ} 56''$ , W. Long.  $8^{\circ} 46,37''$  which Dr. Leach has named *Z. Clavata*, from the club-like shape of its dorsal and lateral spines.

Of the two species observed by the author in 1816, that taken September 17, N. Lat.  $16^{\circ}$  W. Long.  $26^{\circ} 37''$  and figured Plate. I. fig. 2. resembles most the *Zoea taurus* of Slabber, its frontal and dorsal spine shorter in proportion; the lateral spines sufficiently conspicuous; the three anti-

penultimate joints of the tail with a short adpressed spine on each side; the other projections seen in the figure at the sides of the body and tail, are probably parts of the bent up members of the animal; it was quite transparent, and occasionally luminous and scintillating by night. The second species, taken August 22, in S. Lat.  $17^{\circ} 30''$ , W. Long.  $1^{\circ} 30''$  and figured Plate I. fig. 4. *a.* and *b.* was like the former discovered by its luminous scintillations in the dark, and when examined next day, it appeared to have no spines strictly to be called *lateral*, or *dorsal*; the anterior spine is short, as in the former, and posteriorly, the corselet ends apparently in three short spines; the tail being bent up close under the breast of the animal was not observed; the setæ which terminate the feet, were very long and feathered: this may probably be the second species of which Bose appears to have had a glimpse, and which he describes as being black and without any dorsal spine.

Up to the year 1822, these were all the Zocas known to Naturalists, who, while they agreed as to their being Crustacea, could not determine the place they ought to occupy in that Class. Slabber referred them to the Monoculi! although so obviously provided with a pair of extremely large and distant eyes: most of our contemporary Naturalists of the greatest discrimination, still associate them with the Entomostraca, an order formed out of the Linnæan Monoculi;\* others, not less puzzled by the association of characters belonging to widely separated groups, have preferred approximating them to the more perfect Crustacea, thus Bose† places them at the head of the edriophthalma (ouisci &c.) and considers them to be intermediate between these, and the podophthalma (lobsters,

\* Latreille, Hist. Nat. des Crust. &c. Sonnini's edit. of Buffon, 1802, and in his Genera Crust. et Insect. 1807. Dumeril, Zoologie analytique, 1806.

Cuvier, Règne Animal, 1817. Lamarck, Animaux sans Vertébrés, 1818.

† Hist. des Crust, Castel's edit. of Buffon.

&c.) Dr. Leach, with that uncommon foresight for which he is distinguished, placed them at the tail of his mala-costraca,\* until having inspected the species discovered by Cranch, he declared them to belong to the podophthalma, and to the same group with Nebalia.† It will no longer be a matter of surprise, that all the leading Naturalists of the present day, should have been at a loss how to dispose of Zoea in their arrangements of the Crustacea, when it is known, that this singular type, is not a perfect animal, but merely the *larva* or imperfect state of the *Crab*! and not as had been imagined, an animal *sui generis*! This is a discovery quite new, and interesting in a double point of view, as proving their real nature, and that the more perfect of the Crustacea undergo a Metamorphosis, and that of a description totally different from any hitherto known; so little has this been suspected by Naturalists, that as before stated, the contrary has been assigned as one of the distinctive characters of the class, and been used as an argument for their separation from insects. It may be urged, that this is no new discovery, and that Slabber has the merit of having first indicated a metamorphosis in the Crustacea; the metamorphosis however, which this observer thought he witnessed, is of so different a description, that we must either suppose him to have fallen into some error, or that there may be Crustacea which pass through other forms than those now for the first time made known. That Naturalists may be put into possession of all the circumstances necessary to a just decision, we shall first point out the supposed discovery of Slabber, and then state what we have ourselves observed.

Slabber, wishing to continue his observations on his Zoea, took care to renew the water in which it had been placed, and on the third day, finding its movements become slower, and its colour more pale, he subjected it to the

\* Art. Annulosa, Suppl. Ency. Brit. † Captain Tuckey's Voyage to the Congo.

microscope, and found to his surprise, that the anterior portion of the animal had changed its form, and on the fourth day it had acquired the appearance represented Plate I. fig. 1, 6, so that together with the other individuals he had taken, it seemed to have experienced a complete metamorphosis; under this new form, the dorsal spine had disappeared, the front spine had become comparatively small, the antennæ were rendered conspicuous, the feet and eyes were apparently more developed, and the tail had changed from forked to spatulate, fringed by a row of thirteen short spines. It will readily occur to the reader, that observations made in this way, upon aquatic animals at once so minute and so transparent, require the greatest care and circumspection to insure any positive result; from much experience, the author is led to suppose, that Slabber lost his *Zoeas* in changing the sea water, and that the new form came from the added portion, a circumstance rendered more probable, by his having met with both these types at the same season of the year.

It was during the spring of 1822, that the author to his great surprise, first met with *Zoeas* in the harbour of Cove, and that in considerable abundance; the year following at the same season, one of considerable size occurred, amongst a great number of smaller ones, and judging it full grown, (Plate II. fig. 1, 2,) and a fit subject to keep for the purpose of witnessing the metamorphosis observed by Slabber, it was daily supplied with fresh sea water in the most careful manner, from May 14, until the 15th June, when it died in the act of changing its skin, and of passing into a new form, but one by no means similar to that expected, as appears evidently by its disengaged members (fig. 11.) which are changed in number, as well as in form, and now, correspond with those of the Decapoda, (Crabs, &c.) viz. five pair, the anterior of them furnished with a large claw or pincer: the metamorphosis not having been completed, prevented any knowledge



being acquired of its general form, enough however has been gained to shew, that the distinctive characters of Zoca, and of Slabbers changed Zoca, were entirely lost, that the members, from being natatory and cleft (as shall shortly be shown,) become simple, and adapted to crawling only. On the 1st of May of the present year, (1827,) another large Zoca was taken, and dying towards the end of the month without having the requisite strength to disengage itself from the exuvium, presented precisely the same results with the former.

The proof however might be deemed incomplete, had not the author the good fortune to succeed in hatching the ova of the common Crab (*Cancer pagurus*) during the month of June last, which presented exactly the appearance of Zoca taurus, with the addition of lateral spines to the corselet: the *Crustacea Decapoda* then, indisputably undergo a *metamorphosis*, a fact, which will form an epoch in the history of this generally neglected tribe, and tend to create an interest which may operate favorably in directing more of the attention of Naturalists towards them. In their first and tender stage, they are essentially and purely *natatory* animals, and no doubt possessed of corresponding habits, swimming about freely and without intermission in search of appropriate food; in their perfect state, the greater number can no longer avail themselves of the power of swimming, but are furnished with pincers and feet almost solely adapted to crawling, so that they are now under the necessity of confining their excursions in pursuit of prey within more narrow limits. This curious piece of economy, explains what has ever appeared paradoxical to naturalists, viz. the annual peregrinations of the Land-Crabs to the sea side, which, although acknowledged to be true by several competent observers, could never before be satisfactorily accounted for.

Having avoided going much into detail of the structure of the Zocæ so imperfectly observed by the authors cited,

it only remains to unfold this part of our subject, in order to render their history complete, premising, that the following description has been derived from one of the full grown specimens above alluded to, which may therefore be supposed to differ from such as occur of smaller size in the greater degree of developement of all its parts; thus, the eyes are more distinctly pedunculate, the natatory division of the feet have an increased number of plumose setæ, the rudiments of the sub-abdominal fins are quite obvious, and the mandibles shew the rudiment of a palp; in other respects they are essentially the same.

The *Eyes* are large, distant from each other, and although on short footstalks, do not appear to be possessed of any obvious motion.

The *Corselet*, or cephalo-thoracic-clypeus covers the back and sides of the animal, and is prolonged in front into a long deflected spine, and has another long spinous projection on the posterior part of its dorsum, and a pair of short lateral spines.

The *Abdominal* portion uncovered by the clypeus, is composed of four semicylindric narrow joints, each furnished with the rudiment of a pair of sub-abdominal fins, and is terminated by a deeply forked tail, spinous within.

The *Antennæ* or feelers, are double on each side; the inner pair being short, and composed of two basil joints, surmounted by two lobes, of which one lobe is very short, and the other 3-articulate and setose; the outer pair consist of three parts, the central or principal one, large, long, and taper, the lateral ones small and short, one of them of 3 articuli, and attached to the base of the central division, the other also articulate, ending in two setæ, and originating from the first joint of the principal.

The *Members* or legs, consist of but *two* pair, each divided into an outer and inner limb, of which, the outer divisions are adapted to natation, and the inner to the

service of the mouth, the former projecting laterally, while the latter are carried in a forward direction, and nearly concealed beneath the body of the animal.

The apparatus of the *Mouth* consists of a pair of strongly toothed mandibles, furnished with the rudiment of a palp, and of two pair of jaws, (maxillæ) together with an upper and under lip: the maxillæ are lobed and spinous, with an external articulated appendage, the innermost of them furnished with a broad ciliated scale at its base, serving it is presumed to fan or aliment the respiratory organ; the labrum or upper lip, is semicircular and simple, the under lip bilobate and bearded.\*

Independent of the knowledge we *now* possess of these animals, we should from the foregoing detail, refer them without hesitation, as Dr. Leach has done, to the Shizopoda, or cleft-footed Malacostraca, and consequently next to Nebalia, which is also most probably a crustaceous animal in its progress to a more perfect state; in which case, the only true Shizopodæ as yet described, are the animals of the Genus Mysis or Opossum Shrimp, the structure and natural history of which, are detailed in the following Memoir.

\* The French have adopted the term *Zoe* for these animals, which, as more simple, and better suited to the genius of our own language than the Latin, may be used in familiar discourse without any impropriety.

ZOEÆ.

✓ PLATE I. Fig. 1, *a*, *Zoea taurus* magnified, after Slabber. 1, front spine, 2, 3 and 4, three of its four pair of natatory members. *s*, dorsal spine. *s*, 2, spine of the fourth abdominal segment. *f*, sub-abdominal fins.

Fig. 1, *b*, The same animal after its metamorphosis according to Slabber. 1, *a*, interior antennæ. 2, *a*, exterior antennæ. 1, 2, 3, 4, its four members. The want of the spines so remarkable in the former figure, and the changed character of the tail are obvious.

Fig. 3. *Zoea pelagica* magnified, after Bosc. *a*, 1, interior antennæ. *a*, 2, exterior antennæ. *b*, front spine. *s*, dorsal spine. *e*, eyes. *f*, natatory members. *t*, tail.

Fig. 2. *Zoea* observed by the author September 17th 1816, magnified. 1, 2, antennæ. 3, 4, 5, 6, natatory members. *s*, dorsal spine. *s* 2, lateral spines. Fig. 4, *a*, 4, *b*, *Zoea* observed by the author, August 22nd, 1816, magnified. *a*, 1, *a*, 2, antennæ. *f*, natatory members.

Fig. 5. *Zoea clavata* of Dr. Leach.

Fig. 6, *a*, A Crustaceous animal observed by the author, September 19th 1816, S. Lat. 17° 38', Long. W. 27° 12', approximating the second form of *Zoea*, magnified. 1, 2, 3, 4, natatory members. Fig. 6, *b*, its tail more highly magnified.

N.B. On the left hand side of Fig. 2, 4, and 6 the respective animals are represented of their natural size and appearance.

✓ PLATE II. Fig. 1. *Zoea* observed by the author at Cove of its natural size.

Fig. 2. The same magnified. *s*, lateral spines. *s* 1, dorsal spine. *s* 2, front spine. *e*, eyes. *f*, feet or natatory members. *a*, 1, inner antennæ. *a* 2, outer antennæ. *t*, abdominal portion, with rudiments of the sub-abdominal fins. *t*, 1, spinous forked tail—behind the corselet, the rudiments of the limbs of the perfect animal or Crab begin to show themselves.

Fig. 3. One of the mandibles magnified. *a*, toothed extremity. *b*, rudiment of a palp.

Fig. 4. Innermost maxilla magnified. *a*, lobed extremity. *b*, appendage. *s*, ciliated scale.

Fig. 5. Second maxilla magnified. *a*, *b*, *c*, its three divisions.

Fig. 6. One of the anterior pairs of members magnified. *a*, *b*, basil joints. *n*, natatory or swimming division of 2 joints. *f*, inner division of 5 articuli.

Fig. 7. One of the posterior pairs of members magnified, the same letters denote the corresponding parts in fig. 6, but in this the inner division has but 2 articuli.

Fig. 8. One of the outermost pair of antennæ magnified. *a*, *b*, *c*, its three divisions.

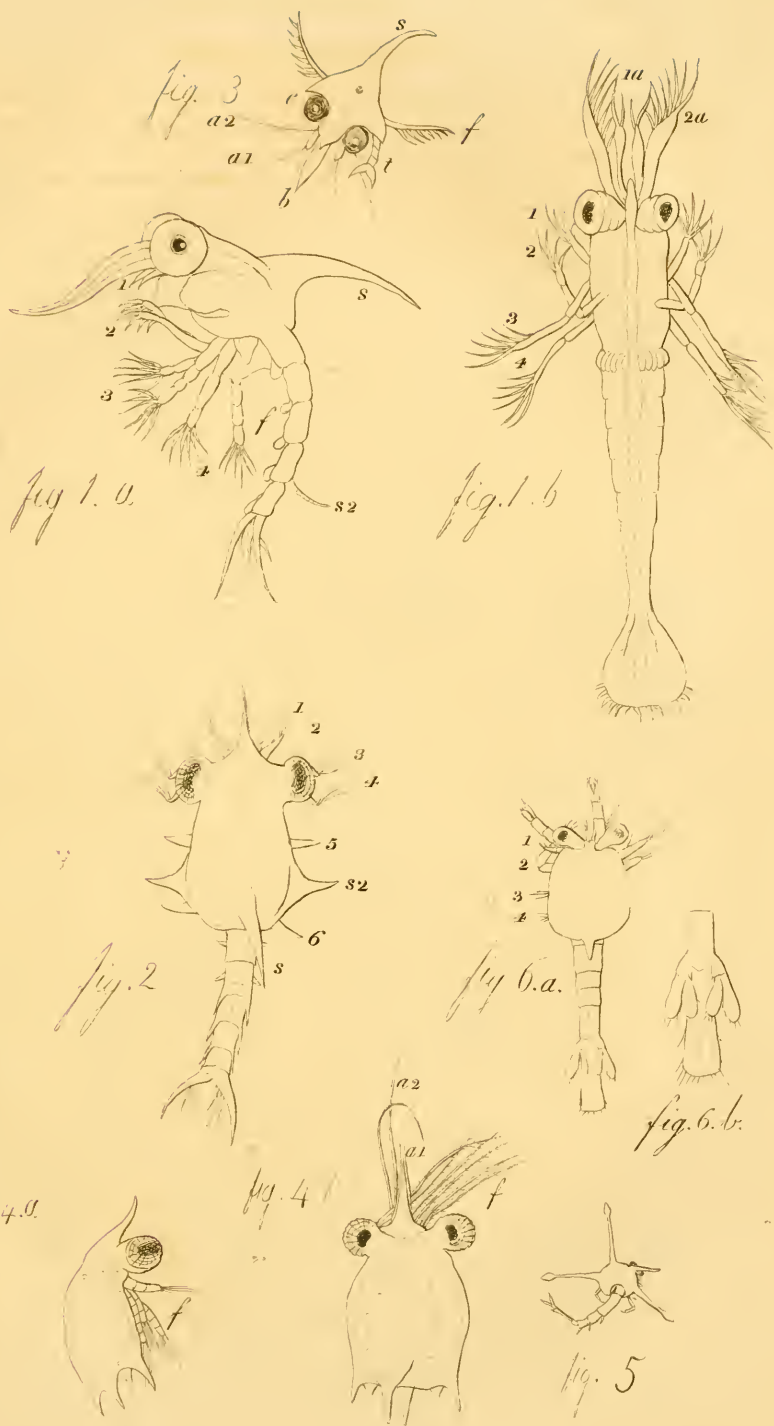
Fig. 9. One the inner antennæ magnified. *a*, *b*, its two terminal lobes.

Fig. 10. *a*, Labrum magnified. *b*, under Lip magnified.

Fig. 11. Limbs of the future Crab disengaged from beneath the clypeus on one side, magnified. *a*, chelate member. 1, 2, 3, 4, other members.

Fig. 12. Member anterior to the claw, the rudiment of the outer pedimaxilla.









NYSIS.

