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ON THE CLASPING-ORGANS ANCILLARY TO GENERATION IN CERTAIN GROUPS OF THE LEPIDOPTERA.

BY

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(*Communicated by* R. McLachlan, F.R.S., F.L.S.)

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IX. *On the Clasping-organs ancillary to Generation in certain Groups of the* Lepidoptera*. *By* Philip Henry Gosse, *F.R.S.* (*Communicated by* R. McLachlan, *F.R.S., F.L.S.*)

(Plates XXVI.–XXXIII.)

Read May 4th, 1882.

Introductory Remarks: Existing Authorities.

The lovely insects, of which I am about to treat, have been the objects of so much ardent admiration and intelligent curiosity, so long have they been collected from all regions, so many cabinets are filled with them, so many treatises have been written and compiled about them, that one may well be accused of presumption in daring to suggest the existence of an uncultivated field of observation in their structure. Yet I venture to lay before the Linnean Society a series of facts, yielded to my own examination in the study of these exquisite creatures, which, while they elicit interest and admiration in an unusual degree, seem to me to have been hitherto almost unsuspected. I refer to the complex apparatus with which the male Butterfly has been furnished for the prehension of the female during the copulative function.

In most of the families of the Rhopalocera the organs devoted to this purpose are more or less patent when sufficient magnifying power is used; and these are often exceedingly curious and exceedingly various. If the Papilionidæ have seemed less profusely supplied, it is, doubtless, because in them the prehensile apparatus is concealed beneath special organs (*valves*), which do not to the eye present any feature differing from the scale-clad body. The family, moreover, is almost wholly Trans-European; and thus, though very conspicuous, they lie somewhat beyond the range of ordinary scientific investigation.

I hope I am doing no injustice to my predecessors, in assuming these researches to be new. The older authors have little more than vague allusions to the existence of auxiliary prehensors, and nothing, that I am aware of, concerning those of the *Equites*. Herold (1815) describes and figures† the "spoon-like" valves, and the "triangle-piece" in *Pieris Brassicæ*. Burmeister (1832) describes‡ the outer and inner valves in a Hawk Moth. Kirby and Spence (1828) devote § a paragraph to the prehensors of the class, but dismiss the Butterflies in a few lines. Siebold and Stannius (1848) assign ‖ to the prehensors of the Lepidoptera one fourth of one sentence.

The most important contribution to the subject seems to be a memoir ¶ read before this Society by Dr. F. Buchanan White, December 21, 1876. This elaborate and very valuable article, illustrated by more than 220 figures, might well seem to leave little room for my researches, but for two reasons:—1, he limits his studies to the Butterflies

* A preliminary sketch of this article will be found in the Royal Society Proceedings, xxxiii. (1881), pp. 23–27.

† Entwickel. p. xiii. pl. iv.

‡ Manual, p. 216 (Eng. ed.).

§ Intr. to Ent. iv. p. 579.

‖ Anat. Inv. p. 462 (Amer. ed.).

¶ "On the Male Genital Armature in the European Rhapalocera," Trans. Linn. Soc. 2nd ser. Zool. i. p. 357.

of Europe, of which only three species come into my subject; 2, he does not look *within* the anal valves, within which my study begins.

Somewhat earlier than this, however, viz. in the 'Proceedings of the Boston (U. S.) Soc. of Nat. Hist.' for April, 1870, Messrs. S. H. Scudder and E. Burgess had published a conjoint memoir, of much interest and value, and illustrated by many highly magnified figures, "On Asymmetry in the Appendages . . . in the Lepidopterous Genus *Nisoniades*." The specific variety and individual uniformity, which I hope to show in the genital armature of *Papilio*, mark the corresponding organs in this genus of Hesperiadæ; nor is the apparatus less elaborate or less curious. The learned authors designate by the terms "clasps" and "upper organ," what Dr. White calls "harpagines" and "tegumen."

Prof. Graber, in his valuable work, 'Die Insekten' (in 'Die Naturkräfte'), 1877, has devoted half a dozen pages to the male genital auxiliaries (äussere Hilfsorgane des Hinterleibes); but has taken no illustration from the Lepidoptera.

I am indebted to my honoured friend Prof. Westwood for bringing to my knowledge some descriptions and figures by Dr. De Haan on the subject, which, so far as they go, do really anticipate my own. The book is rare and difficult to consult; but my son, Edmund William Gosse, has made for me, from the copy in the library of the British Museum, a translation of the Dutch text, and careful tracings of all the figures that relate to the subject.

It is a thin folio, a livraison of a large publication, entitled 'Verhandelingen over de natuurlijke geschiedenis der Nederlandsche overzeesche bezittingen (Transactions regarding the Nat. Hist. of the Dutch Transmarine Possessions), by various authors. The sub-title of the treatise itself is "Bijdragen tot de kennis des Papilionidea: door Willem de Haan." Leiden, 1842.

The observations of this author on the genitalia, since they are brief, and the work is little available to English students, I shall be excused for giving *in extenso*.

"The Sexual Organs.

"These parts are, especially in the male, very various in form. The outermost valves [*kleppen*] of *Ornithoptera Amphrisius* shut closely against each other, and conceal two lateral appendages [*zijdelingsche aanhangsels*, = the *harpes* of the following memoir?], which turn over at the end in the form of a hook, and are provided with spines along the upper edge. The truncated, and sometimes even hollow, end of the hinder part of the body, which lies within these valves, bears upon the upper edge a pointed spine bent downwards [=uncus, P. H. G.], with two lateral plates [*zijdelings plaatjes*, = scaphium, P. H. G.?], which lie close to it. From the middle of the hinder part of the body the penis [*roede*] is exposed, which is gristly [*kraakbeenig*], straight, blunt, and shorter than the lateral valves.

"Those of *Papilio Memnon, Pammon, Helenus, Machaon*, are similar to this, except that the lateral appendages lie along the lower edge, and the hook on the back is usually more elongated; in *Memnon* the penis is thrown over from below. In *P. Coon* the outer valves are wholly opened from above, and, to a great extent, also from below; so that the inner parts are scarcely protected by them: the penis is very pointed, and a little longer than the valves. *P. Liris* and *Polydorus* have the hinder part of the body naked; the valves are very short, armed from within to the top with a hook, and the lateral appendages (of *Amphrisius*) are placed under it; the spine of the back is blunt; besides this there are also two spines present on the upper edge, and these are curved inwards; so that altogether the outer

edge is provided with seven appendages, which all rise free from one another. Between these lies the penis, which, as if pressed together, has a sharp edge above and below.

"In *Thais Hypsipyle* the valves are turned towards one another at the end, open above and below, toothed along the upper edge, and armed along the under edge with a sharp spine; the lateral appendages, and the spine at the back, are very small, and, indeed, scarcely visible. *Parnassius Apollo* has the valves puffed out, and gaping wide open; the lateral appendages are entirely free, of the same length [*eens zoo lang*], and in the form of two half-sheaths; the back-spine is broad, and ends in two short points. *Eurycus Cressida* has two flat valves placed on the under side of the body, which are covered from above by the last two abdomen-segments, and show on their inner edge, close to the joint, an indentation. The penis is pointed, and longer than the valves. *Doritis Apollina* has two little pointed valves, also placed under the last two segments."

The work is illustrated by eighteen figures of the sexual parts of eight species, on a scale considerably smaller than mine. They are thus distributed:—

Ornithoptera Amphrisius...	3 figs.	*Thais Hypsipyle*.....	2 figs.
Papilio Coon.....	3 ,,	*Parnassius Apollo*	2 ,,
—— *Liris*.....	2 ,,	*Doritis Apollina*.....	2 ,,
Leptocircus Curius	2 ,,	*Eurycus Cressida*	2 ,,

It so happens that not a single species illustrated by Dr. De Haan is identical with any one of mine; though two approach very nigh, viz. his *O. Amphrisius* to *O. Rhadamanthus**, and *P. Coon* to *P. Doubledayi*.

My own attention was first directed to the subject when, examining the anatomy of the remarkable genus *Euryades*, I referred for comparison to the structure of the genital organs in *Papilio* and *Ornithoptera*. The elaborate apparatus which I found hidden beneath the valves, like delicate surgical instruments in their protecting cases, drew me on into the examination of one species after another, until I had studied and figured nearly a hundred members of these two genera.

Dr. Buchanan White says †:—"I regret very much that, from want of material, I have been unable to examine, amongst the Rhopalocera, any but European species. It is much to be desired that some one, who has at his command a large collection of the butterflies of all regions, should investigate, more extensively than I have been able to do, the structure of the genital armature."

Nothing, unless it be the exquisite beauty of the workmanship, is so astounding as the variety, in form and detail, presented by these hidden instruments. Out of the number that I have examined, I have not found any two species whose apparatus is alike, or even so nearly alike that a moment's observation is not sufficient to show the difference. I do not think this rule of diversity holds in respect of other important organs. I do not know that microscopic examination would show that the antennæ, or the tarsi, or the spiracles, vary markedly in every species ‡.

* Perhaps his *Amphrisius* is the species which in M. Lucas's 'Lepid. Exot.' is so named in the plate, but *Rhadamanthus* in the text. It is certainly not the *Amphrysus* of Cramer's plate 219.

† *Op. cit.* p. 366.

‡ "Aucune autre partie du corps des papillons ne dénote des variations si nombreuses que la terminale avec les organes génitaux des deux sexes; variabilité qui ne nous permet pas de nous occuper de ce sujet d'une façon plus générale, parce que son explication détaillée est l'objet d'une monographie spéciale."—Dr. Burmeister, *Lepid. d. l. Rep. Arg.* p. 21.

It might seem that, by the aid of organs so uniformly present, so easily examined, and so varied in different species, while constant in the same, great facilities must be afforded for the determination of specific identity and limitation. Yet, in practice, I fear this cannot be carried out, without severing species which otherwise seem most closely allied, and linking others which have little else in common. Look, for instance, at the three African species *Papilio Bromius*, *P. Nireus*, and *P. Phoreas*; how consimilar are these in their forms, colours, and markings! yet how diverse in their whole prehensile apparatus! The shape of the valve, its fringing; the shape of the harpe, its armature; the uncus; the teeth of the scaphium; and, finally, the penis;—all these differ signally in one from their conditions in the others, as may be seen, at a glance, from the following pages. The like terms might be employed concerning *P. Demoleus* and *P. Erithonius*.

It needs scarcely to be told that all the following observations were made on *dried* specimens. The desiccation of the soft tissues, causing them to shrink, throws into distinct prominence the hard chitinous organs with which these pages have mainly to do; and *their* form is not affected by drying. Indeed, the density and unyielding hardness of this material are manifest by the depth of colour it can assume, often approaching to black, by its brilliant polish of surface, by its transparency like that of glass, and by the delicacy with which it is fashioned into the thinnest edges and cut into the sharpest teeth, which, strange to say, we never see blunted by use.

Let it be remembered that, while a considerable number of the following descriptions and figures have been confirmed by observations repeated upon two, three, or even more successive examples, many (somewhat more than half) rest upon individuals. These, though made with all care, are like the ἅπαξ λεγόμενα of the critics, and must be accepted with a certain measure of caution.

Manipulation.

My methods of manipulation are of the simplest. With a penknife, worn by age to a very fine and keen point, I make incisions, vertically as the insect lies on its side before me, along the hinge-line of one valve (I have usually selected the right): presently, using, with a gentle violence, such a lever as the tip of a toothpick, the valve is *prized* off. By practice, I am able to do this with very little chance of injury to the specimen; and when my examination is completed, I restore the valve to its place, with the minutest touch of gum-tragacanth; so that, when it is dry, and the butterfly returned to the cabinet, I am often quite unable, some time after, even myself to determine, with certainty, of two or three examples in the drawer, which it was that I had used for the operation*.

The detached valve is then submitted to strict search with the various powers of a triple lens, reaching in combination to 24 diam. When the information deducible from this aspect seems exhausted, if the harpe appear to promise any more, I essay to lift it

* The circumstance that the exotic Papiliones are often of high monetary value has no doubt much impeded our acquaintance with their anatomy. Our museums and private collections are rich in species; but few possessors are willing to submit their treasured beauties to the anatomist's scalpel. Perhaps Prof. Siebold's sarcasm is not yet wholly without force:—"Most collectors seem ambitious only to keep their butterflies neat and untouched, or to gain thereby advantages other than scientific" ("On the ♀ of *Parn. Apollo*," Stett. Ent. Zeit., 1851).

from its adhesion to the valve-cavity with the same knife-point. I do not always succeed; but if I do, I have an object, often of brilliant transparency and lustre, and of extreme delicacy, which I can put on a slip of glass, and transfer to the stage of a compound microscope, using any powers that I please.

The organs which project from the abdominal cavity cannot be detached with certainty of success. These, therefore, I usually view with the lens only*. After exhaustive study of these parts, *dry*, since the scaphium and, in part, the penis are composed of soft tissues which change form in drying, I introduce into the cavity, with the tip of a fine hair-pencil, a drop of clear water. This is presently absorbed; the superfluous water is removed with a point of blotting-paper, and the organs are again examined as before. The shrivelled parts have now become much more plump, assuming something approaching the form which they had during life. The study of them in this condition often reveals facts that had been obscure before.

On detaching a valve there are often found many plume-scales and atoms of meconium, scattered over the organs within, as well as all about, the anal cavity. Since these hinder distinct vision, I remove them by touching the parts with the tip of a fine camel's-hair pencil slightly moistened, wiping the tip on a linen cloth after every contact.

Curious records of past history may be read in such impediments. Minute fragments of a pulverulent, drab-coloured, chalky substance are, as I have observed, occasionally found adhering to the harpes. On one occasion I found, on carefully removing one of the valves from a cabinet-specimen of *Ornithoptera Rhadamanthus* ♂, the cavity *quite full* of this substance, partly in coarse powder, and partly in somewhat coherent lumps of the size of mustard-seed downwards. Now, I have no doubt that this male had effected coitus with a female, at so early a period after her evolution from pupa, that she had not discharged the fæcal accumulation of the pupa stage, which subsists "sous la forme d'un fluide jaune ou brun, comparable au *méconium* des enfants nouveau-nés" (Burmeister). The excitement of the sexual copula would provoke the instant discharge of the meconium, a large portion of which would fill the valvular cavity of the grasping male; and this, presently coagulating, remained to be at length revealed by my dissecting scalpel.

A phenomenon exactly similar occurred with a specimen of *Papilio Zalmoxis*. But in this case the cavity was occupied with a dirty mingled mass of meconium and *body-scales*; and that so fully as completely to conceal all the organs, till it was gradually extracted. These scales were surely those of a female abdomen, removed *in coitû*: the meconium discharged at the same time had agglutinated the scales into a composite mass, which, in drying, had divided into fragments and coarse powder; and these, the male having been presently captured, had remained a record of the history.

See also, for similar conditions, the account of *Papilio Axion*, and of not a few other species.

The illustrative drawings have all been made, not with the aid of the camera, but by the eye and hand alone. They have not been drawn to scale; but those of the *valves*

* I have occasionally viewed these as opaque objects under condensed reflected light, both artificial and solar; but the result has been (in general, though with exceptions) hardly worth the pains.

follow a pretty uniform ratio, which may be set down as about 7 diam., with which ratio the figures of the other organs may be compared.

A General Description of the Organs.

The organs with which I propose to deal, as limited to the male sex of Butterflies belonging to the two genera *Ornithoptera* and *Papilio*, are the following:—1. The Valves; 2. the Harpes; 3. the Uncus; 4. the Scaphium; 5. the Penis.

1. *The Valves.*

To the overlapping edges of the eighth abdominal segment, from the indefinite points where the projecting angular portion produced by the rami of the uncus merge into the vertical, to two prominent rounded pieces within the ventral margin, there are united, by free-working joints, two broad plates, well known under the name of valves *. Every collector is familiar with these organs; for he has recourse to them to determine, at a glance, the sex of his specimens, since, in the grand genus *Papilio*, they are peculiar to the male.

Their outline is usually more or less trigonal, often becoming semiovate, or even subcircular. To be more precise, the prevailing shape is that of an oval, or rounded rhomboid, cut off obliquely, so that as we look on the inside of the right valve the tip points to the left—that is, toward the dorsal side.

They are clothed on the exterior with scales like those of the body. Their direction follows the general plane of the sides of the abdomen; they are convex externally, concave internally. Their free edges are commonly furnished with a fringe of modified scales, taking the form of thick hairs, which are parallel, close-set, often dense, and often long; thus these practically enlarge the area of the valves, and help to exclude, more effectually, extraneous matters from the genital cavity when the valves are closed. Sometimes dense brushes of long hair, of quite different structure, arise from within the interior of the valve, which spreading, conceal the margin, and greatly modify the apparent outline; e. g. *Policenes*, *Ucalegon*.

The fringed edges come into contact when the valves are at rest, inclosing a spacious chamber, the anal, or genital, cavity. The edge is occasionally turned over, narrowly, within; e. g. *Ornithoptera Haliphron*; and still more commonly the interior surface continues flat and level for some distance within the margin, then abruptly drops to the central cavity; e. g. *Agamemnon*, *Hesperus*, *Lycidas*, *Anchisiades*, *Euryleon*. Occasionally a sort of wall, of distinct form and surface, borders the edge, and overhangs the interior; e. g. *Zalmoxis*. The floor of the interior, whether flat or hollow, is often studded with short scattered hairs, each springing from a dimple, or crowning a minute round hillock, where it is not occupied by the harpe: but sometimes this surface is cloth-like; e. g. *Erithonius*, *Lycidas*.

* A better name would be *tegumina*, covers; but this word has been chosen by Dr. B. White for a very different neighbouring organ. *Colei* (κολεὸς, a sheath or scabbard) might be used; or, to avoid ambiguity with the genus *Coleus* of the botanists, it might be spelled in its Ionic form, κουλεὸς. But I adopt the appellation already in familiar use.

In those abnormal cases in which the valves are partly or wholly aborted, e. g. *Diphilus*, *Polydorus*, *Hector*, the thatch of long hair that occasionally projects from the dorsal arch of the eighth segment, and thus fills up the triangular space left by the receding dorsal edges of the valves, is particularly abundant.

The extremity of the valve shows, in *almost* all cases, some indication of a projection of the outline into a point. Usually this part is as soft and flexible as any other; but in some instances, e. g. *Semperi*, *Ucalegon*, there seems, in its definite form and darker hue, an approach to that condition which occurs in other families of the Rhopalocera, in which the valve and the harpe become one organ *.

Mr. Wallace, in his very valuable Memoir "On Variation, &c., in the Papilionidæ of the Malayan Region" †, is inclined to rest on the peculiarities of the valves of *Ornithoptera* for generic diagnosis. Having rejected certain points that have been relied on, he says, "There remain, therefore, only the characters of the perfect insect, the most important of which are the anal valves in the male. These are very large, ovate or rounded, coriaceous, and not hairy, and are furnished with projecting points or spines (sometimes very conspicuous) which serve to attach the male more firmly to the female *in copulâ*. In several species, I have observed, these points or hooks were buried in the protruded anal gland of the female, and thus effectually prevented the great weight of the insects causing them to separate upon suddenly taking flight" ‡.

2. *The Harpes.*

The interior surface of each valve, which, as I have said, is hollow, is the seat of a peculiar organ, which appears to take a very prominent part in the prehensile function. The floor proper of the valve-cavity is a thin membrane of slight tenacity, more or less of a dark brown hue, and of a dull unreflecting surface. Within the hollow lies a plate of what I presume to be pure chitine §, usually as transparent as glass, but tinged with a yellow-brown hue, thickening at various parts, especially at its margins and irregular

* Dr. F. B. White's memoir affords abundant examples of this combined condition. The transition seems to be made in the family (or subfamily) Pieridæ. (See the supplementary note to this Memoir.)

† Trans. Linn. Soc. xxv. p. 35, 1864.

‡ But the valves in *Ornithoptera Arruana* and *Amphrysus* are densely fringed with hair-scales: *Papilio Semperi* has as distinct a finger-point to the valve as *O. Amphrysus*; while the broad rounded outline is seen in the valves of *P. Zalmoxis*, *Axion*, and *Bromius*. This projecting finger-point, moreover, while well marked in *O. Amphrysus* and *Rhadamanthus*, becomes feeble in *Arruana* and *Haliphron*, evanescent in *Remus*, and is absolutely wanting in *Brookeana*, where the valve is surrounded by a fringe of unusual density. But generic lines are not mathematical lines; and the features mentioned by Mr. Wallace are certainly characteristic, and, with the prevailing form of the harpe, go far to establish *Ornithoptera* as a good genus.

Mr. Wallace's observation about the function of the points is most interesting: would that we had more of such! but, if I may venture to correct the dictum of so great an authority, I would suggest that, most probably, it was not the flexible finger-point of the valve that had seized the protruded vulva of the female, since it has no resistent power, but the harpe, well toothed, and of almost metallic hardness, that was concealed just beneath the valve-tip. Yet, in some cases, as in *P. Ucalegon*, I am not sure that the valve-point may not have a harpe-power—as I presume that it has in some Pieridæ, as *Callidryas*.

§ The various degrees of flexibility found in the integuments of insects is believed to depend on the extent to which they are permeated by this substance, "a peculiar azotic matter insoluble in caustic potass" (Siebold, 'Anat. Invertebr.' Lond. 1854, p. 401).

ridges, where the substance deepens in hue, often to an intensity almost black (but still like black *glass*), and where it manifestly acquires great density, elasticity, and hardness, with a reflective power equal to that of polished glass. The gleam and glitter of the surface imparts a wonderful attractiveness to these most diversified organs. The parts thus thickened are also elevated, not merely in the bounding walls and ridges that I have mentioned, but, in general, by the separating of a portion of the organ from the cavity-floor; so that this particular part shall be elevated, and projected freely into the inclosed space between the valves. And these projected portions either take the forms of curved acute spines, or, more frequently still, are notched into sharp teeth standing in serried rows.

To attempt to indicate the various forms which these curious weapons assume, would be to anticipate the greater part of the descriptive pages which are to follow; for the variety is about commensurate with the number of species examined. I propose presently to attempt a rough casting of them into groups; but it will be little more than an arbitrary classification, useful as an aid to memory, rather than any thing else. Projecting claws, hooks, pikes, swords, knobs, and strange combinations of these, abound, whose prominences are very commonly brought to a keen edge, and then cut into sharp teeth. The species of one group, *Agesilaus*, *Parmatus*, have harpes in which many such projections are strangely crowded. In others, *Ulysses*, *Macedon*, the formidable teeth are themselves cut into many minuter toothlets of wonderful delicacy.

Sometimes this polished weapon occupies almost the whole area of the valve-cavity, *Agesilaus*, *Podalirius*, *Erithonius*; sometimes it is a slender staff or rod, *Memnon*, *Erechtheus*, *Polymnestor*, with the extremity expanded to form the weapon, whether axe, or sword, or saw, or spear-point. Whatever the form, the base is always expanded, often with ridges (like as where the trunk of a tree dilates into roots), spreading over the basal edge of the valve, and manifestly stretching beyond its area, as is often very clearly seen when the valve is forcibly detached. Examples of what I mean may be seen in my figures of *Papilio*, *Axion*, *Ascalaphus*, *Pammon*, *Macedon*, *Childrenæ*, *Vertumnus*, *Zalmoxis*, and several others. In all these a kind of disk is observed; which more or less clearly shows that there had been a dilated attachment of the harpe to a surface which had lain in a plane quite different from that of the valve, face to face with it, indeed, close to its hinge. (See, specially, *Euryleon*.)

Hence I very confidently infer the function of two short thick eminences of hard chitine, having convex surfaces, which are generally to be observed occupying the bottom of the abdominal cavity, when the valves are removed; *e. g. O. Remus*, *P. Pammon*, *Rhetenor*, *Mayo*. They afford, doubtless, a broad and firm basis for the attachment of muscles which move these important prehensores, so constantly exposed to shocks and violent strains. And the fact of such an attachment explains an otherwise puzzling phenomenon which not very infrequently occurs,—that, when the valve is detached by force, it occasionally comes away empty, the chitinous armature being left behind. (See *infra*, page 293.)

If there existed any reasonable doubt of the work performed by this well-armed organ, it would be removed by a due consideration of that curious accumulation of foreign

matter to which I have already alluded,—the thick mass of dislodged body-scales with which we frequently find the chitinous armature clogged, particularly its serrate parts. How came those scales there? The answer is patent. This apparatus has been provided to enable the male butterfly to grasp and hold the female during the process of impregnation. And these accumulated scales show that this very individual insect had been so engaged only just before its capture and death.

I have hence no hesitation in assigning a distinctive epithet to the organ in question; and it is known, throughout this memoir, by the term Harpe (ἅρπη, a grappling iron)*.

It is the rule, subject to very rare exceptions, that when the two valves are closed, as generally during life, the chief armed parts of the two harpes approach each other at a point in space, within the post-anal cavity, exactly where the tip of the uncus comes down from above. Hence I infer that the function of this latter organ is similar and ancillary to that of the harpes—the three combined constituting a threefold grip, which it would be difficult to break.

It seems scarcely credible that elaborate instruments, such as these, so constantly present in this popular family, and so readily found, should not have already been the subjects of ample examination and familiar knowledge. Yet, with the exception of Dr. De Haan's brief allusion to the "lateral appendages," and one equally brief in Dr. Burmeister's latest work, the 'Lepidoptera of the Argentine Republic' †, I know not any.

I have already spoken with admiration of the surprising variety which the prehensile apparatus displays; it is in the harpes that the extreme diversity mainly resides.

Yet it is by no means a vague, come-by-chance variation; it does not extend to individuals of the *same* species. I have, in many instances, examined several examples of the same species, and have always found that the identity of the harpe is wonderfully close and minute, the diversity very trifling.

3. *The Uncus.*

The eighth segment of the abdomen, in the male of *Ornithoptera* and *Papilio*, in general, has the posterior ‡ outline of its dorsal arch produced in the middle line, and terminating in a point, with receding sides; so that, looked at vertically from above, it is

* Dr. White has used the term *harpago* for the organ which, in the other Rhopalocera, appears to represent the valve and harpe united. But, in the Papilionidæ, where these are separate, it is desirable that they should receive separate designations. The terms *harpago* and *harpe* are sufficiently distinct; while they bear a relation to each other not unlike that of the things designated.

† "Entre ces deux valvules, se trouve, dans le fond de la cavité, l'ouverture sexuelle, accompagnée, principalement chez les mâles, par des appendices *en forme de tenaille*, qui renferme l'organe mâle, le penis." I conjecture that, by these "appendages in form of pincers," he means the *harpes*. But the term is vague, and I do not feel quite sure.

‡ To avoid ambiguity, I would distinctly notify to the reader that I shall use terms of relative position, as back and front, before and behind, in describing the organs of the genital cavity, as if they were independent organisms, and not parts of the entire animal. Thus, if I speak of the uncus, I might describe it as narrowing *behind* the tip; of the smaller scaphium-tooth as *behind* the larger; of the aristæ of the cheeks as directed backwards; of the sheath of the penis as running *back* to its base. Now, in each of these cases, the direction intended is certainly from the tail *towards* the *head* of the insect: yet, limiting our attention to these organs, it would be most unnatural and misleading, to speak, for instance, of the tip of the penis as its hinder portion, of the basal bulb as its front. In speaking of the abdomen generally, or of its segments, I shall use the ordinary terms, as above.

a triangle, of which the base is the edge of the seventh segment, the sides are often incurved, and the point is, in general, prolonged into a strong, horny spine; e. g., *Orn. Amphrysus*, *P. Merope*, *Erechtheus*. This point, however, varies much, in different species, in length, breadth, sharpness, curvature, and direction; and, as it is one of the elements of the prehensile apparatus which I am proposing to describe, I distinguish it by the term *uncus*, a drag-hook. The term "tegumen," adopted by Dr. White, seems hardly appropriate for this spinous, often wiry, point, which is certainly in no sense a *cover*. But it does express the function of the wide annular part of the segment, from which the uncus projects; and in this sense I use it.

Viewed from the side, the tegumen and uncus together often present a very curious resemblance to the skull of a bird without the lower mandible, *e. g. Erechtheus*, *Demoleus*; which latter, however, is simulated occasionally by the *scaphium*, so as to complete the likeness—*Deiphontes*, *Homerus*, *Childrenæ*, and very curiously in *Parn. Apollo*. I occasionally avail myself of this and like accidental resemblances, for more definite and graphic description.

The extreme point is generally somewhat swollen and flattened, spoon-wise—and this even when the organ is of a wiry slenderness, as in *Rhodifer*. Sometimes it is bifid—*Agamemnon*, *Polydorus*; more rarely even trifid—*Argesilaus*, *Archesilaus*; sometimes it is curved upward—*Agamemnon*; sometimes vertically downward—*Hector*, *Lycidas*, *Agavus*; sometimes it is short, thick, and uncouth—*Antenor*, *Zalmoxis*, *Bromius*; almost straight—*O. Arruana*, *P. Hesperus*, *Rhodifer*; often nearly a half-hoop of very slender wire, displaying a strength, elasticity, and polish, almost of steel—*Vertumnus*, *Macedon*, *Turnus*. The receding margins are often turned up to a height that considerably exceeds the plane of the dorsal surface, which then becomes transversely concave—*Mayo*, *Machaon*, *Zalmoxis*, *Merope*; this surface is sometimes indented with a trilateral (*Antenor*) or quadrilateral (*Agesilaus*) depression. Often it is clothed with a median ridge of long and close-set hairs, which project horizontally, and, so to speak, thatch the cavity and its organs—e. g. *Agamemnon*, *Codrus*, *Homerus*, and, signally, *Diphilus*, and the abnormal *Hector* group, though here there is no *uncus*. More commonly the stiff ridge-hairs are erect—*Erechtheus*, *Rhetenor*, *Merope*; or, at first erect, and then arching forward—*Menestheus*, *Machaon*.

When the valves are perfectly developed, as in *Ornithoptera*, the uncus is projected immediately under the line produced by the meeting of the dorsal edges of the valves; and then the median ridge of long hair helps to fill the blank space between.

The inferior surface of the uncus usually bears two conspicuous laminæ descending vertically from it, more or less deep, which take their origin insensibly near the point, and increase in depth gradually—*Erechtheus*, *Rhetenor*, *Helenus*, *Merope*, following the curvature of the margins till they are lost in the descending rami; but in some cases this keel begins at some distance from the point, and with its full depth—*Deiphontes*, *Homerus*.

On each side, near the spot at which the rami of the keel can no longer be distinguished, a conspicuous horny tooth often projects horizontally from the edge of the segment—*Helenus*, *Turnus*.

The uncus is apparently composed of nearly pure chitine, whose varying density is

perhaps indicated by its colour, which may be pale fawn, or rufous, or deep sienna-brown, or even almost black, always with a polished surface.

4. *The Scaphium.*

By this term I indicate a curious organ, which I find almost always present, of complicate structure, apparently having an intimate relation to the uncus, and even, in general, organically united with it, but yet occupying its proper place even in those rare cases in which the uncus itself is obsolete, as in *Orn. Brookeana*, *P. Podalirius*, and *Bathycles*. Indeed in this last-named it is seen to great advantage; and still more so in *Mayo*, the beautiful representative of *Polymnestor* in the Andaman Isles; and most of all in the African *Merope*.

The instant we have removed either of the valves from one of these Butterflies, our attention is arrested by a great mass of shining white tissue, occupying the chief place in the genital cavity, and projecting far into its area. We trace it up to an intimate and apparently organic union with the lower surface of the uncus near its origin, far back in the *palate* of the *bird's skull* (if I may use my own comparison on p. 274, *suprà*), whence it descends and dilates, sending large angular lobes back even into the abdomen (*Bathycles*), but chiefly developed forward, like the contiguous organs. I have likened this prominent part of the organ to a lower jaw (rather *mammalian* than *avian*, however) —*Machaon*, *Turnus*, *Erithonius*, *Demoleus*, *Macedon*; I have likened it also to a boat— *Mayo*, *Pammon*.

Of the function of this conspicuous organ I cannot speak with certainty. I adopt a distinctive appellation for it (presuming it to be important and undescribed), which leaves function untouched, and looks only at the accidental resemblance alluded to— σκάφη, σκαφίον, a boat.

Where it is most perfectly developed, e. g. *Mayo*, the sides swell out like the bows of a ship, while the mesial portion is abruptly thinned away to a deep projection, like a cut-water and a keel. The upper surface forms two dilated margins (the gunwales of the boat), with a deep sulcus between, in which in some cases—*Vertumnus*, *Erechtheus*, *Rhetenor*—the uncus lies. More usually there is considerable vertical space between the uncus and the scaphium-margins. These very generally bear (here the simile shifts back from the gunwales of a boat to a lower jaw) a compound armature, most difficult to explain, but in which surely lies hid the key to the explanation. In some clear examples it mimics the double molar tooth of a mammalian jaw, the outer usually much more distinctly developed than the inner, often rising to a strong, conical, produced spine, which may take the form of a straight blunt pin or peg—*Memnon*, *Nireus*; or that of a canine tooth, erect, acute, recurved—*Mayo*, *Pammon*, *Arcturus*, *Macedon*, *Thoas*; horizontal, recurved—*Machaon*, *Ulysses*; horizontal, decurved—*Rhodifer*. Both may appear as two equal, stout, polished cones—*Homerus*; more commonly the secondary is reduced to a mere conic knob, or is even obsolescent; occasionally a third supernumerary tooth or knob appears—*Mayo*, *Homerus*; and not infrequently *neither* can be detected, e. g. *O. Arruana*.

Besides these teeth, there is another kind of arming: the gunwale-like margin rises

into an elevated ridge, which is thinned off to an edge, and is then cut into a number of parallel erect membranous points or bristles. When the double teeth are wanting this aristate crest appears to supply their place, as in several of the *Ornithopteræ*; but yet occasionally *both* are seen, and then the aristæ are more baseward—*Erechtheus*.

But the most remarkable form of the scaphium known to me is that of *Merope*, in which the teeth are stout, broad, and most elaborately notched and bristled on their edges; for the details of which, with other points of interest, I must refer to my account and figures of the species, *ut infra*.

The lower parts of this organ are obscure, descending and receding towards the abdomen. Sometimes it is patent that the descending rami do certainly embrace the basal region of the penis, and appear to unite again below it, but are not, I think, organically united with it—e. g. *O. Amphrysus*, *P. Rhetenor*, *Bathycles*, *Agamemnon*. But such connexion of the scaphium with the penis cannot by any means *always* be affirmed.

The usual appearance of the organ is opaque white, smooth, shining, like polished ivory, often very pure, particularly the keel. Sometimes, however, it becomes partially or even wholly pale, or even dark, brown—*Podalirius*, *Zalmoxis*, *Lycidas*, *Macedon*—as if the chitinous element pervaded it, which microscopic examination confirms *.

By the same test the substance appears to be mainly muscular—a conclusion to which I had already come from the armature of the double teeth. It was impossible to look upon those formidable weapons, in *Merope*, for example, without inferring that the compact mass upon which they are seated must be muscular, or they would be useless. But I suspect that in this organ reside the muscles which move the uncus—perhaps also, at least in part, the valves and the harpes, for which offices they would need to be vigorous and massive.

Many modifications of the form and conditions of the organ occur in different species, which will be described *seriatim* †.

On the nature, or even the existence, of the scaphium, I have little help from my predecessors. Herold, in *Pieris Brassicæ* ‡, does not distinguish it from the uncus, which I find quite distinct, both being present, but contiguous. He, however, confounds the two organs under the name of the triangle-piece ("Triangelstück"), which he cites from De Geer. The minute projection from beneath the point, which he takes to be the end of the rectum, is surely the keel of a small scaphium. The anus is, as I believe, in the middle of that transverse line at which the muscular base of the scaphium is united to the palate-like under side of the uncus §. (See *P. Arcturus*.)

* The scaphium of *P. Machaon*, macerated and torn from its uncus, showed, at the upper part (the *gunwale*), a clear yellow-brown tissue, with smooth edge, and minute bristles growing from the surface. This ran off into colourless transparent tissue, decidedly fibrous, several of the bundles being formed of longitudinal fibres, which were more or less covered with thin laminæ filled with excessively minute but perfectly distinct regular parallel oblique *striæ*.

† For some further researches into the structure and relations of the scaphium, made after this memoir was handed in, I beg to refer to the account of *Ornithoptera Remus*, infrà.

‡ Entwickelung der Schmett. xiii. tab. iv. figs. 3–6.

§ The fact that the uncus is tubular, as may be clearly seen when it is forcibly broken across, suggested the thought that perhaps itself might be the termination of the intestine. But very exact and repeated examinations

Neither Burmeister nor Siebold makes any allusion to the scaphium. De Haan's slight mention of "lateral plates" has been already cited. From his figure, I suppose he alludes to the scaphium, by this phrase. In the numerous figures of Dr. White's Memoir *, minutely beautiful, and carefully executed, as these are, I find no trace of the organ; and I think that probably it is peculiar, *or nearly peculiar*, to the true *Equites*. I say "nearly peculiar," because, though Dr. White finds it not, as a separate organ, in the European Pieridæ, yet I hope presently to show that unequivocal traces of it are to be found in certain members of the family.

5. *The Penis.*

This organ forms, strictly, no part of my subject, which is not the function of generation, nor the organs that perform it, but certain prehensile apparatus that are ancillary to the performance. Yet, as this member is so essentially the centre around which the whole apparatus waits and serves, and as it forms so conspicuous an object in the accompanying designs, I can scarcely avoid giving some account, at least, of its varying form and position.

The penis is usually seen, when the valves are opened, in the lower half of the genital cavity, in the form of a column, more or less cylindrical, varying much in diameter and in length, projecting from the interior of the abdomen. In some instances it is so short as not to appear beyond the walls of the eighth segment, e. g. *Vertumnus*, *Lycidas*; but it is doubtless capable of being protruded, to a certain extent, by its proper muscles †. In others it is so long that it cannot be contained within the cavity, but projects beyond the margins of the valves when these are shut. In *Merope*, *Ucalegon*, *Hesperus*, *Rhetenor*, the tip just reaches the edges of the valves, or exceeds them in a slight degree; in *Podalirius*, *Bromius*, *Macedon*, and still more in *Bathycles*, the protrusion is remarkable; but, in the *Coon* group, including the beautiful *Rhodifer* lately sent from Andaman, the penis projects from the hinder extremity to an extraordinary degree, like a fine steel wire, that quite arrests the attention as we see the insect in a cabinet. No less notable is the extreme slenderness, and, at the same time, the strength and elasticity, of the organ in the just-mentioned species.

As to position, the penis appears so high as almost to be in contact with the scaphium —*Turnus*; again, almost on the very floor of the cavity—*Deiphontes*; and, in some species or other, in every intermediate stage.

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have convinced me that the extremity of this organ is solidly chitinous, and absolutely imperforate, at least in *O. Remus* and *O. Haliphron*. But, when the uncus is removed, there is clearly discerned, under the very middle of the tegumen, a circular orifice leading from the abdomen into a groove, which is hollowed along the median line of the scaphium-sulcus. In dried specimens the intestinal convolutions are reduced to an undistinguishable mass of yellow dust. Yet, on one occasion, I detected (or fancied) a thread connecting the mass with the orifice just described. It had, however, vanished in an instant.

* *Op. cit.*

† In an abdomen of *O. Haliphron* I carefully laid bare the penis till I traced the base of the chitinous cylinder, originating in firm muscular tissue, in the ventral arch of the seventh (that is, the ante-penultimate) segment. But, in *P. Merope*, I laid bare the cylinder to its base in muscular tissue, in the sixth, or even the fifth segment.

A curious variation lies in this circumstance, that, while the proper condition is that the darker, more chitinous side of the cylinder, that which terminates in the finger-point, is uppermost, there are numerous examples in which this order is reversed, and that side is undermost, as in several of the *Ornithopteræ*, *P. Agamemnon*, *Agavus*, and others. More rarely this (normally) upper side is only partly turned round; so that the odd notion is suggested, that the penis has the power of turning round on its long axis at the will of the insect.

It is also variously subject to curvature, often simply arched, with the tip downward, by the lengthening of the middle line dorsally—*Mayo*, *Rhodifer*, *Polycaon*; sometimes with the tip upward—*Pammon*, *Hesperus*; sometimes to either side—*Memnon*, *Vertumnus*, *Agesilaus*; sometimes it is thrown into a double (sigmoid) curve—*Rhetenor*.

The form is ordinarily cylindrical and tubular—*Pammon*, *Zalmoxis*; sometimes spindle-shaped—*Podalirius*, *Agamemnon*; the upper (denser) line very frequently produced into a finger-like point—*Mayo*, *Nireus*, *Macedon*, of varying length. The extremities of the sides usually expand, so as to make a wide, very oblique trumpet-mouth—*Helenus*, *Erithonius*, *Ulysses*; and sometimes project beyond the general level into distinct lips, or a sort of prepuce, often corrugated—*Erechtheus*, *Mayo*. In *P. Semperi* the expanded orifice is of extraordinary dimensions.

In its structure the penis seems to be formed of two distinct tissues, often well defined. That side of the length which is normally the upper is a cylinder of more or less dense and polished chitine—*Hector*, *Podalirius*, which is lined by another tissue of soft, pulpy, white matter, of shining surface. The former is often (not always—*P. Sesostris*) divided along its underside throughout; and the white tissue then exceeds its bounds—*Hector*, *Macedon*, *Podalirius*; sometimes notably, *Codrus*. This white element has other very singular developments, for particulars of which I must refer to my detailed descriptions and figures, particularly the curious globe protruded from the wiry organ of *P. Doubledayi*, and the still more curious and thought-evoking cases of *Orn. Richmondia*, *Haliphron*, and *Darsius**.

The variety of position and direction assumed by this organ, as has just been described, seems to imply almost unlimited freedom of motion upon its basis. Yet, now and then, we discern surrounding and, as I presume, supporting and restraining ligatures. That the scaphium seems normally to send, inward and downward, fleshy branches, which, in certain cases—*Bathycles*, *Mayo*, *Agamemnon* (all which see for particulars), surround the penis, I have already mentioned. In *P. Erechtheus* a thick white ligament rises from the floor of the genital cavity, or from each of the chitinous knobs which afford interior bases to the harpes, and, thrown over the penis, not far from its tip, appear to bind it downward. But I have seen nothing like this elsewhere.

In *P. Doubledayi* and *Rhodifer* (and also, on De Haan's authority, in *Coon*) the long

* In the great Asiatic Moth, *Attacus Atlas*, where the organ has exactly the same form and position, I find, *during life*, that the terminal tissue, which fills the expansion, is very definitely separated from the brown chitinous walls of the tube; it is pellucid-white, soft, and pulpy.

wiry penis issues from a conical sheath, which closely envelops it, as if an organic part of it. This does not appear to be a process from the scaphium.

Finally there is that remarkable dividing wall, of hard, horny chitine, which I describe and figure in *Erithonius*, perforated in the middle, manifestly for the egress of the penis, yet which, strange to say, I have met with in no other species *.

The Purpose of the Structural Variations.

If it be asked, What is the definite purpose, in the economy of the creature, of this extreme variation? I am obliged to answer, I do not know. That, viewed in the large, the object of all these organs that crowd around the termination of the male abdomen is the firm grasp and sustained retention of the female abdomen, in the delicate and most essentially important function of reproduction, is sufficiently evident. But why the diversity of detail? Why would not one good and adequate form suffice, again, and again, and again, subject to no more variation than are the antennæ, for example, or the tarsi?

It naturally occurred to me, very early in these researches, that every peculiarity in the prehensile organs of the male would have a correspondent peculiarity in that part of the female body which they were formed to grasp; and I eagerly turned to the examination of the female abdomen. But the repeated search left, and still leaves, my question—cui bono?—without an answer.

The position of these organs, and their relation to the surrounding parts, when *in situ*, show indubitably that it is the *exterior* of the final segments of the female abdomen, that are seized *in coitu*. The harpes and the uncus are certainly not intruded *into* the female abdominal cavity. Thus the field of search is at once limited to the outer surface, from the very nature of things; and this is confirmed by the occasional clogging of the harpes with body-scales, as I have already noticed. It was then sufficient to denude the female abdomen of its clothing-scales, without disturbing the parts.

But though I did this with species after species, selecting those whose males have diversely-armed harpes, no solution of the inquiry was obtained. The females of *Papilio Thoas*, *Polydamas*, *Anchisiades*, *Helenus*, are, as to the point in question, mutually

* The genital organs and their accessories have been minutely described and exquisitely figured in another Order of Insects. The question may be asked,—What homology (or analogy?) exists between the organs herein described by me and those of Trichoptera described by Mr. McLachlan? I have examined every figure in his great work, and confess that I know not how to institute any satisfactory comparison with those parts in *Papilio*. It is just possible that the "dorsal process," in such forms as *Rhyacophila*, may be equivalent to my "uncus;" but of "scaphium" I see not a trace. Possibly, too, the "inferior appendages," so largely developed in the same genus, may represent the "valves;" but the resemblance is most evanescent. The penis seems formed on a plan wholly different.

In one point my own observations agree with those of the learned author—the remarkable fact that no two species seem to have the same forms of armature.

My friend has been so kind as to send me his paper "On the Sexual Apparatus of the Male *Acentropus*" (Trans. Ent. Soc. 1872). Looking at his figures, I should have been inclined to say, if I had not been told, that they represented the parts of some *Papilio* or *Pieris*. We seem to have the valve (*a*), with its dorsal moiety, indeed, absorbed the tegumen projected into an uncus (*b* and *c*); and the scaphium (*d*, *e*) small, but normal in form, connected basally with the uncus, and bearing its usual lateral elevations, duly crowned with teeth or the characteristic aristæ. The parallel is most curious. I should expect some form of harpe lurking within those *appendices inferiores*.

undistinguishable. Under the microscope, the whole surface, after denudation, appears pitted with very minute shallow depressions, each with a knob at the bottom. They are arranged in transverse lines; and those of each line alternate with those of the lines preceding and following it, but this by no means with mathematical precision. These pits are well known as the receptacles of the clothing scales. Possibly, indeed, they may have a second use, even to afford hold for the saw-points of the male harpes; and the clogging scales, carried away by the latter, had been, no doubt, displaced by the saw-teeth in securing their grip-hold.

At the posterior margins of the seventh and eighth segments, these surface-pits appear closer together and larger than in other parts of the female abdomen.

The surface of the ninth segment, which consists of the valvules of the vulva, is peculiar—not clothed with scales, but cloth-like, being composed of hairs nearly erect, placed exceedingly close together, and, though very fine, so short as to be, in places, of a length not more than five or six times their thickness, as may be discerned when under the microscope we view the very edge of the rounded surface against the light.

Now, though it is not improbable that these last-named parts, the exteriors of the valvules of the vulva, may be the spots ordinarily grasped by the approaching harpe-tips, yet I can discern nothing in the nature of their surface, nor in that of the proximate surfaces, to distinguish one species from another—each surface, in one, exactly corresponding to the same surface in each of the other species, whose females I examined. And so there is nothing, so far as I yet know, to account for the astounding variety in the harpes of the males.

Yet, if I see a number of keys, of very minute and elaborate workmanship, all different, I cannot doubt that every one is intended to fit some special lock, though I have not examined the wards; and this conviction is the stronger, the more varied, and the more complex are the keys. We cannot withhold a hearty assent to the conclusion of one of the most eminent of modern physiologists, who, speaking of these organs in the class of insects generally, says, "They prevent allied species from producing bastards by adulterous connexions; for the hard parts of the male correspond so exactly with those of the female, that the organs of one species cannot fit those of another"*. And Léon Dufour speaks of them as "a guarantee of the conservation of types, and a safeguard for the legitimacy of species" †. But I should like to see these axioms demonstrated.

What anomalies remain to be discovered, I cannot guess by the closest scrutiny of the lovely wings spread out in our cabinets. The strangest deviation from normal form that has occurred to my notice, is the unvalved abdominal apparatus in the beautiful *Papilio Hector* of India. It is most aberrant; but what hint of this is conveyed by the gay body and wings? Who could conjecture, by looking over a cabinet, that *Ascalaphus* and *Helenus* are so alike in their genital armature, while *Hector* and *Agavus* are so unlike?

On the Harpe-types.

As the harpe appears to be the leading organ in the prehensile apparatus, the most fully elaborated and the most varied, I attempt a grouping of the different forms of this

* Siebold, Comp. Anat. § 354, note 2.

† Ann. des Sci. Nat. i. (1844), p. 636.

organ. The result is an order of succession which, it must be confessed, sets at nought that which is founded on the form, neuration, and colours of the wings. It is not proposed as, in any sense, a natural arrangement of the species, but as a help to reference and memory, and as a means of comparison of the varying conditions of this special organ. The groups themselves are loosely defined, and run into each other.

It must be recollected that the armature of only sixty-nine species, out of the four hundred and more described *Papiliones*, is here recorded. A fuller examination will doubtless bridge-over many gaps, and supply other forms.

Ornithoptera.

1. A broad arm ending in a bent spiniferous hand.

Arruana.	Haliphron.	Heliacon.
Pronomus.	Darsius.	Heliaconoides.
Richmondia.	Rhadamanthus.	Brookeana.

2. A long wire, springing from a square plate.

Amphrysus.

3. A small hollow shell, with toothed edges.

Remus.

Papilio.

4. A shaft with securiform head, and generally a tooth beneath.

Memnon.	Schmeltzi.	Nephelus.
Mayo.	Polymnestor.	Chaon.
Erechtheus.	Protenor.	Menestheus.
Rhetenor.	Ascalaphus.	Pammon.
Deiphontes.	Helenus.	Agavus.

5. A sword with a saw-edge, or pointed, and set edgewise.

Machaon.	Merope.
Arcturus.	Brutus.

6. A long two-pointed blade, not serrate.

Homerus.

7. A long pointed style, not serrate.

Ulysses.	Phorcas.

8. A broad thin plate, with thickened edges, especially the ventral; variously toothed.

Thoas.	Bathycles.	Sesostris.
Turnus.	Agamemnon.	Childrenæ.
Polycaon.	Erithonius.	Lysander.
Axion.	Anchisiades.	Eurylcon.
Hesperus.	Vertumnus.	Ergetcles.
Demoleus.		

9. The plate obliquely truncate, serrate, or running into broad points; with deviations.

Macedon.	Latreillei.	Doubledayi.
Bromius.	Semperi.	Rhodifer.
Podalirius.	Lycidas.	

10. The points produeed into long styles.

Archesilaus. Zalmoxis.

11. The plate eomplicate, sending off many laminæ and points, often serrate.

Policenes. Agesilaus. Codrus.
Ucalegon. Parmatus.

12. Rotundo-triangular, with a spoon-like knob, usually studded with points.

Nireus. Polydorus. Hector.
Diphilus. Antenor.

Specific descriptions.

Ornithoptera arruana, Feld. (Plate XXVI. figs. 1–3.)

In this grand butterfly the *valve* is of unusual size, measuring ·3 ineh in length, and ·33 in breadth. Externally it is uniformly brilliant yellow; internally, rich velvety brown. Its outline is rotundo-triangular, with the dorsal side eut off obliquely at the basal moiety, and the ventral side correspondingly produced. The ventral margin is broad and flat, or rather slightly ehannelled; there is a projecting blunt tooth, about one third down this margin; and the whole is surrounded by a narrow fringe of hairs, blaekish and dull on the dorsal, brassy and glittering on the ventral edge. The ventral margin forms a wide flat shelf throughout, before the level desecnds to the eoncavity.

At the very base of the valve begins an ample *harpe*, in the form of a broad plate of glittering ehitine, narrowed slightly in the upper part, and then expanding into a spoon-like disk, of which the terminal edge is flat, oblique, and beset with minute blaek glittering, curved, aeute spines, the points direeted ventrally, arranged, inexaetly, in transverse rows, of which there are about seven on the dorsal edge, diminishing to one before the ventral angle is quite reaehed *.

The *harpe* eonsists of two surfaees, as if a tube had been flattened; and, besides this, the upper surfaee is hollowed both immediately below the spined disk, and in the basal moiety. The terminal portion, about one fourth of the whole, is diseonneeted with the lining membrane of the valve, to whieh the remaining portion adheres; but the whole ean be lifted, and separated from the valve by delieate manipulation, and plaeed on a glass slide for higher amplification. The component ehitine is now seen to be quite transparent, of a rieh yellow-brown colour, deeper at the edges, and speeially at the extremity, where the spines are glittering deep blaek. All over the body of the harpe ramify many irregularly sinuous lines, like rivers in a map; and these, I found, by an accidental fraeture of the strueture, are not on the outside, but on the inside of the walls. When the valves are elosed, the pair of spinous disks meet accurately at the very tip of the uneus, as may be seem with the left valve in Pl. XXVI. fig. 3.

The *uncus* is a wire of extreme slenderness, blaek, polished, very slightly eurved, ending in a point, not sensibly dilated, not very aeute; the basal portion of the upper surfaee bears a ridge of elose, stiff, blaek hairs, which stand nearly upright.

* It must be remembered that, as in many other eases, this is the careful deseription of *an individual*; the minuter features may not be repeated in every example.

The *scaphium* is very difficult to understand without dissection, to which I have been reluctant to resort with so valuable a species, contenting myself with careful study of the parts *in situ*. It seems to me, after much consideration, that the scaphium proper is reduced to a slender "*boat*" running off to a point under the tip of the uncus to which it seems attached, above the triangular basal expansion, by fibrous processes on each side. I can see nothing answering to the ordinary "double teeth." The keel, on the other hand, seems to be unusually developed into the large bagging body which hangs below *.

In the lower part of the cavity is seen the *penis*—here a moderately thick column of polished brown chitine which projects almost horizontally from the abdomen to the edge of the valve, and terminates in a long drawn point, just before which it sends off two expanded foliations on the upper side (the organ being reversed), which are of thinner substance than the tube, and which face each other.

Towards the base of the genital cavity, projecting from one of the lower dilatations of the scaphium, I find, in the forms of this species, particularly distinct in *O. Richmondia*, two short sharp polished spines on each side of the penis, so placed that the four are in a line with it. I cannot suggest the use of them; their position seems to preclude prehension.

Ornithoptera pronomus, G. R. Gray. (Plate XXVI. fig. 4.)

The *harpe* is not distinguishable from that of *O. Arruana*, except that the armed disk is a little wider. In removing the valve, the harpe detached itself, together with a portion of the lining-membrane, so that I could lay it, quite alone, on a glass slide for the stage of the microscope. The black shining teeth are about fifty in number, arranged exactly as in *Arruana*, and interspersed with stout bristles or straight spines, all projecting at nearly a right angle to the plane of the stem. The teeth are some larger than others, irregularly crowded, decidedly curved, stout, pointed, black, glittering in the light; the chitinous substance of the disk and stem translucent, gall-yellow by the transmitted light, varying in depth of tint, according to the thickness, and, as I think, according to the density, of the material.

The *uncus* differs much from that of both the preceding and succeeding forms. It is rather short, not uniformly curved, but bent down near its middle with a kind of knee; it widens rather rapidly to the base; and the vertical rami, which I will call the *keel* of the uncus, increase in depth rapidly. The uncus is not wiry.

I could find not the least trace of a *scaphium*, in the single specimen that I examined.

The *penis*, reversed, was abruptly inclined from near the base downward; so that it lay in the very angle between the valves, and was so long that the tip was fully seen without, pointing obliquely towards the head of the insect. The expanse of the lips was empty to a considerable depth; the median line channelled beneath, as if the integument there were thin, and had contracted in drying.

* Since the above was written I have made examination of the specimen in another mode. Having softened the parts by moisture, I stretched them apart with needles, and thus satisfied myself that my explanation hazarded above is the true one.

The scaphium may have been accidentally lost; but the peculiarities in the uncus and penis are considerable, and, if these prove to be constant, are good distinctions between this form and its fellows.

Ornithoptera richmondia, G. R. Gray. (Plate XXVI. fig. 5.)

Here the *harpe* diverges from the preceding forms. The disk is considerably wider and shorter, without any sensible diminution into a neck, and it shows a distinct tendency to that form, which I have compared to an *open hand bent back from the wrist*, conspicuous in the black and yellow species of the genus, but which is scarcely seen in the Priamoid races. The teeth are crowded along the truncate extremity (the "fingers"), and within (on the "palm"), and more on one side than on the other; but, whereas, in *Pronomus* and *Arruana*, the main crowding is at the left corner (as looked at), here, in *Richmondia*, it is at the right. The teeth, though minute, are seen, when viewed at the proper angle, to be curved, acute, glittering spines; their number is about fifty.

The *uncus* and *scaphium* are as in *Arruana*; but the former is somewhat more curved. The *penis* also agrees fairly; but the expansion (in one examined) was much less corrugated, and had a broader, more truncate point. The organ was manifestly empty, as my lens reached for some distance up the interior. But another example was full, to swelling, throughout its whole length, on the inferior side, with the singular white pulp, which also had filled the expanded lips, and reached to some distance beyond. Moreover, as I had removed the valve from this example, with a slight jerk, there had been projected from it a compact shining white globule of this same matter, as large as a rape-seed, which I have every reason to believe had originally borne the same relation to the penis as the like knob represented in my illustration of *P. Doubledayi* in Pl. XXXII. fig. 18.

Ornithoptera Haliphron, Boisd. (Plate XXVI. figs. 6 & 7.)

Outline of *valve* rotundo-triangular, the sides much rounded, occasionally so as to approach the circular form. From the tip projects a minute horny point, which bends inward, towards the opposite valve. Interiorly, the margins slightly overlap, and the edges are sparsely set with short hairs. The concavity is smooth, not polished.

The *harpe* occupies the middle of the valve, and is a flattened tube (?) of rufous, transparent, highly polished chitine. It springs from a wide base, like the trunk of a tree, which, on one side, adheres to the base of the valve, and, on the other, to a stout angular projection at the bottom of the abdominal cavity. Thence it pursues the concavity of the valve, narrowing as it proceeds, adhering to the lining-membrane, and scarcely elevated above it, till about two thirds of the length of the valve are reached; here the chitinous column is detached from the lining, and rises sensibly from it. It is here narrowed to a sort of neck, then abruptly widens to a broad ovate disk, studded all round its margin with stout sharp glittering teeth, fifteen or sixteen in number, all of which point inward when the valve is closed.

The armed disk is abruptly bent backward, and a little to one side. It may not inaptly be compared to an open hand, bent back upon the wrist of a naked arm, as far

as it will go, the upeurved fingers representing the hooked teeth, and supplemented by a ridge of teeth running obliquely across the wrist itself.

The *uncus*.—When the two valves are closed, as in life, the hand-like disks approach each other; and, between the facing rows of teeth, deseends the point of the uncus. This organ is not so wiry as in the preceding species, but rather suggests the blade of a elasp-knife, projecting, with a wide triangular base, from the dorsal areh of the eighth abdominal segment, having a moderately eurved upper edge, and ending in a sharp hooked point. What looks like the blade is truly the side of eaeh of two vertical rami, which, supporting and strengthening the strueture, pass off laterally into the walls of the segment. The whole is formed of hard horny ehitine, dense in texture, dark in eolour, and glittering in surface, even as are all the prehensile organs which form the subjeet of the present memoir. Sometimes the edge of the uneus-blade has a eonspicuous notch; but the minuter details of all the organs are not absolutely identical in different examples of the same species. One example had a minute supernumerary point just under the proper point; in another, the triangular base, viewed vertically, was distinetly notched on eaeh side, just where it narrowed to form the blade.

The *scaphium* is large and plieated, white, shining, firm, the keel always prominent, but in some more than in others. As in *O. Amphrysus* and *Rhadamanthus*, the rounded lobe on eaeh side rises to a thin erest, divided into notehes, eaeh of whieh is crowned with an erect bristle, rising above the level of the uneus. The horizontal point of this lobe, somewhat eondensed in texture, seems to represent the "double tooth" of other speeies. The median groove reeeives the blade of the uncus, as into a haft.

The *penis*, as usual in the genus, is large, and funnel-like at its extremity; in position it is reversed, the more ehitinous side, whieh terminates in a finger-like point, being downward. In one specimen, this organ displayed a remarkable phenomenon (whieh, under modifieations, has reeurred to me sinee), whieh I cannot satisfaetorily explain. Even the unaided eye eould diseern a thiek white mass, eonnecting the trumpet-mouth of the penis with the inferior surface of the scaphium. I immediately introdueed a drop of water into the genital cavity, and allowed it to stand awhile. I then removed, with absorbent paper, the superfluous moisture, and applied a considerable magnifying power. The appearance now presented, I have depieted with great eare, in Pl. XXVI. fig. 7. A eylindrieal column of soft, subgelatinous, milk-white substanee, of a diameter slightly less than that of the expanse of the penis, had, apparently, risen vertically from the interior of this organ, till it had eome into eontaet with the seaphium, against which it had flattened by the eontinued *vis à tergo*. The lower part of this eolumn was tinged with the yellow-brown hue of the organ itself. The ehitinous lips of the expansion seemed to have been forced wider apart—split, in short—by the protrusion; and, what seems to me very suggestive, eertain lines of very pale ehitine-colour, agreeing in form with the outlines of the ehitinous lips, looked as if the lining membrane consisted of *several* eoats, and as if these had been protruded, suceessively, one after another, as the white matter had been pushed out!

But, what is the nature, what the function, of this white jelly-like matter? Is it an integral part of the organ? Is it a seeretion from it? Is it the semen, under novel

conditions? Its firm consisteney, even when softened by the absorption of water, and its condition, when dry, of a firm, solid, shining white mass, seem inconsistent with such a conclusion. It may, possibly, not be without relevance, that the spinous disks of the harpes were, in this specimen, unusually clogged with meconium and scales, suggestive of a recent coitus at the period of capture.

But I would rather incline to seek analogy with cases, not very infrequent, in which the penis is manifestly separable into two longitudinal portions—a split tube of brown chitine, and a pulpy white mass occupying, and more than filling, it *. (See my figures of *Hector*, *Codrus*. *Agamemnon*, *Erithonius*, *Podalirius*.)

Ornithoptera Darsius, Gray. (Plate XXVI. figs. 8–11.)

Valve almost exactly as in *O. Haliphron*, save that the terminal finger-point is a little longer, and spathulate. The interior has a rather wide space within the ventral margin, level with it, before it abruptly drops to the cavity.

The *harpe* also has a general resemblance, but is narrower, the disk more truncate, more excavate, furnished with eight or ten stout and sharp teeth, all marginal. Viewed sidewise (Pl. XXVI. fig. 10) it takes something of the form of the human arm and open hand, but less bent back upon the wrist.

Uncus, much as in *Haliphron*, viewed laterally; vertically, it is more slender, with a slight dilatation just behind the point.

Scaphium, ample, with a deep thin keel, quite white.

The *penis*, in the individual examined, again presented the very remarkable phenomenon which I have described in *Haliphron*. The organ was reversed, slender in the column, with a very ventricose, one-sided trumpet-mouth, that had apparently been split open by the extrusion of a great globose mass of the white substance. Here, as there, several successive laminæ had, apparently, been thrust out, in various degrees, just as I have there represented, all showing definite angular points. The white substance, so much resembling the albumen of an egg coagulated, was, when I first looked at it, in contact with the scaphium. It absorbed water: after which I could easily, with a needle, detach minute portions for microscopic examination. These, diffused in a drop of water on a slip of glass, showed no trace of organization, but resolved themselves into irregular atoms of amorphous matter. Fig. 11, Pl. XXVI., represents this penis viewed nearly from the front, when most of the white matter had been removed.

This phenomenon, which has occurred in three distinct species of *Ornithoptera*, viz. *O. Richmondia*, *Haliphron* and *Darsius*, appears to me very curious and puzzling. I have assumed that the strange substance is extruded; but I am not sure. The splitting of the walls of the penis, or, at least, the forcing apart of what, if expansible and separable before, were normally closed, certainly suggests a thrusting-in from without, rather than a thrusting-out from within. Yet this would be, *a priori*, most unlikely. Whence should come the matter? Why should it be pushed into this organ, when it does not pervade and fill the surrounding parts? This thought must be dismissed; and the

* Dr. Burmeister (Man. Ent. 1836, p. 329) speaks of the *turgescence* of the organs of generation, *before and during* copulation.

appearance of the successive coats pushed out, one beyond the other, as well as the flattening and expanding of the white column against the bottom of the scaphium, in the *Haliphron* case, seems to me overwhelming evidence that the movement has been from within.

If we compare the penis as it appears in *Rhadamanthus*, *Amphrysus*, and *Arruana* (see the figures on Plates XXVI. and XXVII.) with the same organ in these three cases, or, better still, the penis in one specimen of *Haliphron* with the same in another, the one filled, and burst, with this white matter, the other normal in form, brown in hue, empty at the lips, without the slightest trace of white matter, the thought occurs that possibly we find here not specific differences, but only two interchangeable conditions. The shining, expansile, open and empty lips may give the ordinary passive condition; the white pulp pervading the tube (see *Hector*, Plate XXXIII. fig. 31), filling the orifice, and expanding it to overflowing, and even to a breaking of bounds, may give the condition when the "*furor igneus*" is raging—may be analogous (I do not say identical, seeing we have to do with bloodless invertebrata) with *erection* and *emission* in the higher vertebrata.

Observations carefully made, *in hac re*, in individuals taken *in coitu*, as well the female as the male, might be of great interest and value.

Supplementary Note to Ornithoptera Darsius.

The globule of white substance from *O. Richmondia*, I submitted to my friend Professor Gladstone, F.R.S., Pres. Chem. Soc., who has favoured me with the following report.

"On examining your little particle, I have obtained a more satisfactory result than I had anticipated. Though the piece of white excretion was no larger than a small pin's head, I have been able pretty well to determine its constitution. It was quite hard, but easily pulverizable, and consists mainly of earthy phosphate and some fatty or oily matter.

"The phosphate melts, when strongly heated, like the 'fusible phosphate' which is common in urinary calculi: but the quantity was so minute that I cannot say, with certainty, whether it contains *magnesia*, as well as *lime*; but my impression, from the chemical tests applied, is, that it does consist of both.

"There is a considerable proportion of *organic* matter mixed with this phosphate. Ether dissolves it out; and, on evaporation, it is obtained again in what, under the microscope, appears as oily drops.

"No trace of uric acid could be detected."

According to Léon Dufour and other anatomists, the urinary organs in insects "always consist of tubes which are inserted in the pylorus and terminate cæcally. . . . . The granular contents of these vessels . . . . flow gradually into the digestive canal. Thus excreted they accumulate in the colon, and are evacuated with the fæces, or separately as a turbid fluid . . . . . With the holometabolic Insecta, the urine is evacuated isolately when they approach the completion of their pupa state. It is well known that the Lepidoptera, when bursting from their pupæ, emit a considerable quantity of

urine, of a variable colour." (Siebold's Comp. Anat.—Burnett's Transl. 1854, page 441 and note.)

If this statement is correct, the penis is never used for the evacuation of urine: urine being identified with that copious fluid which Dr. Burmeister compares to the *meconium*, and which I have had repeated occasion to mention in these pages. But the frequent recurrence of this white pulpy matter within the penis and manifestly ejected from it appears to show its normal, if occasional, connexion with this organ. I cannot help thinking of the thick white creamy substance, of an overpowering fetor, which I have seen copiously discharged from the cloaca of Serpents, which, however, is said to be the urine, "consisting mainly of uric acid" (Grant, Comp. Anat. p. 631). The oil-globules may possibly look to a changed condition of spermatozoa in residue of semen partly discharged from the organ, or to fatty degeneration of some tissue.

More recently, my kind friend Mr. Robert M'Lachlan, F.R.S., has favoured me with some correspondence on the subject. He mentions to me a fact, of which I was not before aware, that a mass of spermatozoa is sometimes "exeluded by other insects in dying;" and this on the authority of the Rev. Alfred E. Eaton, M.A., whose words, in a letter to him, my friend thus quotes:—"*Oligoneuria rhenana* [a May-fly, common on the Rhine] discharges either spermatozoic paste, instead of spermatozoic liquid, or else discharges spermatozoic cysts. I have introduced, into plate iii. of my promised work, a figure of the lobes of the penis with the two threads of paste, or the tubules (as the case may be) like transparent vermicelli, partly extruded. But nothing has been published about this. In other *Ephemeridæ*, the matter ejected is fluid."

The second of these alternatives is, I think, inadmissible. The matter is not contained in a *cyst*, if this term implies an enclosing wall, but always as a mass of paste, undefined, save by the cessation of its own substance.

Yet later, I had occasion to examine several examples of the noble *Papilio Gigon*, from Celebes. Within the expanded lip of the penis of one of these—protruding, but not extruded—there was a rounded mass of the dried white pulp, which also was seen filling the whole cylinder of the abnormally large organ. I easily detached an atom with a needle, and transferred it, with a drop of water, to the compressorium of a microscope (Powell's), subjecting it to graduated pressure with a square of thin glass.

The appearance now was as of an infinite multitude of filaments, most unequal and irregular in thickness and direction, anastomosing (or else crossing) at various intervals, and enclosing excessively minute areas, having refractive power. At the edge, where it thinned off to nothing, these areas resolved themselves into minute flattened corpuscles of no definite form, but always with outlines irregularly sinuated, never angled or pointed. These corpuscles, closely appressed in the denser parts, made the bright interspaces, and their edges the darker network. Among them were a few yellowish molecules, larger and more opaque, irregularly roundish, of various sizes, and also a good many clear oil-globules, some few of which last were drawn out into slender tails, of the same substance.

I have taken great pains to be accurate in describing what I saw (under a $\frac{1}{8}$-in. power); but I fear it is not very intelligible. I had never before examined spermatozoa that

had been dried; but the impression was strong on my mind that this was indeed the nature of what I was looking at. Thus Mr. Eaton's suggestion solves the problem: these discharged masses consist of paste mainly composed of *spermatozoa*.

ORNITHOPTERA RHADAMANTHUS, Boisd. (Plate XXVI. figs. 12–16.)

Valve much as in *Haliphron*. The *harpe* is separable (clean, and with ease) from the parchmenty skin which wholly lines the valve; the latter itself also separable in the dry state. It is a long narrow plate of shining, transparent, yellow chitine, not quite so much dilated at the base, with a cavity sunken in the middle of the basal half, having abrupt irregular edges. The extremity is slightly oblique, pointing dorsally as in *Haliphron*, but not in the least dilated, armed with eighteen stout curved teeth, all placed at the very edge, except two or three which are submarginal. There are also a few long black bristles, or spines, scattered over the surface.

The teeth, as in the allied species, project from the plane; hence, when the harpe is laid on the stage of the microscope (as at Pl. XXVI. fig. 14), an inadequate idea is formed of the power of the armature. When it is tilted, so as to be viewed edgewise, the teeth, which had looked like low cones, are seen to be strong and very acutely pointed semi-crescents, bearing a very close resemblance to the spines on the stem of a rose (see fig. 15, which represents the four teeth on the dorsal margin, viewed sidewise).

A second example had the form of the valve, and of the harpe, almost exactly the same; the teeth seventeen, with almost the very same arrangement, even to the trivial circumstance of two on the ventral curve being double.

In a third example*, the tip or disk of the harpe was a trifle longer, and decidedly bent back (like a hand from the wrist) towards the valve-cavity, the middle part of the arm being bent up to allow this, so that a longitudinal section of the harpe, viewed laterally in the plane of the valve, would assume this form (see woodcut).

Harpe of *O. Rhadamanthus*, enlarged.

In the intra-abdominal apparatus there is a general agreement with the allied species. But the *uncus* is rather shorter and stouter, with a less graceful curve. The *scaphium* differs much, a difference better expressed by the figures than by words (see Pl. XXVI. figs. 12 and 16). There is a similar aristate crest on each side of the uncus, whose points rise above its level; and from the bottom of the lobe projects a long horizontal black tooth on each side. The scaphium-keel is unusually developed, projecting with a sinuous bend, and having a slightly expanded, corrugated point; its surface bears many irregular, but symmetrical prominences, hollows, and folds of the firm, shining, white tissue, which, here and there, deepens into brown or even black—indicative, I presume, of a more copious supply of the chitinous element to those parts.

* Often my observations have been limited to single examples of each species; wherever, as above, I have had opportunities of comparing other specimens, I gladly record the results. Their cumulative tendency is to show that the features of the prehensile organs, and especially of the harpe, are constant, and characteristic of species, not varying with individuals.

I have noticed that, in this species, when the valves are *in situ*, what I have compared to the wrists of the two harpes meet and close together some considerable distance beyond and above the point of the uncus. This latter, however, is then in actual contact with, or in very close proximity to, the stout spines that beset the ventral edges of the harpe-arms.

N.B.—My examinations and figures are all from specimens which agree minutely with Lucas's description of "*O. rhadamantus*" (Lepid. Exot.; Paris, 1835, p. 5), called "*O. amphrisius*" in his plate ii. fig. 1, having, on the under side of the fore wing, the nervures and nervules conspicuously bordered with light grey.

Ornithoptera heliacon, Fabr. (Plate XXVII. figs. 1 & 2.)

Valve more regularly rhomboidal, terminating in a finger-point well formed and symmetrical. Exterior scale-clothing very thin and close, therefore projecting very slightly from the edges, mingled with a few short inconspicuous hairs. The level of the interior forms a narrow shelf as high as the margin on each side, and then descends abruptly to form the concavity. Lining-membrane dull, dark brown.

Harpe attached by a widely dilated base, whence it proceeds in an oblique direction, unusually close to the dorsal margin, and there, bending abruptly at nearly a right angle, projects more than half the length of its disk beyond the dorsal edge of the valve—a circumstance quite abnormal. The stem is nearly parallel-sided, narrower than usual, appearing to the eye as if a cylinder pressed nearly quite flat, with one of the sides wanting in the area of the disk, and at the lower half of the column. But, I think, this appearance is delusive, depending upon the fact that the plate of chitine is thickened irregularly in certain parts, and somewhat bent up at the edges. Disk (Pl. XXVII. fig. 2) wholly hollowed, with a very irregular cavity. The whole organ is glittering; the uneven surface reflecting points of light from every prominence; colour gall-yellow, both by reflected and transmitted light. It is armed with but eight teeth, all standing up around the edge; but the second and fourth, on the ventral side, are either double-pointed, or consist each of two teeth planted close together. All are shaped as in *O. rhadamanthus*. I detected no scattered bristles.

Ornithoptera heliaconoides, Moore.* (Plate XXVII. figs. 3 & 4.)

Valve almost exactly as in *Haliphron*, in outline; finger-point small, but varying in individuals; exterior well clad with white scales, which project as a close, even fringe of hair-scales very narrowly beyond the margins. Interior level, with a narrow shelf on the ventral margin: lining-membrane dull chestnut, or sooty brown.

The *harpe* has a strong general agreement with those of *Darsius* and *Heliacon*; yet two examples agreed *inter se* in points in which they disagreed with *Heliacon*. The terminal moiety is free; and the whole is easily detached with a fine knife-point. The disk is merely a portion bent dorsally, at nearly a right angle, but not reaching the margin of the valve: it does not narrow, is scarcely hollowed, scarcely thickened. It

* I give the name on the authority of Mr. A. Doncaster, of 36 Strand, who supplied me with specimens from Andaman Island. But it cannot be separated, even as a variety, from the preceding.

resembles a very flat spoon or slice, with the edges turned-up like a dish; there is no sensible thickening at the bend (or "wrist"), as is usual; the teeth are about fourteen, sharp and strong, varying in size *inter se*, standing up around the edge, and one or two within the edge. They are not black, as usual, but of a deeper tint of gall-yellow, proper to the chitine.The arrangement was not quite the same in the specimens; but a common pattern was quite discernible. The three behind the bend were much longer and slenderer than the rest, in each example.

Uncus moderately long, little decurved, of a shining red hue, indicating, like the paler colour in the teeth of the harpe, an inferior degree of density in the chitine; rather slender, the base small, the extremity subdigitate.

Scaphium large, long; keel abruptly deflected, much as in *Rhadamanthus*; the aristate lobe set nearer to the base.

Penis dark red, glittering; its extremity widely ventricose, one-sided, exactly as the organ in *Haliphron* and *Darsius* would be if not burst. By looking steadily into the expanded orifice, under a very good light, I could distinctly see that there was nothing in the throat but the wall of the organ, thick, indeed, and apparently composite, but pellucid. Not the slightest trace of the white pulpy matter was visible in any part.

Ornithoptera Brookeana, Wallace. (Plate XXVII. figs. 5–8.)

Valve small, of peculiar form, almost circular, with irregular projections, having a marked resemblance to that of *O. Remus*, but still further removed from the normal form. There is no finger-point at the usual place; but a prominent one at a part of the margin diametrically opposite, viz. at the back of the dorsal margin very near the hinge*. The exterior is densely clad with minute scales of dead-black hue, which become a very wide fringe of dense brush-like hair all around the margin. The interior, which is very concave, almost hemispherical, with no submarginal shelves, is lined with a separable membrane, dull black.

Harpe of unwontedly large size, not only relatively, but actually; of peculiar form, broad, fiddle-shaped, concave, the extremity semicircular, expanded, slightly separated from the lining membrane, and bent up; set with about twenty-five very minute, irregular, black teeth, along its upturned edge.

The toothed margins of the opposing harpes converge upon the spot, within the genital cavity, where the hook of the uncus should be. But this ancillary organ is, in *O. Brookeana*, wholly aborted, the posterior edge of the dorsal arch of the eighth segment forming—instead of a projecting triangular point, = the *tegumen* of Dr. Buchanan White,—two rounded lobes, with a deep mesial notch between them (see fig. 10); while the middle of the outline, which ought, normally, to be prolonged into a curved wiry uncus, projects but a very shallow point, barely sufficient to fill the notch.

The *scaphium* is very large; the two lateral hemispherical lobes well developed—with the median furrow, along which the uncus usually passes—but no bounding crests of

* When the valves are shut, these two projecting points, one from each valve, fill up the blank left by the absence of the usual advancing rami of the uncus.

bristles, and no distinct "double teeth." Of the other constituent parts of this organ I must speak with a measure of doubt. In the first specimen of this noble species that I examined, the parts already mentioned were of a dirty drab or "whity-brown" hue; but below them descended what I supposed to be a symmetrical *keel*, of pearly white substance, pellucid, almost semitransparent; very firm, almost cartilaginous, in texture.

But was this, indeed, the *keel*? For, with a very slight touch it came away, and then seemed to be not an animal tissue at all, but amorphous substance.

And, in another specimen of this same species, the scaphium appeared of the form which I have with great care delineated in figs. 7 and 8. Here the keel, or what I identified as such, though of unusual shape and direction, was in the general plane of the organ, with an open expanded extremity, bounded on each side by an ovate knob, and carrying the usual lobes on its upper surface, without elevated crests of aristate points. Immediately beneath, and even in contact with it, but in *direct* position, was seen the trumpet-mouthed penis, with a horny finger-like tip.

The examination of this second specimen augmented my doubts of the nature of what I had seen in the first; and reminded me of what I have recorded in *Haliphron*, *Darsius*, &c. But whether what I saw in *Brookeana* was of the same nature, and, if so, whether it was an excretion from the penis, I have not yet sufficient light to determine.

N.B. In fig. 8, the left valve and its harpe are indicated in faint outline, to show that the point of the scaphium-keel came just within the serrated edges of the two closed and opposed harpes.

Ornithoptera Amphrysus, Cram. (Plate XXVII. figs. 9–11.)

Valve pure white, on the golden-yellow abdomen; well-developed, large; form that of a semicircle, with the dorsal side cut away obliquely, terminating in a strongly projecting point. Both the margins are fringed with white hair-scales, the ventral narrowly, the dorsal very broadly and densely, its edge forming a right angle with a point in the middle. The finger-point of the valve is unusually large, and slightly incurved, so that, when the valves are *in situ*, the two points cross. I have no reason to believe that these points have prehensile power.

On removing a valve, I could find no trace of a *harpe*; and when—suspecting that this might be accidental, the result of a morbid atrophy—I carefully examined another specimen, in perfect condition, with well-formed abdomen, I still found nothing to break the uniformly concave surface of the valve. Only, at the base, near the dorsal side, there was, in each, a pear-shaped area, occupied by a multitude of very fine and close corrugations in parallel lines. But, afterward, when I was examining the uncus and its accompaniments, the mystery was solved. I observed a long black slender wire, incurved at the tip, projecting from the interior, nearly horizontally, below the scaphium; which I could not at all account for. Tracing this to its origin, I found that it belonged to that one of the valves that yet remained *in situ*; that the place of the corrugated area was normally occupied by a curved plate of polished brown chitine of trapezoidal figure, from the dorso-basal angle of which proceeded the long curved wire, of extreme tenuity throughout.

The two inner angles of the trapezoid were stout short points, rising free from the valve, and all of deep hue and glittering surface, indicative of great density.

This, then, is doubtless the *harpe*; and the reason why I had not found it in either of the separated valves is, that it is very readily detached from the lining-membrane; and so, when the valve is removed from the abdomen, it is apt to leave behind the harpe, which remains *in situ*. It is, indeed, widely different, both in form and position, from the organ, as I have found it in all the other species of *Ornithoptera* that I have examined; but it is probably very effective, as I hope to show.

The *uncus* is long, slender, wiry, horizontal, nearly straight, bent slightly down at the tip, proceeding from a very small triangular base. The *scaphium* is greatly developed, forming various folds, the usual white hue becoming brown, and even black in several places. Its "double tooth" is a long horizontal spine on each side of the uncus, with only a slight projection behind it; and, behind this, the upper edge of the scaphium rises above the level of the uncus, in several minute bristled points.

The *penis* is thick, enlarging to the extremity, which is truncate, with a corrugate expansion, and a terminal finger-point, which, as well as the denser, darker side of the column, is here placed below. It issues from a sheath formed by a descending fold of the scaphial tissues. Between it and the scaphium on each side projects the long wire of the harpe already alluded to. Though its position and direction, when in the valve, look awkward, yet, when viewed *in situ*, we see that, on each side, this acute elastic wire brings its curved point just below the spot where the similar wire of the uncus comes; so that the three points converge, and doubtless secure a very effective grasp of the female abdomen; though I must confess the scaphium appears to be very much in the way.

The *O. amphrisius* mentioned by Dr. De Haan (see p. 267, *suprà*) is certainly not this species; but appears to be the *Amphrisius* figured by Lucas (Lep. Exot.; pl. ii. fig. 1), which is the same as the preceding *O. rhadamanthus* of Boisduval (*ut suprà*, p. 289).

Ornithoptera Remus, Fabr. (Plate XXVII. figs. 12–20.)

Valve transversely ovate; a small horny curved finger-point on the dorsal corner of the front edge, not quite constant, being sometimes reduced to a low prominence. There is another similar prominence somewhat more in front, which also varies in height. Little fringe is seen, and that only on the dorsal margin. The cavity is diminished by an obscure, wide, flat shelf, extending along the ventral slope, studded with minute bristles pointing inwards, and also by a curious large knob, at the dorso-anterior corner, very constant, which is followed, in front, very abruptly, by a deep sulcus. This knob is black, hirsute, often hoary, and lies immediately behind the finger. Occasionally, the valve, when detached, brings away a hollow, shell-like, triangular plate of chitine, which had formed part of its hinge.

Harpe an irregular rotundo-triangular shell, or ear-like body, of polished black chitine, broad, but unusually short, often not reaching halfway from the base to the point of the valve. Its edge is seen to be minutely serrate. When removed, and viewed on the stage of the microscope, very obliquely, so as to bring the free edge (the ventro-anterior edge)

into full square view (as in Pl. XXVII. fig. 13), the serration of the edge is seen to be very fine, and slightly irregular. Its base has a remarkable upturned lobe.

The form of this organ may be well imitated, and illustrated, by cutting a paper pattern into the shape of fig. 14, and rolling it into a tube, of which the dotted line is the longitudinal direction. If then it be pulled gently open, it will assume the exact curvature of the harpe. The long oblique point at the lower end of fig. 14 is, *in situ*, upcurved, and appressed to one of the flattened knobs which occupy the floor of the abdominal cavity. The expanse of the harpe resembles clear yellow glass, intensified into nearly black at the edges all round.

The *uncus* is of regular curvature, about one fourth of a circle, moderately slender, black, polished, coming down just between the two shell-like harpes. It is closely embraced by the lateral lobes of the *scaphium*, in which I see no bristle-bearing crest, and no "double teeth." But the upper edges are pilose, with short, stiff, close, shining hair, pointing towards the dorsal surface of the abdomen, as is usually the case with those species of *Ornithoptera* which have not aristate crests.

The *penis* is a moderately thick red-brown column, which protrudes from the midst of the eighth segment into the midst of the genital cavity, curving upward, nearly to the tip of the uncus. It is obliquely truncate at the point, where (in the specimen examined) there was what had the appearance of a *glans*, surrounded by a preputial thickening. But this is, indeed, so much like the remarkable appearance described and figured in *O. Haliphron* (see p. 285 *suprà*) that I am inclined to refer it to the same origin—as if the pulpy substance that (at times) occupies the interior of the penis had been forcibly pushed out from within, against the underside of the scaphium. Here, however, the walls of the penis had not been burst, as there; the orifice was not sensibly trumpet-mouthed; and there was no other trace discernible of the pulpy matter. The mass in question, moreover, instead of being white, was dull brown. Possibly, these features may indicate that the extrusion had not been very recent. The organ is reversed.

The two projecting knobs of hard polished chitine, which serve as ancillary supports for the bases of the valves and harpes, are large and conspicuous. The use of the knobs admitted of no doubt, as I, slowly and gradually, removed one of the valves *.

Papilio Memnon, Linn. (Plate XXVIII. figs. 1–3.) [Cram. i. 91. c.—Borneo.]

Valve-outline ovate, obliquely truncate at base; edge narrowly turned-in, or forming a narrow shelf fringed with short spare hairs; interior floor smooth, but not polished.

Harpe, a narrow blade of dark polished chitine, which, springing from the base of the valve, runs close to the edge of the shelf, all along the ventral margin, to the very point, where it ends abruptly. This long blade may be compared to a knife affixed by its back to the lining membrane of the valve, but sloping inward, its free edge having several excavations in its outline; the organic adhesion of the lower edge is, moreover, lacking for the terminal fourth of its course.

This blade can, without much difficulty, be lifted out of the valve, the basal membrane yielding to force. The outline now can be more correctly perceived. At Pl. XXVIII.

* For further notes on this species see Appendix.

fig. 2, the longitudinal portion is shown, laterally, more magnified, and viewed as a transparent object on the stage of the microscope. It now appears still more like a knife-blade, of thin material, transparent, but of a deep yellow hue, the surface studded with numerous minute round eminences, each of which is surmounted by an erect bristle. The inferior, adhering edge, is thickened into a narrow rim, which is fringed with a row of close-set short hairs which grow in a direction across the blade. The free edge is notched into a number of minute saw-teeth, not quite uniform in size or distance. These serrations are seen only on the blade proper, the free terminal fourth.

The abdominal armature is normal, the *uncus*, the *scaphium*, and the *penis*, being all well developed and of ordinary proportions. When the valves are in place and closed, the tips of the two harpe-blades meet close to the tip of the uncus. The scaphial "double teeth" have this peculiarity: the inner (base-ward) member is obsolescent; the outer stands up quite perpendicular, a straight needle of polished horn. The penis has a broad expanded hiant extremity, which turns towards the right side. Fig. 3 shows these parts *in situ*, the right valve having been detached, the left and its harpe indicated in outline.

The continental form, marked by broad red ocelli with black pupils, more or less conspicuous, at the anal angle of the hind wings beneath, has been lately distinguished, even by such an experienced naturalist as Mr. Wallace, as a true species (Tr. Linn. Soc. xxv. p. 47); and Mr. Kirby gives it a specific place as *P. Agenor* (Syn. Cat. 552). But if any faith is due to the organs of which I am treating, the distinction cannot be maintained.

I examined a ♂, which agreed, in all essentials of form and marking, with Cramer's pl. xci. A, B, whose name of *P. Androgeos* Mr. Wallace would retain. But I can find no feature of valve, harpe, uncus, scaphium or penis, in which it differs to any appreciable degree from examples of *P. Memnon* received from Borneo.

Papilio Mayo, Moore. (A. D.) (Plate XXVIII. figs. 4–8.) *

Valve agrees closely with that of *P. Polymnestor*. So also does the *harpe*, as it lies *in situ*; perhaps still more with that of *P. Memnon*. But when lifted from the valve (which is done with readiness) and examined separately, there is considerable difference. The blade is not so regularly securiform, and the end is not so decidedly bent-over; the blade is rudely triangular, serrated with minute teeth all along its dorsal edge, and the greater portion of its broad end.

The *uncus* and its accompaniments are on the type which I have figured in *P. Memnon*. The *scaphium* is very well developed; and I take advantage of this to make a more careful examination of the organ.

If we compare the uncus to the upper mandible of a bird's head, we see a white fleshy body filling the place, and taking much of the form, of the lower mandible. In this

* For a few species examined, I have been dependent on loose abdomens, supplied by Mr. Arthur Doncaster, of 36 Strand, London, who has verified their names. These are indicated by the initials above.

species, as in many others, it takes a boat-shape, swelling into rounded sides, and narrowing abruptly in front.

If now with the point of a needle, we raise the upper mandible till we break it off by force, we see more clearly the upper surface and attachment of the scaphium. At the back of the "palate," there was an organic attachment of the scaphium, all across its width (see figs. 7 and 8), apparently perforate in the middle; and this perforation I take to be the anal orifice, though I have not been able to trace the connexion of it with the intestine. The middle and front are hollow and capacious; the edges (the "gunwales" of the boat) are high, broad, and flat; their summits crowned with what mimic true molar teeth. In the present species, the apparatus (on each side) consists of, first, a small acute, recurved tooth, with a secondary one by its side, nearly transverse to the (supposed) jaw (fig. 7), then a low conical point, and behind this a flat black mass, like a real grinder. The verisimilitude of these points to real teeth, and the organ which carries them to a real jaw, is wonderfully exact, especially as we cannot suppose any chewing-function to exist.

The back (*apparently*, but really fore) portion of the scaphium sends off, below, two rami of the same white flesh, which are soldered to the sides of the eighth segment, near the bottom, leaving a slender aperture through which the *penis* protrudes, whose sheath is, I think, made by, or united with, these rami (fig. 6). This organ comes forth pointing upwards, but then bends to a nearly right angle, and points obliquely downwards. It is flattened, and even guttered along its upper surface, and ends in a bifid point, dilating below into a broad membranous expansion, whose sides fold together, the inferior half of the column apparently the more densely chitinous.

The segment ends below in two large, blunt, extremely polished, hollow tooth-like knobs, placed close together, the inner supports of the harpes.

Papilio Erechtheus, Donov. (Plate XXVIII. figs. 9–13.)

Valve-outline an oblique triangle with swelling sides, or a pointed semi-oval; both margins fringed, the dorsal chiefly, the fringe running to an acute point: interior surface grey, dully shining; a narrow, deep channel runs through the ventral half of the cavity, which else is shallow.

Harpe a knife-like ridge of rich brown chitine, highly polished, affixed by one edge to the bottom of the channel, and running through the length of the valve, parallel to the ventral margin. It has a narrowly dilated base, a wide triangular tooth projecting from near the middle and leaning-over dorsally, and a wide hatchet-like head, which also leans-over. From the adherent edge, on the dorsal side, springs a line of close-set bristles having a golden lustre.

When the harpe is removed from the valve, and examined by transmitted light, both the median tooth and the head appear as thin plates of clear, sienna-brown glass, each brought to a keen edge, and cut into minute saw-teeth, not perfectly uniform. Both plates show dark irregular lines of corrugation meandering like map-rivers on their surfaces.

The *uncus* (figs. 11, 12) is the beak-like produced extremity of the eighth segment, which

takes conspicuously the form of a bird's skull. Ordinarily this part is clothed densely with the common scales and hair-scales; but, when denuded of these, it is seen to be smooth (not polished), thin, pellucid, light brown, composed of a very firm and bony chitine. There is no joint between the ventricose "skull" and the slender "beak," so that the latter can move only as the whole segment moves; but its acute point (as seen in figs. 12 and 13) falls normally just between the two terminal plates of the harpes when the valves are closed. The uncus is slender, wiry, dark brown, glittering, moderately curved, its tip slightly spathulate, its rami coming to a point horizontally and vertically at some distance short of the tip.

Scaphium essentially as in *P. Mayo*; but the sides are much less bulging, the keel not pointed, and the black knobs behind the erect "teeth" are replaced by tufts of crowded brown bristles, which much resemble those usually seen in the *Ornithopteræ*, but are not, as there, limited to a linear series on each side. What in *Mayo* I compared to the gunwales of a boat, are here flat triangular expansions.

The *penis* is short, with a thin expanded orifice, shrivelled, showing no apparent structure.

Papilio Rhetenor, Westwood. (Plate XXVIII. figs. 14–16.)

Valve of an outline resembling that of the outer half of a lemon, oblique, the ventral edge by much the longer; exteriorly dull black, thinly clad with scales; hair-scales projecting in a wide and close fringe beyond the dorsal margin, augmented by a forest of slender bristles springing from the interior, so that the actual edge of the valve is here much concealed, except in oblique lights. Along the ventral margin the fringe is thin, and composed almost wholly of bristles from the cavity.

The *harpe*, viewed *in situ*, Pl. XXVIII. fig. 14, is a long tubular rod of glittering chitine, terminating in an oblique hatchet-shaped head, facing the dorsal side, and set with strong bristles below. On carefully removing it from the valve, and changing the angle of vision, we find the head to be much of the form of an American woodman's axe, fig. 15. Its edge is of semioval outline; and, under increased magnifying power, is seen to be notched with teeth of excessive minuteness and of no great regularity, of which the three combined lenses of a specially powerful pocket-glass revealed no trace.

The *uncus* is nearly bill-shaped, with slight curvature, sharp-pointed, deep-bladed, the summit crowned with close, tall, erect hair-scales; the rami stout and broad.

Scaphium large, with a deep vertically truncate *keel*, wide margins, on which stand conspicuous "double teeth," the principal one of each pair being a tall recurved spine. The white fleshy rami of the keel descend to form an investing sheath, whence the *penis* protrudes to a great length, almost horizontally, yet in a sigmoid curve, terminating in a finger-point above, and a triangular expansion with thin edges, below.

Papilio Deiphontes, Wall. (Plate XXVIII. figs. 17–19.)

Valve of the same form as in *P. Rhetenor*, *Protenor*, &c., but peculiar in having the cavity marked on both sides, towards the point, with a number of parallel ridges; both margins are broadly fringed.

The *harpe*, *in situ*, bears a close resemblance to that of *P. Polymnestor*, a slender

tubular rod, with a hatchet-shaped tip bent-over dorsally. But, separating it from the membrane of the valve (to which it adheres somewhat tenaciously), we find that the end, which stands obliquely erect from the plane of the valve, is broadly semicircular in outline, and that this outer edge is serrated with delicately formed but sufficiently strong spine-like, acute teeth (as seen in Pl. XXVIII. fig. 18.).

The *uncus* is long, slender, wiry, curved to one fourth of a circle, clothed along the median line of its summit with a ridge of erect black hairs, tall at the base and diminishing to nothing near the point; the point a small blunt spathula; the under surface a narrow keel of uniform depth.

Scaphium little developed in its white fleshy portion, but well in its horny armature; two black, shining, upcurved, stout teeth projecting from the extremity, each with a low conical knob behind it. Between these, the usual fleshy keel is represented by a narrow plate of shining brown chitine; and true keel there is none*.

The *penis*, of ordinary form and size, projects from the very bottom of the cavity, leaving a great vacant space between it and the scaphium.

Papilio Schmeltzi, Herr.-Schäff. (A. D.) (Plate XXVIII. figs. 20–22.)

Valve rather small, pointed; the narrow hair-like black clothing-scales of the exterior projecting beyond the margins slightly and raggedly. Cavity shallow.

Harpe a chitinous ridge (or thin blade set edgewise) of rufous hue, which runs through the length of the valve (Pl. XXVIII. fig. 20, right valve) in a sigmoid line, not separable from it without tearing. It does not appear to dilate into a lining plate throughout its length. The base spreads like that of a tree-trunk. At the lower curve of the ridge is projected a stout triangular tooth; and the extremity dilates into a broad axe-shaped blade, somewhat thick, as if the axe were unfamiliar with the grindstone. The dorsal side of the ridge is fringed with a line of stiff hairs.

In these observations I have several times fancied a slight difference in the armature of the two valves of the same individual †. In this example it was quite manifest; for in the *left* valve (fig. 21), the sigmoid curve was very much slighter; the lower knob was more produced, and more decidedly a tooth, bent-over dorsally; and the securiform head differently shaped, itself approaching the form of a broad tooth; both projecting towards the dorsal side at an angle of about 45° with the floor of the cavity. There is, too, a secondary ridge, very evanescent, running down from the point toward the dorsal margin of the valve; and a third ridge, which seems not connected with the harpe, running through the length of the valve, centrally.

Up to this point my observation had left the impression that the machinery seemed inefficient in this species; the rounded outline and blunt edge of the "axe-head" seemed incapable of any seizing or holding function, like that of the sharp points with which I had become familiar in these elaborate harpes. But, on submitting it to an increased magnifying power, viz. of 140 diameters, the "axe" assumed a quite different aspect. Now the edge was seen to be studded closely (see fig. 22) with minute, acute,

* But this needs reexamination.

† See the Memoir by Messrs. Scudder and Burgess, on Asymmetry in the Hesperiadæ, in Proc. Boston Soc. Nat. Hist. for April, 1870.

curved teeth, which were also distributed for some distance from the edge, on the surface of the blade. Thus a resemblance is suggested with the harpe in *Ornithoptera* of the *Priamus* group, whose crowded glittering points make, doubtless, a sufficiently effective prehensile apparatus.

The *uncus* does not differ importantly from the same organ in *P. Erechtheus*. It is deeply channelled along its upper surface; and the channel, as well as the summit-ridge of dense black scales, very long and narrow, extends almost to the spathulate point. The white fleshy conical *scaphium* with the "double tooth" on each side, is as in *P. Demoleus*.

Papilio Polymnestor, Cram. (Plate XXVII. figs. 23, 24.)

Valve long and narrow, blunt-pointed, semiovate, deeply concave; the margin sharp, not overarching in any part. The dull black scales of the exterior project ruggedly all round to a slight extent, and there is a crowd of slender hairs growing from the floor of the cavity, especially near the tip and the dorsal margin, most of which reach beyond the edge, but do not constitute a fringe.

The *harpe* is of the securiform type, yet with peculiarities of its own. The hollow between the head and the secondary tooth is here filled up, so as to form a long blade with a continuous even outline, which follows the curve of the ventral margin of the valve, and leans considerably inward. The very edge is, so to speak, bevelled off; and, at the lower end, where would be the secondary tooth in the most usual form, project from the very edge six (or seven, one being double) exceedingly minute saw-like teeth. These, as well as the whole plate, are highly polished; indeed, the glittering brightness and deep colour of these prehensile structures, generally, are most attractive features, and convey the idea of their almost metallic hardness. High magnifying power showed minute grey body-scales, still adhering to these teeth, and to the extreme point of the harpe—trophies, doubtless, of battles fought, *prælia Veneris*, in which these are effective weapons *.

Papilio Protenor, Cram. (Plate XXVIII. figs. 25, 26.)

The *valve* is of the ordinary form, margined by a broad fringe of hair-scales along the dorsal, but nearly bare on the ventral side. The latter has a flat ledge or shelf bordering the margin within, whence the cavity abruptly descends. A broad blade-like *harpe* pursues a corkscrew-like course, affixed by one edge, and running to a free point, the terminal half of the upper edge serrated with numerous, tall, close-set, curved teeth, even to the tip. Pl. XXVIII. fig. 25, shows the interior of the right valve with the harpe *in situ*; fig. 26, the harpe separated, viewed from the ventral side, and further magnified.

The abdominal armature agrees generally with that of *P. Rhetenor* and *Erechtheus*; the uncus and penis with the former specially.

* Professor Owen says (Comp. Anat. Invert. 1855, p. 397):—"The structure of the intromittent organ in the Lepidoptera is such as to preclude the repetition of the act; and they consequently live in a state of compulsory monogamy. The bifid hooks on the terminal segment of the dorsal valve of the penis, whilst they seem to retain the female, prevent the entire extraction of the virile organ."

I cannot reconcile this description with any thing I have seen in the Papilionidæ; and I strongly doubt the inference.

Papilio Ascalaphus, Boisd. (Plate XXVIII. figs. 27, 28.)

Valve having the outline of the terminal half of a lemon cut obliquely. Interior cavity very slightly fringed on the dorsal side alone, and that chiefly with hairs growing from within; umber brown with a dull satiny gloss. *Harpe* of the pattern of the *Memnon* group, near to that of *P. Deiphontes*; and, like that, serrated along the free erect edge, the form, however, differing in detail, as shown in the figures (27, *in situ* in the valve; 28, removed, viewed from the ventral side, and further magnified).

Uncus with a similar curve to that of *P. Deiphontes*, similarly clothed above, and similarly keeled; but not nearly so wiry, widening rapidly from the point. The *scaphium* is furnished with a thick white keel, whose descending rami behind—that combine to embrace the *penis*, as a sheath for its basal portion—are so short that this latter organ protrudes obliquely upward, its extremity appearing almost close beneath the scaphium-keel*. The "double tooth" is very small, but distinct, erect, and curved back.

I have not yet found any two species so closely assimilated in the details of the prehensile apparatus as *Deiphontes* and *Ascalaphus*; yet the differences here, if mostly minute, are quite distinct. The radiating ridges of the valve, the marginal fringes, the axe-head of the harpe, the scaphial keel, the scaphial double teeth, and the position and direction of the penis, all present marked diversities of form and detail.

I subsequently examined another specimen of *Ascalaphus*. It agreed with this one in the minutest details, except that the tiny half-separated lobe at the point of the harpe I could not find. This was, therefore, in all probability, accidental.

Papilio Helenus, Linn. (Plate XXIX. figs. 1–3.)

We have in the *valve* of this species almost the very counterpart of *Ascalaphus*. The *harpe*, *in situ*, looks different, indeed, because the extremity is not bent-over quite so much, and the line of direction is more incurved in the middle. But, when it is viewed separately, and from the side, it takes almost precisely the same form, broadly crescentic; and its edge is, in like manner, serrated with excessively minute spines.

So the abdominal apparatus is of the same type. The *uncus*, circularly curved, is ridged above with stiff hair. The *scaphium* is almost exactly on the pattern of *P. Demoleus*; but the double tooth more developed, high, slender, acute, incurved. Finally, the *penis* has its more chitinous side uppermost, is dilated at the point, and is of considerable thickness and length.

Papilio Nephelus, Boisd., differs in nothing of importance. The *harpe* runs very close to the ventral margin, but its form is exactly that of *P. Ascalaphus*. *Scaphium* large, and its double teeth almost exactly as in *P. Helenus*.

Papilio Chaon, Westw., scarcely differs, but the *harpe* is not quite so close to the ventral margin.

* Subsequent observations lead me to doubt whether the *direction* of this organ is a character of specific value—whether it is not one of the conditions which vary at different times, even in the same individual.

Papilio Menestheus, Drury. (Plate XXIX. figs. 4–6.)

Valve-outline a long, narrow, pointed arch, swelling on the dorsal, excavated on the ventral side; fringed with black bristly hairs around the point, which grow from within the margin, and disguise its form; the ventral margin, from the excavation downward, fringed with close-set long white hair-scales, connected with the clothing of the exterior.

The *harpe*, a slender curved rod of polished black chitine, running up close to the ventral margin, and following its outline; it sends off a strong, acute, conical spine about the middle, which is free, pointing to the dorsal base; in its terminal half, it expands into an ovate blade, convex ventrally, concave dorsally, standing on one edge, and having the free edge, as well as the spine, minutely serrate. Pl. XXIX. fig. 4 represents the right valve, with the harpe *in situ*; fig. 5, the harpe dissevered from the valve, viewed on the stage of the microscope as a transparent object. It is now wholly of a rich sienna-brown; the edge cut into curved spinous teeth, far more minute and far more numerous than I have been able to figure. The side, moreover, is marked with a multitude of fine slanting lines crowded together, which, by delicate manipulation of the magnifying power, resolve themselves into so many linear series of very minute pits on the surface, the edge of every one reflecting a semicircle of light.

The abdominal apparatus has much in common with that in *P. Deiphontes*, &c.; and the valvular armature may be resolved into the same type (fig. 6).

Papilio Pammon, Linn. (Plate XXIX. figs. 7–9.)

The *valve* and the *harpe* belong to that general type which we see in the *Memnon* group, the former presenting little notable, the latter coming near to the forms in *Deiphontes* and *Ascalaphus*, especially when it is detached from the valve, as at Pl. XXIX. fig. 8; for, strange as it may seem, the outline of the harpe, when detached, is not always the same as when it was *in situ*. In this case, the disk, which takes a hatchet-form, occupies a much greater area of the valve (fig. 7) than in the species named; it is, as in them, of polished, pellucid, brown chitine, the edge serrated, rather unevenly, the whole stem (the haft) and a broad area at the back of the blade (shown at fig. 8) having been in contact with the floor of the valve, while the blade itself stood up free.

The *uncus* is slender, curved almost to a semicircle, with a small spathulate tip, a moderate vertical divaricate beam below, notched on each ramus, and the ridge crowned with erect hairs (fig. 9), which do not diminish in height to the tip, but end abruptly.

The *scaphium* is well developed, nearly free from lateral folds; the "double teeth" prominent, the principal one of the pair projecting obliquely towards the tip of the uncus: the fleshy keel thin, short, but very deep, ending in a minute point. The *penis* is long, moderately thick, truncate, scarcely expanded.

At the bottom of the abdominal area (fig. 9) is shown the nearer of the pair of prominent angular knobs, to which had been attached the triangular base of the harpe-shaft, and that of the right valve.

Papilio Agavus, Drury. (Plate XXIX. figs. 10–13.)

From a certain resemblance in the form and colours of this South-American butterfly to the Indian *P. Hector*—near which it is placed, in efforts made by entomologists to

arrange this vast genus in naturally allied groups—I expected to have here another example of abnormality, such as we see in the *Polydorus* group. But, except that the uncus is abruptly bent perpendicularly downwards, as it is in *P. Hector*, the organs are of the usual type, though peculiar in detail.

The *valve* is small, semioval, the outline slightly bulging dorsally and fringed only with a few very minute hairs. The interior is almost level for a wide space within the ventral margin, then abruptly descends with a deep cavity, which extends close to the dorsal margin; internal surface cloth-like, nearly black. Within this cavity lies a great semicrescentic *harpe* of shining chitine, its lower half divided off into a kind of stem, the whole somewhat like a butcher's cleaver with its handle, and all springing from a dilated base by which it is affixed to the proper knob, within the bottom of the 8th segment, apparently distinct from, though in close proximity to, the conjunction of the valve itself with the segment. By removing the harpe, which is very readily separated, we see clearly (what is, indeed, discerned by the aid of a pocket-lens, even *in situ*) that the straight side, or what answers to the cutting-edge of the cleaver, is serrated with sharp teeth, somewhat irregular both in size and arrangement*.

The abdominal organs (fig. 13) are remarkable for the abrupt deflection of the *uncus* (perhaps accidental), the extreme minuteness of the *scaphium*, and the great development of the *penis*, which is reversed.

Papilio Machaon, Linn. (Plate XXIX. figs. 14–16.)

In our own familiar Swallow-tail the *valve* is of the ordinary subtrigonate outline, with a rounded point. Externally it is clad with a close dense coat of pale-yellow scales, which do not project beyond either margin; there are, however, black hairs, growing from the interior, more than usually stout, long, and close, along the dorsal side, and forming a produced point. These crowded hairs, the whole cavity being of a sooty brown hue, effectually conceal the marginal line on that side.

A low pale ridge runs through the valve along its central line, which does not seem connected with the *harpe*. Just within the ventral margin, following its line from base to tip, runs a plate of glittering black chitine, fixed to the floor by one edge, while the other is free, and leans over towards the dorsal side. At mid-length its height abruptly increases; and thence to the point it is a keen knife-blade, only cut into minute sharp teeth, about a score in number, exactly like a saw. This harpe is of chitine so dense as to appear quite black, but transmitting a rich translucent golden-brown hue when viewed against the light, except a slender line just below the teeth, which is considerably paler, as if there were a band of less density just there, or possibly a groove, though it is not a place at which one would expect the structure to be weakened.

The shining chitinous material is spread widely over the valve-cavity as an exceedingly

* As a rule, I content myself with delineating one of the valves. But of *P. Agavus* I have given the left as well as the right. In the course of examination this left valve came away, leaving the harpe still attached to the segment. When I detached this, in turn, I observed what appeared an accessory piece behind the blade, and following a similar curve: this I delineated as I saw it, without understanding it (see fig. 12.) Replacing the harpe in the valve, I drew it, as I supposed, *in situ*, as at fig. 11; but, afterwards, having detached the right valve and its harpe entire, I saw nothing of this additional piece; I therefore conclude that it is a piece torn off accidentally from the back of the harpe.

attenuated plate. It adheres so tenaciously, that I did not succeed in separating it from the lining-membrane without much laceration.

Another example agreed minutely with this description. The only differences that I could detect were, that the valve was slightly narrower, and more acutely pointed, the outline being a nearly perfect isosceles triangle. The harpe extended to the very point of the valve; yet along its edge I could count only fourteen teeth.

The abdominal armature, in general, agrees with such examples as *P. Mayo*. The *uncus* (in the specimen figured) was long, narrow, the margins much elevated, displaying a deep keel, and was so strongly downcurved that the small, polished, spathulate tip was bent considerably within the perpendicular *. Its upper surface is partially concealed under a dense thatch of long arching hair, mingled black and yellow, which, springing from its basal part, projects far beyond its downward curve †.

The *scaphium* is of moderate dimensions, and of normal form, with a rather small keel. The lateral expansions, "gunwales," are wide, and are furnished with "double teeth," the principal of each pair being sufficiently conspicuous, projecting almost horizontally. There is a strong projecting point from each lateral edge of the *tegumen*.

The *penis* is moderately large, trumpet-mouthed, the expanded lips notched (corrugated?) along the edges, and surmounted by a short finger-point. Its protrusion from the abdomen is high, even so as sometimes to press the under side of the scaphium.

Fig. 16, the abdominal organs viewed from the right side with the right valve removed; the left *in situ*, shown in outline.

Papilio Arcturus, Westw. (A. D.) (Plate XXIX. figs. 17–19).

Valve-outline that of a Gothic arch, with the point rounded and the dorsal side a little hollowed; a wide fringe of coarse brown hair-scales along the dorsal margin. The cavity-floor has an abrupt depression along its middle, broad at the base, and tapering to the point.

Harpe a slender wire bounding this depression ventrally, rising at about two thirds of its length into a rather broad blade, the edge of which leans-over dorsally. More highly magnified, it is seen to be somewhat semiovate in outline, curved at the tip into a strong hook, and beset, along its free edge, with a number (about forty-five) of minute close-set, sharp saw-teeth, the intervals between which run down in grooves upon the blade; in other words, the teeth are the extremities of ridges. The whole harpe can be separated from the valve only by tearing the adjacent portions of the lining-membrane, to which it appears to adhere organically, for almost its whole length. Some examples have the blade less irregular in form.

The abdominal organs are almost the counterpart of those in *P. Mayo*. The *uncus* presents nothing worthy of remark. The *scaphium* is scarcely distinguishable from

* But examples differ in this respect, the uncus being, in some, nearly horizontal at first, and abruptly and strongly curving toward the tip.

† The organ is perhaps unusually subject to malformation; for, in one example, its form and curve were quite asymmetrical, and it was accompanied by a supernumerary tooth, much like itself, but shorter, on its left side. Yet another example had a shapeless knob projecting from the right side of the tegumen.

what I have described and figured under that species, save that:—1. its keel has no minute point, but ends with a deep round thin edge; 2. the double tooth, instead of being followed by a flat black knob, has, in place of it, a second minute conical point, and clusters of bristles.

On my lifting the uncus till I broke it from the tegumen, I could see, by means of a lens, a distinct orifice. I studied it carefully, and am sure it was not a rent, but a true organic orifice, tubular, central in position, under the tegumen, with minute protrusile lips, which merged into the sides of the scaphial groove. This surely was the anus.

The keel, or "cutwater," runs off, as I have just said, to an extremely thin vertical plate. This I suspect to be the seat of some special function; for the terminal portion, for a considerable width from the edge, well-defined, has a peculiar surface, finely granular, almost pilose, whereas the other parts of the surface are shining, white, smooth, though plicate.

I am again struck with the wonderfully close resemblance which the scaphium and the uncus together bear to a bird's skull and beak, with a mammalian lower jaw.

The *penis* is of moderate size, pointing obliquely upward, with expanded lip, thin, transparent, corrugated. It proceeds from the midst of a white fleshy veil*, which occupies the entire back of the genital cavity, formed by the dilated rami of the scaphium†.

Papilio Merope, Cram. (A. D. *partim.*) (Plate XXIX. figs. 20–23.)

Valve subtrigonal, more or less regular; furnished with a fringe of thick, close, and fine hair-scales, of pale buff hue, which widens uniformly along each margin from base to point. Internal cavity dark brown, smooth but not polished, and beset with a few fine hairs.

Harpe a thin and very narrow lamina running through the whole length, near the ventral margin, and subparallel to it, affixed by its inferior edge, and leaning-over towards the dorsal side. It terminates sometimes in a fine-drawn point, which even extends beyond the limits of the valve, as far as the point of the fringe. At other times the blade is rounded at the end, and of equal width throughout from its abrupt expansion a little way above its base. The terminal third is free, and springs up at an acute angle from the lining-membrane. The whole blade is serrated with minute teeth, more than fifty in all, pointing backward. From the point where the stem dilates to form the blade, a curious finger-like process is given out, which goes nearly across the valve dorsally; it is straight, cylindrical, obtuse, and unarmed.

The *uncus* makes a curve of about a quadrant of a circle, ending in a very sharp spa-

* Equivalent to the "curtain" of the Supplementary Note to *Ornithoptera Remus*, p. 336, *infrà*.

† By a subsequent observation of *P. Arcturus*, made under unusual advantages of sun-light, I am able to supplement the above description, but unfortunately not in time to add some figures to Plate XXIX. The scaphium has little resemblance to that of *P. Machaon* or *Zolicaon*. It is a perfect boat in form, of what a sailor would call beautiful "lines;" apparently quite empty, save for the two great round-bottomed teeth, one on each side, which take the exact form of the boat-curve. The "cutwater" runs off in front straight and clean, its front edge sloping away downwards; though it is thin, it is immediately behind abruptly hollowed to a yet thinner lamina. The "gunwales" of the boat expand amidship, much like those of a paddle-wheel steamer (when viewed vertically from above), and then descend to unite with the wall of the abdominal cavity. The great scaphial teeth are stout upcurved spines, studded sparsely with minute hairs, while ridges behind and between them bear long, stout, erect bristles.

thulate point, and a deep angular keel. Its summit is crowned with an erect ridge of stiff hair, pointing slightly forward (fig. 23).

The *scaphium* is more than ordinarily developed, and it presents some peculiarities so suggestive that I bestowed upon it more than usual attention. The mass of flesh, of conspicuous whiteness, and glistening at all its prominences, occupies almost one third of the volume of the visible cavity. The keel is deep and ample, though thin; it is much excavated, the surfaces full of irregular hollows, with slender threads, and isthmuses of white connecting flesh stretching across; the hollows are more or less tinged with black, and of a minutely granular surface.

The "double teeth" attain here a development to which I have observed no parallel*. They are seated in the usual place, on the summit of a great rounded mass of polished flesh, which swells out on each side (fig. 22) from beneath the base of the tegumen, gradually becoming of a deeper and deeper hue, apparently more and more chitinous, until the colour merges into the glistening black of the teeth. Of these the principal —which one can scarcely help calling the anterior (though it is strictly the posterior), being next to the point of the uncus—is a broad, curved, acute *spoon*, cut on both its edges, and also *on its bowl*, with stout *serræ*. The other tooth, equally tall, but slenderer, curved in the same direction, viz. toward the base, is similarly serrated on several lines. The whole space between the two teeth is a continuation of the spoon-bowl, and is everywhere studded with sharp points. It is strange that most, if not all, of the serrations are surmounted each by a stiff golden bristle, which seems likely to interfere with their effectiveness †; but the number of pale-yellow body-scales clinging to all parts of these notched teeth show that they have done duty as prehensors. Certainly, viewed in sunlight under the compound microscope, they are formidable weapons to look at.

At its very base, where it springs from under the deep keel of the uncus, the scaphium forms a globose knob, skull-shaped, which is shining brown. But for this, and the tooth-knob, and the cavities of the keel, the whole scaphium is brilliantly white, reflecting the sunlight like the albumen of a boiled egg. The lower portions, both of cheeks and keel, run obliquely downward and abdomenward in strong longitudinal folds.

I know of no species in which the scaphium can be so effectively studied as this. Yet I am compelled to confess an humbling uncertainty of its function. I carefully dissected away the surrounding parts, and found this white organ to be firmly connected with the chitinous base of the uncus (that is, with the eighth segment), and, apparently, with a tube proceeding from the mass of convoluted yellow tubes which lie immediately behind, which I suppose to be the biliary vessels of the colon. The orifice, however, is, so far as I am able to judge, not at the extremity of this organ, as described by Herold (if this indeed is his *Triangelstück*, as I presume), but in the middle of the upper part of its very basis, where it is united with the uncus. Projecting thus between the uncus and the penis, we might call the scaphium a process from the perinæum.

* But see *P. Demoleus*, p. 313, *infrà*.

† These great spoon-teeth are thus clearly identified with the aristate cheeks in *O. Remus*, &c.

Whatever its office, I infer it to be, in part at least, muscular, from its so often carrying those remarkable weapons which I have called "double teeth." For, based on yielding and non-contractile tissue, they would be ineffective and useless; whereas their firm chitinous substance, their depth of colour, and their high polish, indicating hardness, and, as just described, their notched edges and acute points, all indicate vigorous and definite action, dependent on strong muscular contraction.

Nevertheless, I am bound to confess, the position of these weapons and their direction just under the uncus do not seem the most favourable for the only function which we can attribute to them, viz. copulative prehension.

The *penis* is a straight, nearly horizontal column of brown clear chitinous substance, moderately thick, not sensibly expanding, as usual, but rather diminishing to the extremity, and ending in a finger-like point and irregularly lobed lips. I carefully removed the walls of the abdominal segments, till I exposed the root of the cylindrical penis in a mass of muscular tissue, just at the insertion of the sixth segment.

Papilio Brutus, Fabr. (Plate XXIX. figs. 24, 25.)

The details that I have just been giving were from specimens labelled as having been taken at Calabar, in West Africa; and they agreed in markings, almost exactly, on both surfaces, with the *Merope* of Cramer's plate 378. D, E. But I have examples of a style of colouring that differs much from any that I have seen figured or described by authors. These two males, ticketed *P. Brutus*, I purchased from a small collection made at Ellongo, in Madagascar, are distinguished by having the black spot at the anal angle of the hind wing above *very small*, and the whole of the hind wing below, of a warm yellow-brown hue, with an undefined light dash across the middle, and scarcely any trace of the dark lines so conspicuous in the ordinary forms.

Now, in these Madagascar examples, the *harpe* takes a form very different from that in the continental *P. Merope*. The *valve* has much in common; and so has the harpe, *in its plan*; but the serrated portion, which is marked off by abrupt dilatation, is reduced to a small ovate blade at the very termination; and the projecting arm is placed close beneath it, is swollen in the middle, sinuately curved, and tapered to an acute point. The staff is very long and slender, cylindrical, pale, shining, bending from the base to the dorsal corner, sunken in a deep abrupt depression of the valve-cavity. The head or blade is free, a thin oval plate of polished black chitine, brought to an edge all round, and cut into strong saw-teeth, which are divided by grooves that run up into the area of the blade. Just at the point where it adheres to the lining-membrane, there is an angular expansion of the staff which sends off, nearly at a right angle, the polished taper arm, in quite a different plane from that of the blade; this is not serrated.

This long sharp spine, and its fellow, stretch away on either side of the uncus, when the valves are closed, and are doubtless effective prehensors; whereas the short, blunt arms, in *Merope*, placed so low down in the valves, one cannot well suppose to be of any prehensile power. On the other hand, in *Merope*, the extent of serrated blade is greatly superior.

The abdominal organs are the same, essentially, in both. For though, in one speci-

men, the *uncus* was aborted, leaving only a slight irregularly pointed projection from the *tegumen*, and in each the fleshy portions of the *scaphium* were partly gone, yet in one case the uncus was perfect; and in each one pair of the "double teeth" was left, and in one case, one of the other pair; allowing to me to see that their form and armature were exactly as I have described in *Merope*. In one example the entire soft parts of the scaphium were lacking (perhaps eaten by *Psoci*), leaving the central mass that supported the serrate teeth *merely as a thin transparent shell of horny chitine*.

I remarked that the abdominal cavity, in all the specimens that I examined, of both the forms, and all the included organs, even to the fringe of the valves, were much clogged with meconium and adhering body-scales, received, of course, from females.

Papilio Homerus, Fabr. (Plate XXX. figs. 1–4.)

The grand *P. Homerus* of Jamaica has a prehensile armature of much simplicity, but quite unlike that of any other known to me. The *valve* is somewhat long, with a rounded point bent-over towards the ventral side. It is dull, dark brown, clad with small scales interspersed with hairs, externally; internally it is simply hollowed, the scales scarcely protruding beyond the margin; but a crowd of very fine hairs spring from some distance within the margin, on both sides, and extend considerably beyond it.

The *harpe* consists of a simple rod of brown chitine, hollow throughout, very slender at the base, widening abruptly in the middle into a flattened blade, which terminates in two nearly straight points, of which the dorsal rises above the margin of the valve, and the ventral dives into the hollow. The chitine is darker and, I presume, denser in the vicinity of these points than elsewhere. The whole blade is sparsely beset with long slender bristles. The harpe runs in nearly a straight line along the middle of the valve, through its entire length; but adheres only by the slender portion.

The *uncus* is long and stout, but has only a moderate downward curvature, very regular and graceful, however; the keel, produced by the united *rami* or vertical supports of the sides, is deep. Viewed laterally, the uncus ends in a very sharp point; viewed posteriorly, it is a narrow, tapering spathula.

The *scaphium* is broadly boat-shaped, with little depth, and nothing that can distinctly be called a keel; the "double tooth" on each side is remarkably stout and strong, consisting of two conical cusps of shining brown chitine, united on a single basis, seated on an ovate expanse, or dilated lip. These are angular-sided; and the interior edge, especially of the hinder cusp, is beset with numerous short bristles, from which the extreme points are free. A supernumerary spinous tooth, polished, slender, acute, erect, rises from a knob situate centrally in the midst of the scaphial furrow, close to the extremity.

The *penis* is rather small and short, little protruded from the abdomen, chitinous brown, turgid at the extremity, hiant, not expanded, with no finger-point.

Papilio Ulysses, Linn. (A. D.) (Plate XXX. figs. 5–8.)

Valve of more than ordinary dimensions; outline a long semioval, blunt-pointed, with a considerable sinuation on the dorsal side of the point. The black, coarse hair-scales of the exterior project notably along the dorsal margin, and around the tip,

where they are longest; then suddenly cease, giving place to a series of very fine shinin hairs, which spring from the cavity, within the ventral margin, and reach beyond it. The whole valve-floor, which is of a bright brown hue and has a velvety texture, is more or less studded with gilded hairs.

The *harpe* is a slender rod, black and polished throughout, affixed to the lining-membrane, parallel with the ventral margin nearly to the valve-tip; then it makes a sudden bend, and projects as a curved acute spine-like point as far as the ends of the dorsal margin-scales. From the bend onward the rod becomes free, springing from the cavity-floor, but proceeding laterally, nearly in its plane, the taper point describing a full semicircle, curving at last quite upward. It is a simple polished wire, densely set along its inner side with long shining hairs, but quite void of serration in every part.

The abdominal organs present some peculiarities of form. The *uncus* is unusually broad and short, taking the shape of a very wide but pointed spoon-bowl, clothed almost to its termination with coarse, brown body-scales, among which individual blue scales gleam like tiny sapphires.

The *scaphium* is of moderate size, its most conspicuous feature being the lateral teeth. The ridge, or cheek, on each side carries a stout and strong spine of polished black chitine, which projects horizontally forward at first, and then bends up at the point, the secondary tooth being represented by a low conical knob at the base. The whole tooth is beset with long bristles, especially about the middle; but immediately in the vicinity of the point these are very few and minute. High magnifying power shows (fig. 8) that, as in *P. Merope*, the scaphial teeth are themselves toothed; but here the notching is shallow, and the minute bristles, instead of being seated on the summits of the toothlets, are sunk in the insterstitial angles.

The *penis* is moderately large and protrusile, bending upward and outward its column of brown translucent chitine, and terminating in a dilated, but not expanding, orifice.

Papilio Phorcas, Cram. (Plate XXX. fig. 9.)

Valve small, but comparatively long and narrow, and slightly fringed.

Harpe of the very simplest form, a mere narrow rod-like elevation of the chitine, running, in a slightly bent line, throughout the length of the valve, and terminating in a fine smooth point, which protrudes even a little beyond the fringing hair-scales. The whole rod is of polished dark brown chitine. (Pl. XXX. fig. 9.)

Uncus well developed, long, slender, curved into a nearly complete semicircle. The adjacent parts present nothing calling for special notice.

Here is a very close ally of *P. Nireus*, a West-African species (the specimen labelled as captured at Accra), yet widely differing from both it and its nearer compatriot *P. Bromius*, in the form of the genital armature. It approaches the Oriental *P. Ulysses* and *P. Arcturus* in the form of the harpe, but exceeds both in simplicity.

Papilio Thoas, Linn. (Plate XXX. figs. 10, 11.)

In this noble American butterfly, so abundantly found from Virginia to La Plata, we have a new type of valval armature. The outline of the *valve* is rotundo-triangular,

moderately regular, the ventral side the longer, the whole margin broadly and pretty evenly fringed.

The *harpe* consists of a very thin crystalline plate of chitine, which sits close upon the central cavity of the valve. It is thickened on each side into two slender ridges, black, polished, wire-like, which, springing from a wide basis, proceed in curving lines, and meet in an acute point a little on the dorsal side of the extremity of the valve. The extreme point separates from the lining-membrane, and projects at a very acute angle, firm and hard, like the point of a needle. Under a high power the ventral side of the point is seen to be notched into half a dozen minute saw-teeth: the whole triangular hollow plate may be, with care, lifted uninjured from the valve; it is then of a glassy transparency and polish, slightly tinged with brown, like glass very slightly smoked; very slender veins issue from various points of the deep-black thickened marginal walls, and ramify over the clear surface.

The abdominal armature of the first specimen I examined, seemed to be peculiar. A deep, but short, *uncus* was seen descending perpendicularly and abruptly from the tegumen, with almost no curvature at all, the upper surface hollow, from the turning-up of the lateral edges, the tip slightly spathulate.

The *scaphium* was with difficulty recognizable, wide, shallow, and so short as scarcely to reach the vertical uncus.

But a second example proved that this condition of the organs was a case of accidental distortion, not very rare. The uncus now was normal in length and curvature, wide, with a small spathulate point, followed almost immediately, in full depth, by a deep and strong radial keel. (Pl. XXX. fig. 11.)

The scaphium is on the same pattern as in *P. Mayo*, still more closely like that of *P. Helenus*, both the lateral teeth being very stout, long, acute, dark, and polished. The hinder tooth is rather a high conical incurved point on the thin shelly edge of the cheek, whose summit bears a crest of small erect aristæ. The edges are simple, not serrate. Viewed from above, the cheeks take a subglobular, inflated form, and both the teeth of the right side slope-over towards the median line of the uncus. The keel of the scaphium is large but shallow, polished ivory-white, strongly defined in colour from the cheeks. Its form is very boat-like, projecting its point horizontally; the extreme point is minutely complicate in surface, and diverse in colour and appearance from the contiguous parts.

The *penis* presents little noteworthy; it is of moderate dimensions, a tube apparently subcylindrical, but slightly enlarging to the tip, which ends in a lengthened curved acute finger-point.

Papilio Turnus, Linn. (Plate XXX. figs. 12–15.)

Valve very regular in form, of the outline of a Gothic arch, the dorsal margin concealed under long shaggy black hair, springing from within, and projecting far beyond, the edge; the ventral margin is also hairy, but less conspicuously. A flat shelf runs all round, broadest at the extremity, within which the cavity abruptly deepens.

Harpe of the *Thoas* pattern, consisting apparently of a dark shining wire, running up on each side, and meeting in an arch towards the tip. In reality, these are but the thickened edges of a continuous plate of chitine, of extreme delicacy and glassy trans-

parency, which occupies the central area of the valve. Each wiry edge is armed with a prehensor; the ventral edge, a little beyond its middle, bears a long acute spine, which stands up from it, and curves obliquely forwards; the dorsal, a thicker cone, more erect on its base, which first sends off a nearly straight horizontal spine obliquely forwards, and then terminates in a shorter and blunter point.

The *uncus* arches in a regular semicircular curve to a small spathulate point; a deep keel beneath the receding rami; between which issues the moderately large *scaphium*, well keeled, the only peculiarity noticed being that the extremity of the keel, by its deepening hue, appears to become more chitinous, until it ends in a minute horny point. The double teeth are minute, but distinct, conical points.

The *penis* is small and high-situate.

Papilio Polycaon, Cram. (Plate XXX. figs. 16–19.)

Valve-outline subrhomboidal, with rounded angles, thickly fringed on the dorsal (short) side, but thinly on other parts.

Harpe a broad, concave plate of thin, clear, shining chitine, beset with fine, short bristles, pointing outward, as is also the lining-membrane where it is exposed. The ventral edge of this plate is a slender nearly straight rod, polished, black, with a fine-drawn acute point, free for some distance. The upper edge of the thin plate usually springs from the spine a short distance down, and rises into a wide curve; sometimes it follows the spine up to its point, and descends at an acute angle; but presently, on what I may call its dorsal corner, it gives rise to a curious appendage, which usually takes the form of a thick, short, solid column of black chitine, set, all round its summit, with stiff tooth-like spines (fig. 18); but sometimes appears as a smaller knob, with a slender base, whence rise three diverging laminæ, united by their inner, and serrate on their outer edges (fig. 17). In either form, the spines are of a clear, glassy, blue-black substance, and most of them are double, *i. e.* each has two points from the same base. The spinous rod of the ventral edge bears a triangular thin elevation (and sometimes a secondary one) near the base.

The *uncus* is long, slender, evenly curved, acute; the keel of its united vertical rami deep, and diminishing in depth gradually to the tip.

The *scaphium* is very ample in all its constituent parts; the cheeks rise into high arching crests, with notched, aristate edges, but destitute of double teeth, so far as I can discern; the sides run down on either hand in great oblique folds; the keel is pointed, large, and deep; all the parts are shining white. The *penis* presented no features worthy of special notice, other than can be observed in the figures.

In my cabinet are examples of six very diverse kinds of butterflies, all large, imposing, and richly coloured, labelled thus:—*Androgeos*, Cram., ♂ and ♀, from Brazil; *Thersites*, Fabr., ♂ and ♀, from Jamaica; *Polycaon*, Cram., ♂, and *Lycophron*, Hübn., ♀, from Corrientes, in the Argentine Republic *.

* These may be readily distinguished thus:—Males: 1, hind wings with no yellow lunules=*Androgeos*; 2, with shallow yellow lunules=*Thersites*; 3, with deep yellow lunules=*Polycaon*. Females: 1, fore wings with a broad straight yellow bar across=*Androgeos*; 2, with a narrow curved yellow band across=*Thersites*; 3, no yellow band across=*Lycophron*, i. e. *Polycaon* ♀. I describe from my own specimens, which differ from Cramer's figures. But what I call *Polycaon* may possibly be the *Ocbalus* of Boisduval (Sp. Gén. p. 360), with whose description they fairly agree, except that I see no trace of the "red-brown lunules" that he assigns to the hind wings above.

Now the genital armature, in these widely severed forms, is essentially the same. Of that from Jamaica, and that from Corrientes, I have received a considerable number of examples, taken at different times by my own friends; so that I am sure of the habitats. The Jamaican specimens have the isolate knob of the harpe three-sided or concave, the main spine slightly curved, and with but one baseward elevation. The *Androgeos* from Brazil, and several *Polycaons* from Corrientes, show absolutely no difference *inter se*. The characters are constant, so far as my experience goes.

The precision with which this very peculiar harpe is repeated in these widely spread varieties is something noteworthy. It suggests the notion that, in this organ, we have a specific character of much value. *Androgeos*, *Thersites*, *Polycaon*, and *Lycophron*, are assuredly but a single species.

Papilio Axion, Boisd. (A. D.) (Plate XXX. fig. 20.)

The armature of this noble butterfly is remarkable. The *valve* is almost as large as that of an *Ornithoptera*, and of similar shape, viz. semioval, or of the outline of a half lemon cut obliquely, the dorsal side by far the shorter, as usual. Exteriorly, the valve is clad with dull white scales, which become black at the dorsal edge, and these project pretty evenly beyond the margins. Interiorly, it is umber-brown, with a dull gloss.

From one specimen, on removing a valve for examination, the whole cavity was found quite full of a light brown dust, composed of amorphous fragments (of *meconium*, surely), together with a considerable number of fine hair-like scales, such as are proper to the hinder regions, gathered, I doubt not, from the body of the female during an act of coition.

The *harpe* belongs to the pattern of *Thoas* and *Turnus*. It is an ample plate of thin glassy chitine, which closely lines the greater part of the entire cavity; yet can be easily separated from it, in its integrity, when it is a curious and attractive object. It is a broad hollow plate, of exquisite delicacy and tenuity, translucent, slightly tinged with horn-yellow, the extreme edge, all round, thickened and deepened in colour, polished, and furnished at two points with two long, taper, curved, acute spines, much resembling the prickles of a rose in form, colour, and polish. Both are on the ventral margin, the one just below the apex of the valve being the proper prehensor, laterally opposable, conjoined with its fellow in the other valve, to the uncus. Besides these spines, there are several minuter ones on the dorsal edge, the chitine rising here into a thin wall, which is cut into teeth, three or four, the number and arrangement being not quite the same in two individuals that I examined. The form of the whole harpe varies also; for while, in the specimen figured, which was the first I examined, the apical arch was somewhat flattened (as represented), in a subsequent example the outline was much more graceful, more nearly corresponding to that of the valve, and so more closely resembled the form in *Thoas* and *Turnus*.

The *penis* appears to be small, short, and curved into a semicircle; but it was so closely enveloped in its ligaments, that I could not very satisfactorily examine it.

The *uncus* with its concomitant parts presented nothing specially notable.

Papilio Hesperus, Westw. (Plate XXX. figs. 21–24.)

Valve of the outline of a Gothic arch obliquely cut off at base, wholly surrounded by a dense and wide fringe of grey-brown hair-scales, densest and widest at and around the tip. Interior surrounded by a wide flat shelf, within which the cavity abruptly descends, and is deep.

The *harpe* occupies the whole of this deep area, and fits it accurately with a chitinous hollow plate of extreme delicacy and transparency, thickening and darkening all round into a narrow edge, which stands up free, like a little wall, the summit rising into rounded eminences here and there (Pl. XXX. fig. 21). The structure could not be detached in integrity; the ventral portion of the circuit is represented at fig. 22, viewed from the ventral side. It is now seen that the free edge is cut into saw-teeth, and these by no means simple, but elaborately compound, each tooth, at least for a considerable portion of the edge, being itself cut into three, or even four toothlets, and each of these compound teeth being the termination of a rounded curved ridge on the outer surface of the wall. I have found no structure elsewhere quite analogous to this. Fig. 23 represents some of the teeth on a more enlarged scale.

The abdominal apparatus is of the ordinary type; the *uncus* is moderately long, inclining downwards, nearly straight, crowned with a ridge of stiff erect hairs, deeply keeled. *Scaphium* moderate, double teeth strongly developed, erect, incurved, acute. *Penis* doubly curved, finger-pointed, moderately thick, and so long as to project horizontally between the valves when these are closed.

Papilio Demoleus, Linn. (Plate XXX. figs. 25–27.)

Valve-outline an oblique semiovoid; exteriorly clad with a coat of drab-white, short scales, which project in a very slight fringe just around the extremity. Interiorly the surface smooth, but not shining; the cavity rather narrow, running to a point, bounded by a broad flat shelf on each side, of which the dorsal extends only half down, the ventral the whole length.

Harpe a broad thin plate of yellow transparent chitine, not very concave, reaching to within two thirds of the valve's length; its ventral edge an elevated ridge, apparently tubular, with an expanded base; the ridge, like a clear glass tube, is marked, at short intervals, by ten or twelve distinct black transverse lines, suggesting joints, or rings of metal binding a pipe for increased strength. Close to, but not quite at, the extremity of this ridge, which diminishes to a thin scalpel-like edge, there is a single minute black tooth projecting obliquely towards the dorsal side, the upper edge of which, in the specimen examined, showed a few minute notches, possibly accidental. The area of the harpe is corrugated into fine ramifying wrinkles, and studded with very minute circular areolæ (pits ?), from each of which springs a hair, varying in fineness. The lining-membrane of the valve is similarly studded, the areolæ and hairs specially crowded toward the point. The fringing hairs (hair-scales) are in the same plane as the valve-surface; these perpendicular to it. Besides these hairs, there lie, about the area of the harpe, many body-scales, of varying forms, which, derived doubtless from the other sex, usefully illustrate the function of this organ.

The abdominal apparatus is normal, and well developed. The *uncus* is moderately long, well curved, slender to the tegumen, terminating in a minute spathula; the keel, reaching to the point, is moderately deep, the edges not upturned.

Scaphium of the pattern seen in *P. Merope*. Its keel is more produced, and of less irregular surface. Its "double teeth" are not quite so much developed, particularly the secondary one of each pair, which is little more than a conic knob, both, however, set with prominences and bristles as in that species, though in a less degree.

Penis of moderate length and thickness, increasing to the extremity, which is truncate, hiant, without lateral expansions.

Papilio Bathycles, Zink. (Plate XXXI. figs. 1–5.)

Here are very abnormal structures.

The *valve* is small, short, almost semicircular, widely fringed with dense white hair-scales. The *harpe* is a broad segment of a sphere, of glassy chitine, thickened at the two margins, and rising at the summit into two divaricating branches, each of which, the dorsal especially, is studded with short stiff blunt teeth; on the dorsal edge, near the base, there is also a conical process. Parts of the surface are beset with fine scattered bristles.

There is no *uncus* proper. The regions are sheltered by a dense horizontal thatch of long white hair-scales. When these are removed (by the persevering friction of a camel's-hair pencil cut short), we get an instructive sight of the organs. The median line of the eighth segment projects into a very shallow point, from under which a well-formed white *scaphium* is moderately developed. At fig. 3 is shown the transverse terminal line of the eighth segment, and a vertical view of the scaphium; the lip-like lateral edges bear no trace of the ordinary "double teeth." At fig. 4 is given a lateral view of the organs. The vertical dotted line shows where the lateral edge of the dorsal arch of the eighth segment falls normally; but this has been removed, so that we can still follow the outline of the scaphium somewhat further into the abdomen. The median line of the arch is supposed to be retained, forming the roof of the cavity; and to this we perceive the scaphium is organically attached, descending from it in a great angular heel, in the free interior, and projecting, in the familiar form, from beneath and within the spreading rami of the uncus, where this is (as is usually the case) present. From the median part of its inferior surface there descend membranous laminæ of irregular shape, perforated to allow the exit of the penis. Here this organ, seen *in situ* at fig. 4, and its tip, more magnified, at fig. 5, is of great length. It appears to be invested with a thin glistening membrane, but only partially throughout its length, expanding and dilating near the tip, which, furnished with a minute finger-like point, is free. In the normal condition it protrudes far beyond the limits of the closed valves.

Thus every one of the organs is remarkable. The valve, the harpe, the uncus (absent), the scaphium, the penis, all present something unusual. The very simplicity of the scaphium, its lack of teeth, spines, or bristles, seems to deny the "reason of its being."

Papilio Agamemnon, Linn. (Plate XXXI. figs. 6–8.)

Valve small, short, rotundo-triangular, fringed with long hairs, not very dense. There is a broad, flat shelf, going nearly all round, except at the base; this shelf is beset with stout but short hairs, which bend over the inner edge; and the very edge itself is fringed with short stiff bristles, almost like spines.

At the base of the cavity lies the *harpe*, a shallow cup of chitine, thickened around the edge, and slightly free; on its dorsal side it rises into a tooth-like lobe of thin but dark brown chitine, of rotundo-triangular outline, which does not appear to be serrated (Pl. XXXI. fig. 6).

The circumference of the abdominal cavity is densely set with projecting hair-scales, which in particular rise from the summit of the ultimate segment to its very point, and then, arching forward, form a long horizontal thatch. When these hairs are detached (as, in part, at fig. 7), the point, ordinarily the *uncus*, is seen to be short and slightly bent upward, and, viewed vertically (as at fig. 8), to be truncate, and even very slightly bifid at the tip. Below, there is a well-formed but very small *scaphium*, with no armature; and then a *penis* of much slenderness, and so long that its point protrudes from between the valves, when these are closed. The chitinous portion is downward, ends in a point of great tenuity, and forms an imperfect tube with arching edges above, within which, prominent near the tip, is a pulpy white tissue. The sheath of laminæ descending from the scaphium is conspicuous and shaped like an elegantly pointed leaf on each side, united below.

Papilio Erithonius, Cram. (Plate XXXI. figs. 9–12.)

Valve of an outline somewhat trapezoidal, with the angles rounded, the terminal angle produced, sometimes truncate, and ending in three small obtuse lobes. A fringe of hair-scales beyond the margin on the dorsal side only; the floor of the cavity, where it is not covered by the harpe, having a cloth-like surface, unusual.

Nearly allied, as this Indian butterfly seems, in form and colouring of the wings, to the African *P. Demoleus*, there is no resemblance in the appearance of its valve (see Pl. XXX. fig. 25). Nor is there any more in its *harpe*; for this organ is a shallow cup of chitine, quite filling and accurately fitting the basal half (and more) of the valve-cavity, having its ventral edge thickened, and the dorsal rising into a thin chitinous wall, of considerable height, the summit of which is serrated with sharp teeth (Pl. XXXI. fig. 9). When this harpe is carefully separated from the lining-membrane of the valve, it is seen to be less simple; for the elevated dorsal lobe is now seen to consist of three parallel laminæ, which are of various lengths and heights, of which the inmost (also the tallest) alone is serrated.

In the abdominal apparatus there is a general agreement with the *Merope* and *Demoleus* pattern, with considerable diversity in detail. The *uncus* is short, little curved, ending in a broad and thick spathulate point, the keel deep, the rami rapidly receding, rising above the level of the summit, and forming a wide triangular arched roof to the cavity. The *scaphium* is minute, but possesses the essential features; the "double tooth" on each side is well marked; the frontal keel, however, is replaced by two erect fleshy

points. The *penis* is somewhat thick, moderately long, blunt-pointed, turgid, the white pulpy tissue copious.

At fig. 11 these organs are represented as viewed sidewise, the surfaces having been denuded of the copious scales and hair-scales, and both the valves removed. At fig. 12 is shown the corneous skeleton of these regions. By one of those fortunate accidents of which an observant scient is always so glad to avail himself (as he can never command them) a specimen of *P. Erithonius*, which had been badly infested with mould, came to pieces in my hand, and the terminal segment dropped away from all the débris, clean, just as I have sketched it at fig. 11. Here I saw not only the uncus terminating the final segment, and the scaphium attached to it beneath, but, lower down, the orifice for the extrusion of the penis, pierced through the middle of a vertical curtain of very thin horny chitine, which is suspended in place, by attachments on each side, to the lower parts of the dorsal arch of the eighth (?) segment, as well as by two perpendicular ligaments below, which tie it fast, the one to the middle of the ventral arch of the ninth, the other (wider and thinner) to that of the eighth segment.

Perhaps—since I have never met with any thing like this structure, before or since—it may not be impertinent to add that I have not exercised my imagination upon a piece of integument irregularly pierced and fractured; the screens, the orifices, and their edges were quite symmetrical and smooth, exactly as I have represented them; and this chitinous curtain is still in my possession, in excellent preservation.

Papilio Anchisiades, Esp. (Plate XXXI. figs. 13–15.)

Valve nearly parallel-sided, bluntly arched at the tip; margins furnished, more or less completely, with a narrow fringe of hair-scales. The cavity is abruptly depressed a little way within the margin on each side. Just at the very edge of the descent, on the dorsal side, I observed *in one specimen* two minute black teeth curving towards the cavity; but of these I could find no trace in other specimens.

The *harpe* is a thin concave plate, long, narrow, parallel-sided, seated within the depression, but not reaching either of its margins. It can be easily lifted unbroken and laid on a slip of glass; and is then seen to have a continuous floor of yellow chitine, excessively thin, and yet apparently of two surfaces, since the unequal contraction of drying has raised irregularly ramifying, thickened, fine lines, meandering like rivers on a map; while the bounding lines, and the upper part of the arch produced by their meeting, are of a deep, rich, yellow-brown hue, gleaming and glittering in the changing light, like cut glass. The abrupt termination of this darker part of the arch, within, conveys the idea of an overhanging edge: but this is delusive; for, by careful manipulation under the microscope, I proved that this effect is produced merely by increase of density. The point of the arch is a long taper tooth; and three or four teeth on each side descend along the outer edges of the arch. But the minuter details of number and order are not constant in different examples. The dark tooth-like objects which I have represented within the point, directed inward, are not true teeth projecting from the chitinous surface; for, though they appeared exactly as I have drawn, yet when I slowly and carefully *tilted* the object under the microscope, so as to obtain changing angles of

vision, there was no break of the light reflected from the shining surface. And in other examples there was no trace of them. These appearances, therefore, I cannot satisfactorily explain.

The *uncus* is curved in the usual arc; it is thatched, for most of its length, with coarse shaggy black hair; the extremity forms a thick rounded spoon, bent abruptly downward; the keel produced by the vertical rami is unusually deep.

The *scaphium* is boat-shaped, rather shallow, with a cleft tip, and no proper keel, the sides are full and round; their summits, brown with longitudinal chitinous thickenings, have no trace of the normal "double teeth," but are surmounted with ridges of long stiff bristles.

The *penis* is of moderate dimensions and protrusion, without terminal expansion.

Papilio Childrenæ, Gray. (Plate XXXI. figs. 16–18.)

Valve subtrigonal, pointed, nearly equal-sided, sparsely fringed with hair-scales, and beset with hairs, pointing inward from the ventral margin, and specially crowded near the tip.

Harpe nearly coextensive with the valve, springing from the entire base, and forming a concave triangular plate, with both lateral edges thickened, and a strong ridge running up near the middle. The ventral edge rises from an expanded hollow base, like the trunk of a tree, sending off near its middle point a stout sharp erect spine; at its end, where the central ridge meets it, both expand into a sort of hollow hand, turned up and curved-over ventrally, having five short fingers of glittering black chitine on half of its semicircular edge, the rest being a smooth wall. The dorsal edge of the harpe stands close to the edge of the valve, from which it rises into a thin wall of considerable height, leaning inwards, fringed along its summit, bearing a row of fine hairs.

The chief feature remarkable in the abdominal organs is the *penis*, which is rather thick, and so long as to protrude beyond the closed valves; its hue is pale chitine-yellow; its expanded orifice is filled with the white pulpy tissue, which swells beyond the margins; and there are, on the column, successive marks, which are repetitions of the terminal outline. (See the same organs in *Orn. Haliphron*, p. 285, *suprà*; Pl. XXVI. fig. 7.)

Papilio Sesostris, Cram. (Plate XXXI. fig. 19.)

The general type is that of *P. Childrenæ*; and the similarity is greater (considering the complexity of the armature) than I have observed in any two forms which may be considered species, or even marked varieties. Yet there are numerous diversities between these two.

The *valve* is of a different outline, parallel-sided and rounded, instead of trigonal and pointed; it is more distinctly fringed, along the dorsal margin and around the end, with close-set hair-scales.

The *harpe*, while of the same pattern, is much modified. Its ventral edge is straight, the solitary spine placed nearer the base, and reduced to a wart. The ridge is now the principal feature, which in *P. Childrenæ* is secondary; it is more curved. The hand-like tip is similar in form; but the short blunt fingers, curving over the cavity, are replaced by sharp teeth, curved like the spines of a rose, nearly in the plane of the valve (as

shown in outline in Pl. XXXI. fig. 19). The wall-like dorsal plate does not end abruptly, but is continued all round the extremity of the valve, and even far down the ventral margin, so that the harpe seems to be *quite* coextensive with the valve. Then, between this wall and the main ridge, there is a secondary ridge, of which just a trace appears in *P. Childrenæ*, but which is here conspicuous; membranous for the most of its length, but supported, near the part where it curves up behind the "hand," by a leaning "strut," of deep-brown shining chitine.

These are differences which would require representation on a much increased scale, to make them very appreciable by figures, but which are striking enough on careful examination.

When I came to examine the abdominal apparatus in *P. Sesostris*, I at once found a very glaring aberrance from *P. Childrenæ*. For there was not a trace of an *uncus*, the edge of the upper arch of the eighth segment projecting in only a very gentle curve, beneath which the arch of the ninth was wholly out of sight; the mingled long bristles, black and crimson, that generally project as a tuft, horizontally between the valves, were here bent down vertically into the cavity; and, behind them, a very minute hook was projected. There was, moreover, but the slightest doubtful trace of a *scaphium*, and only when I threw the sunlight far into the abdomen. The *penis*, in size, length and direction, agreed fairly with that of *Childrenæ*, but no white pulp was visible; the whole organ was of an uniform deep shining brown; and instead of expanding, its thickness gradually diminished to the tip.

All the diversities which I have enumerated, minute individually but in cumulation great, seem to me to point to original specific distinction, though the evidence is no incontrovertible.

Papilio Vertumnus, Cram. (Plate XXXI. figs. 20, 21.)

Valve and *harpe* agreeing in plan with those of *P. Euryleon* (infrà), and more essentially with those of *P. Sesostris* and *P. Childrenæ*, particularly the latter. The order of resemblance is—*Childrenæ*, *Sesostris*, *Vertumnus*, *Euryleon*. The two ridges, enclosing a triangular area, are gone in the latter two, and the harpe is a chitinous plate of about equal width throughout. In all, there is the high and broad tooth in the middle of the ventral side, followed, in the latter two, by smaller teeth; the terminal hollow "hand" of *P. Childrenæ* is best represented in *P. Vertumnus*, where the form is similar but wider, and the fringing overcurving teeth are eight.

The abdominal organs are normal. A long slender well-curved *uncus*; an ordinary deep-keeled *scaphium*, with horizontal "double teeth;" and a moderately large *penis*, with expanded orifice, seated far back.

Papilio Lysander, Cram. (Plate XXXI. figs. 22–24.)

Valve semiovoid; very slightly fringed; a flat shelf within the ventral margin.

Harpe a broad triangular plate, that occupies a great part of the breadth of the valve. From an ample expanded base, by which it was attached to the supporting knob, it springs, tree-trunk-fashion, with wide and thick ridges of glittering chitine, to the summit of the

valve, narrowing as it proceeds. Here another wide branch is united to it, or it may be considered as a descending piece, since it has no affixed base; it skirts the dorsal margin. The union of the two pieces seems perfect, though the substance of the secondary piece becomes exceedingly attenuate there. A broad space, well defined, occupying the middle of the valve, is likewise so exceedingly attenuate, that it is only when we lift the harpe out of the valve, that we perceive, by the continuity of the plate, that this median region is chitinous at all. The extremity of this compound harpe runs to a sharp point, and is notched into four teeth, of which the two on the dorsal side are double. But the arrangement and form of the teeth are not quite constant.

The *uncus* is slender, abruptly bent near the base, thence straight but oblique, to the terminal hook. A small *scaphium*, with difficulty recognizable, was (in one example) attached, very closely appressed to its inferior surface, through its length; the proper "double tooth" on each side was represented by a close-lying horizontal spine, dark, polished. But, in two other examples, the scaphium was wholly absent, or apparent only as a minute amorphous rag of white flesh; while, from the middle of the uncus, descended vertically a divaricating fork of two spines, organically (as it seemed) jointed to the two sides of the uncus. In each case these depending spines were the outer margins of veils of pellucid white flesh; and in one case they inclosed white matter, which appeared identical with the pulpy substance of which I have already spoken. For here, again, the *penis*, which was much distended, had its interior filled, to overflowing, with the shining white substance, which not only occupied its whole gaping orifice, but was carried, as a great ball, upon its extremity.

In another example the penis was very large (see fig. 24), diminishing to the extremity, which was furnished with a hooked, slender finger-point; the outer chitinous integument was split through all the length of the organ that was visible; and (what seemed noteworthy) laterally and asymmetrically; so that a wide, gaping slit, obliquely, along the side, looked as if the integument had been violently burst by distension within. As if to confirm this conclusion, the tube appeared perfectly empty; my eye, with the aid of sunlight, could penetrate through the hiant cleft, far up into the interior, and all round; but could not detect a trace of what sometimes is so prominent, the second tissue; nothing at all, but the thin, transparent, gall-yellow, tubular wall of chitine.

We have surely much to learn yet about these obscure organs, and their functions!

Papilio Euryleon, Hewits. (A. D.) (Plate XXXI. figs. 25, 26.)

Valve nearly semiovate, narrowly fringed; the cavity bounded by a marginal shelf, which runs up the ventral side, and a little way round the extremity.

The *harpe* has much resemblance to that of *P. Anchisiades*. It is a rather narrow, parallel-sided, thin, concave plate, both sides of which are bent round dorsally; and the sharp tooth-like points, which in my examples were seven in number, are almost all on the ventral edge, extending from the tip about halfway down. All are overcurved, hard, and horny; the lowest by far the largest. In removing the valve from its attachment, the expanded tissue by which the harpe had been affixed to the basal knob, occasionally so conspicuous at the bottom of the abdominal cavity, came away uninjured; and when

I lifted the harpe from its valve with a scalpel, this basal expansion still came away, as represented in my figures. It appeared shrivelled, thin, and membranous; but a short maceration with water caused this tissue to swell and become plump and soft. It is, I presume, a muscular attachment for the special energetic movement of the prehensile harpe. Maceration produced not the slightest sensible change in the polished chitine, either now or any other occasion.

Papilio Ergeteles, Gray. (Plate XXXI. figs. 27, 28.)

We have here another modification of the *P. Anchisiades* pattern of *harpe*. The ventral side runs up through the very central line of the valve, having a strong tooth projecting from its mid-wall, and three teeth at its extremity, whence a slender branch descends ventrally, as in *P. Lysander*. Then, also, on this edge of the valve, as in the same species, accessory pieces stand up as two half-walls, one within the other, of dark chitine.

The *uncus* and *scaphium* are both normal; the latter specially well formed, though small, with "double teeth." The *penis*, large and uncouth, much as in *Lysander*.

Papilio Macedon, Wall. (Plate XXXII. figs. 1–3.)

Valve of similar outline to those of *P. Ulysses* and *P. Arcturus*, yet sufficiently diverse in other respects. It is scarcely fringed, except very thinly along the ventral edge; but the whole cavity-floor is studded with minute pits, from each of which springs a fine short hair, some of which exceed the margin.

The *harpe* is quite peculiar; at the first sight it reminds us of the form common in the *Ornithopteræ*, the arm and the bent, spine-studded hand; but, when detached, and examined separately, as shown at Pl. XXXII. fig. 2, the armature is seen to be different, and even yet more formidable. If I may repeat the comparison to a hand, the five fingers, of glittering black chitine, are bent over the palm; and each of the five is notched, all down its front, with sharp teeth, of which the uppermost are the longest and stoutest. This and its fellow must make a very effective pair of graspers!

The abdominal organs are all well developed. The *uncus* arches nearly to a semicircle, terminating in a delicate spathula. The *scaphium* is definitely separated into two portions, the upper, altogether of a rich brown hue, apparently chitinous, which bears the teeth, and the lower, uniformly pellucid white. This latter is the keel, though it is not at all produced. The former, in the place of the usual "double tooth" on each side, has but one, erect, acute, recurved, like a viper's fang; but the termination of the scaphium is cut into three abnormal teeth.

The *penis* is very long, and somewhat slender, ending in a produced finger-like point, and not much expanded. It bends obliquely downward, protruding so far as to reach, if it does not exceed, the limits of the valves.

The harpe was, when I opened the valve, much choked with scales, doubtless from some female.

Another example agreed very closely with the above, save that the teeth of the scaphium were nearer the tip; the inner edges were set with low points, each surmounted by a

bristle; and the secondary tooth was represented by a rounded eminence, on which there was a crest of stout glittering aristæ.

Papilio Bromius, Doub. (Plate XXXII. figs. 4–6.)

Valve almost circular, margined, at the ventral edge and at the extremity, by dense fringes of coarse hair-scales, and, along the dorsal edge, by sparse fine long hairs.

Harpe, a bold triangular hollow plate of chitine with thick edges, springing from an expanded base, which almost fills the basal portion of the valve-cavity, and then, rising erect, throws forward a broad truncate sharp edge, cut into four great teeth.

Uncus short, triangular, horizontal, strongly and deeply keeled. *Scaphium* large and conspicuous, the keel bent obliquely downward, the "double teeth" replaced by a long and high crest on each side, having several points. *Penis* of excessive length, slender, wire-like, bent downwards, and conspicuously protruding between the bottoms of the valves, *in situ*; extremity shaped like a horse-hoof.

This is one of the most instructive cases that I have met with. Having examined the South-African *P. Nireus* in three examples, and found no difference in the structure, or arrangement, or relative size, of the parts, in the three, I thought of the West-African *P. Bromius*. The two are so much alike, in every apparent feature, as to warrant the conclusion that they are but "local variants" of one and the same species. But lo! here, in these hidden organs of a function of the most vital importance to the creature, I find with amazement a radical and very extensive diversity.

In one * the valve is trigonal, in the other circular; in one the harpe is a long spoon, studded with cone-points; in the other a horse-head with four teeth; in one the uncus is long and of extreme tenuity, in the other short, deep-keeled; in one the scaphium bears a pair of blunt erect pegs, in the other a series of compressed ridges; in one the penis is short, elevated, and terminates in a finger-point, in the other very long, depending, unarmed.

Can these be descended from a common parentage? and are the diversities merely the result of changes in the climate, soil, and food produced on a party of emigrants, in the course of many generations? Or are they not, rather, powerful, if unexpected, witnesses to the primal diversity of *Papilio Nireus* and *Papilio Bromius*, as distinct creations of the Almighty God?

Papilio Podalirius, Linn. (Plate XXXII. figs. 7–10.)

The *valve* is thin, narrow, sharp-pointed, more developed on the dorsal than on the ventral side, the latter remarkably excavated toward the base; the fringe of hair-scales, moderate at other parts of the margin, is so enlarged around the excavation that the irregularity of outline is not readily noticed (see Pl. XXXII. fig. 7).

A *harpe*, having a base as broad as the whole base of the valve, narrows at about the middle, where it terminates in a summit of dark chitine, shaped somewhat like an eagle's head and beak, looking towards the ventral side. From the thinness of the valve, and from the readiness with which the harpe comes away, the latter is favourable for

* See p. 328, *infrà*.

microscopic examination (see fig. 8). It is now perceived to be a broad concave plate, rising into somewhat thicker walls at the sides, and having an elevated thin ridge running up in the midst. The "eagle's head" is very sensibly thickened, and abruptly, so as to assume the semblance of a twofold wall of the tissue; but very careful manipulation has convinced me that this appearance is illusory. All over the thinner region meander those irregular lines which I have noticed before, so much like rivers on a map, and which I suspect are caused by the shrivelling of the investing tissue in drying. Besides these, there are a few scattered bristles, each rising from a minute elevated knob or bulb. The very edge of the "eagle's head" is a little arched-over; its line is uneven, but I cannot detect any serration in any part.

There is no trace of an *uncus*. The posterior margin of the upper arch of the eighth segment, when viewed vertically (as at fig. 9), is nearly straight, or follows an uniform slight curve, with no attempt at central projection. Immediately beneath its middle is seen a small but distinct *scaphium*, with the "double tooth" strongly developed in its principal member, black, long, nearly straight, horizontal, reaching to the extremity of the scaphium, the secondary visible only as a low shining knob. The sides of the scaphium are rounded, concave exteriorly; and a very distinct thin white keel is below.

Dr. Buchanan White, in his beautifully illustrated memoir, has given a vertical figure of what he considers the tegumen of *P. Podalirius* (pl. lvi. fig. 39 B), which, in his text (p. 361), he says is "almost bilobed." But I venture to think he has fallen into error here, careful lateral examination showing that this structure proceeds from beneath the straight edge of the tegumen, as I indicate at fig. 10. It is certainly, therefore, the scaphium, as the whole details prove.

The *penis* consists of a blade of glittering black chitine, folded longitudinally, and ending in a slender finger-point, with a knob at its origin. Thus folded, the sheath does not half contain the white pulpy portion that runs along apparently within it, and at the tip expanded beyond the finger. Possibly in life the firm chitinous sheath is semitubular, and takes this folded form by drying. It sheds some light on the curious appearance of the organ in *P. Codrus* (infrà).

I have examined minutely two examples of this species, and find no appreciable difference in any of the organs observed.

Papilio Latreillii, Don. (Plate XXXII. fig. 11.)

Valve regular in outline, ovate, nearly equal-sided, pointed; the exterior clad with a dense coat of close-set scarlet hair-scales, which project, in an even thick fringe, beyond the ventral margin throughout, but not sensibly on the dorsal margin, of which a few black hairs only occupy the terminal moiety. Interiorly it is deeply and evenly hollowed; along the midst of the cavity runs an irregular-shaped *harpe*, adherent to the lining-membrane (though readily detached), dilating into a broad blade of brown chitine, serrated with minute teeth along its edge, and projecting a prominent angle at each end. This blade is free, and stands up at an oblique inclination from the cavity.

The intravalvular organs I have examined imperfectly, and only *in situ*. The *uncus*

appears long, slender, and circularly arched, much as in *P. Demoleus*; the *scaphium* large, truncate, unkeeled, somewhat as in *P. Homerus*.

Papilio Semperi, Feld. (Plate XXXII. figs. 12–14.)

The *valve* is moderately large, of irregular outline, having prominent rounded angles, and a sharp projecting tooth at the summit. Exteriorly it is clothed with a coat of short scales, which are black from the base to the middle, and scarlet thence to the tip. Interiorly, the margins are exceeded by a broad fringe of hair-scales, which help to fill up, and so conceal, the irregularities of the outline.

The *harpe* is a shining chitinous plate, running through the length of the valve mesially, projecting two broad and sharp angular points at the extremity, and one in the middle of the ventral side. Pl. XXXII. fig. 12 shows the valve with the harpe *in situ*; but if the harpe be removed, which is done with great ease and perfectness, and viewed almost along the plane in which it lay in the valve, its form is very different; for the terminal portion curves upward, so that the points stand upright, and enclose a great semicircular area, as shown at fig. 13.

The *uncus* presents little that is notable: it is nearly straight, with the point sharp and bent down, bill-hook fashion; and its *scaphium* is rather small, and destitute of "double teeth." The *penis* is of extraordinary dimensions, the triangular dilatation of its extremity being enormously developed. At fig. 14 are presented these organs *in situ*, as they appear viewed from the right side, both the valves having been removed.

Papilio Lycidas, Cram. (Plate XXXII. figs. 15, 16.)

The *valve* is trigonal, short and wide, the margins fringed with black shining hairs mostly springing from within; the interior surface dark brown, velvety, nearly flat to a considerable distance within the margins, then suddenly sinking to a deep semicircular cavity. Within this hollow is seated a short *harpe*, having a widely expanded base, sloping away to the ventral side, and soon rising to a free flat column of dark-red glittering chitine, which is produced at the two corners into long sharp spines. Besides these, there are two minor spines from the slanting dorsal edge, and one near the base in the ventral. I discern no trace of serration in any part.

The abdominal apparatus seems peculiar. The beautiful clothing-scales, velvet-black alternating with pale-yellow, project densely from the segment around the cavity, when a valve is removed, so as greatly to conceal the interior. My cabinet possesses but a single example of the species, which is both beautiful and rare; and this I was reluctant to destroy, contenting myself with close and long-continued study of such organs *in situ* as a powerful hand-lens could resolve. Conspicuous is a slender well-formed *scaphium*, projecting horizontally, of a shining brown hue, with the "double teeth" small and low, but duly developed. At first there seemed no trace of an *uncus*; but at length I found it very far back, under the thatching roof-scales, small and short, sloping downward from its origin, and presently bent with an abrupt angle to a quite vertical line, or even a trifle within the vertical. Its form and direction, as well as I could see it, are much as in *P. Hector*. The uncus, then, it is evident, can here present no

antagonism to the projecting spines of the harpe. These points, in the closed condition of the valves, meet at the very tip of the scaphium ; yet the scaphial teeth, which in some species are long and formidable spines, are here minute and apparently useless.

To complete the series of anomalies, I could find no trace of a *penis*. By so holding the abdomen that the nearly level sun's rays shone into the cavity, I once or twice detected a glittering point very far within ; whether this was a penis, or whether the organ had been accidentally lost in my preparatory manipulation of the specimen, I dare not say.

Papilio Doubledayi, Wall. (Plate XXXII. figs. 17, 18.)

Valve having the outline of a tall cone, edged by a very broad fringe of close-set hair-scales—yellow at their bases, and becoming pale scarlet at their tips—which are continued from the exterior surface.

The *harpe* is commensurate with the valve itself, from which I am not able to separate it. The extremity is double, the dorsal point continuing the general plane ; the ventral really much longer, though not apparently, because it bends upward in the line of vision; it is fringed with fine short diverging hairs, proper to its point (*i. e. not* continuous with the exterior clothing). The dorsal edge also bends up, and becomes semi-erect ; its outline is so cut that, in the middle, it forms a sharp tooth, pointing backward. Except this, I find no serrations in any part of the structure. The prehensile function seems to be limited to the upcurved dorsal point, and to be feeble.

The *uncus* and its accompaniments are exactly as in *P. Rhodifer* (infrà), even to the protrusion of the wiry *penis*, with the single exception that the *scaphium* is here deeply keeled, whereas the keel seems totally absorbed in *P. Rhodifer*.

I subsequently examined another example, in which the penis was exactly as in *P. Rhodifer*, except that the finger-point was not so produced, and the lower lip-like lobe was rounded and of a deep red hue ; but the extruded bladder described there was here a perfect little globe of translucent yellow substance, projecting like a bubble from the expanding lip.

A third example had the tip of the very same form, but without a trace of the vesicle, the hollows of the bifid extremity white and shining.

Papilio Rhodifer, Moore. (A. D.) (Plate XXXII. figs. 19–21.)

In the *valve* of this Andaman representative of the *Coon* group there is a marked generic resemblance to that of *P. Doubledayi*, together with ample specific difference. The description of the valve of *Doubledayi* will well suit this of *Rhodifer*, save that the fringe, which is even broader, is of a purer scarlet hue, and the outline is still more disguised by the dorsal projections.

The *harpe* is again commensurate with the valve, and inseparable from it by mechanical lifting ; though, as in *Doubledayi*, the brilliant glittering polish of the entire surface, which distinguishes the harpe proper from the dull lining-membrane of the cavity, shows in each case that it is organically distinct from the valve. Here the extremity is treble ; the dorsal point, much larger, and directed much more laterally, than in *Doubledayi*, stands erect ; while the ventral division sends off from its surface, a little below its tip,

an adventitious lamina, of conical outline, which also stands up in the line of vision, and doubtless constitutes an auxiliary prehensor. All the three points are thickly beset with fine hairs, which make the resolution of their form difficult, and, one would think, must interfere with their prehensile effectiveness. There is no secondary tooth on the dorsal edge, which curves inward in a deep semicircular sweep to the broad expanded base.

The *uncus* is very long, and of excessive slenderness, almost quite straight, its extremity accurately reaching the point where the dorsal elevations of the two harpes meet and touch each other. The *scaphium* is very small and shallow; its "double teeth" conspicuous as a great spine on each side, having a downward curve. The most remarkable feature is the *penis*, which, like the uncus, is of extraordinary length and slenderness, resembling an attenuated, highly polished, black wire, nearly straight, proceeding from its conical investment almost directly downwards, and actually protruding between the valves below to the distance of an eighth of an inch; so that the insect could be easily handled and turned about by it, as if it were an inserted pin. The extremity of this organ is produced above (*structurally* above, though *actually* beneath, because its position is reversed) into a finger-point, which is abnormally long and acute; while below it forms a wide, somewhat tumid, trumpet-lip, of exceedingly attenuate transparent yellow chitine (?). So far the appearance has been paralleled in many other examples of the organ; but what follows is more remarkable. From out of the trumpet-like orifice proceeded what seemed a blown bladder, wider than the orifice itself, as if it had expanded as it issued, not quite globular, of a substance resembling that of the lip, but still more delicately thin, which, however, had dried in form and in place. It had all the appearance of an integral organic tissue—not of an excretion.

Papilio Archesilaus, Feld. (Plate XXXII. figs. 22–24.)

Valve rotundo-triangular; the extremity very obtuse, but fringed with graduated hair-scales projecting into a long and sharp point; the other margins only minutely fringed. The middle of the cavity is occupied by a large *harpe*, crescentic when viewed vertically to the plane of the valve; the cusps, which point ventrally, are raised considerably from the floor; the one next the base pointed, the other obliquely truncate. Both the points, and the interior curvature, as well as a ridge that takes a parallel curve, are serrated with sharp teeth.

The *uncus* is horizontal in its total direction, but has a double sigmoid curve; and its extremity, which is suddenly bent downward, is trifid, with blunt points. The *scaphium* is small, and so closely adherent to the uncus that the boundaries can scarcely be discerned. I detect no trace of the "double teeth." The *penis* presents nothing specially notable: it is small, fingered, and retreating.

Papilio Zalmoxis, Hewits. (Plate XXXII. figs. 25–28.)

Valve large, trigonal, with rounded angles, nearly equal-sided. Exterior densely clothed with shaggy fur of hair-scales, which project from all the free margins, forming an even, wide, buff fringe to the interior side, which is deeply concave, almost hemisphe-

rical. From the dorsal margin rises a wall-like ridge of shaggy surface and summit, which inclines towards the concavity, curves around the point, and then ceases. From a broad conical eminence at the base (the attachment to the basal knob) rises the *harpe*, a plate of chitine nearly filling the concave floor, its ventral edge elevated into a ridge, which curves in a semicircle to the dorsal wall; the middle of this ridge is lengthened into a long polished black curved spine, broad at its foot, becoming slender towards its tip, which projects over the fringe of scales, just reaching its extremity. At first sight the point of this spine appears simple; but higher magnifying power shows that the extreme point is flattened, and cut into four very minute transverse teeth, of which one is longer and larger than the rest.

The *uncus* is reduced to a small horizontal projection of the tegumen, bluntly pointed, of polished brown chitine, the lateral rami rising considerably above the level of its median ridge, the midst of which is studded with hair arching outwards. Depending from it is a sufficiently ample *scaphium*, of which the two sides slope downward and outward, and the keel descends from the angle. No distinct "double teeth" are developed. The colour of this organ, usually white, was, in two examples examined, of a dull blackish brown; and the surface was shrivelled and corrugated, not symmetrically, and not alike in the two examples. The *penis* is long and slender, slightly enlarged at the tip, black, polished; in one example it reached almost the edge of the valve-fringes when closed.

Papilio Policenes, Cram. (Plate XXXIII. fig. 1.)

The *valve* is one of the most aberrant that I have seen. It is parallel-sided, the end a segment of a circle with a projecting point; exteriorly it is very densely clad with long scales and hairs, the dorsal half black, the ventral white, the colours abruptly divided. The interior aspect is affected by this clothing; all up the ventral side the white furry coat forms a projecting back-ground to the valve, increasing around the extremity, till it becomes nearly half as long as the valve itself. But up the dorsal side the outline is quite lost in close black hair, which, at this quarter of the end, becomes suddenly a thick tuft longer than the valve.

The *harpe* is very complex, and hard to define, harder still to describe in words. Near the tip there are three transverse rows of strong teeth:—first, one tooth at the very edge, making the point, and another at its dorsal side; below a ridge runs across, bearing six stout and prominent teeth; and below this, from the dorsal margin, arches out a thick arm bearing a sort of open hand or curved claw, of four fingers. All of these stand up from the cavity, and project inward. Each ridge, moreover, sends down one or more longitudinal ridges, more or less jutting into points. The whole constitutes a very elaborate prehensile instrument, quite unique, so far as I have seen.

The *uncus* is also abnormal. It is very short, broad, rounded at the tip, with slight curvature, of pale yellow chitine. I could not detect any sign of the *scaphium*; but my observation was unsatisfactory.

Papilio Ucalegon, Hew. (A. D.) (Plate XXXIII. figs. 2, 3.)

Valve very small, parallel-sided; the extremity round, with a regular wart-like pro-

jection at the tip, which is darker and seems firmer and denser than the substance of the valve, as if it partook of the nature of a prehensor. The dorsal margin is fringed by very long projecting hairs; and the interior cavity is thickly beset with fine shining pale hairs, in irregular groups, which spring from various points, and make it difficult to see the outline of the parts. In the delineation, I have omitted most of these tufts of hair, as otherwise nothing could be represented. The *harpe* is complex. First, from the dorsal margin, a little below the projecting terminal wart, rises, almost erect, a stout black polished spine; then, further down the same margin, but a little within, is a similar smaller spine of clear yellow chitine. From a base occupying the whole width of the valve, proceeds along the middle of the cavity an irregularly curving, stout, thick rod, whence, beyond the middle, springs an erect, black, polished spine; the rod then expands, and terminates in a free claw of two pincers, notched along their opposing edges.

The whole anal region is protected and concealed by a wide canopy of long, projecting, parallel scale-hairs, over all, which reaches far beyond the fringes of the valves. These proceed from the dorsal arch of the eighth segment; and other long scales proceed from the sides of the same. When these are all removed, we see a moderately long *uncus*, very slender, acute, nearly straight, and horizontal. Below it is the *scaphium*, dark but translucent, shining yellow, shallow, and narrow but long, the "double teeth" discernible only as a slight thickening.

The *penis* is very long, narrow, pointed, in contact with the lower surface of the scaphium, beyond whose extremity it protrudes.

This and the preceding, both African species, have, in their irregular and complex armature, much in common, with ample diversity.

Papilio Agesilaus, Boisd. (A. D.) (Plate XXXIII. figs. 4–6.)

Valve externally thickly clothed with scales, half white, half black, the colours abruptly divided. Along the ventral margin, around the extremity, and nearly halfway down the dorsal side, a close fringe of long black hairs extends, springing from the very edge. This considerably augments the apparent area. The cavity is almost wholly occupied by a large and very elaborate *harpe*, whose structure I do not quite understand; for though it can be separated for examination, the process inevitably distorts the parts, and alters their relation to each other. There seems to be a great arching ridge of dark chitine, right across the middle, ending in a great erect double claw, near the ventral margin; more or less structurally connected with this, by the chitinous base, rise two other erect pieces, the three standing triangularly, and bending toward each other. From the arching ridge extends a (comparatively) great spoon-like plate, nearly filling the terminal moiety of the valve, its ventral edge, running about parallel with the ventral edge of the valve, of denser and darker chitine than the rest, cut into close minute saw-teeth. This saw-like edge stands, throughout, free above the level of the valve-floor.

An examination of the left valve in some measure cleared the difficulty—at least so

far as to show that what I have called the spoon-like plate is not, as looked at, concave, but convex, the outside of a hollow cone or helmet.

The tegumen, *in situ*, is concealed under the seventh segment, even when this has been considerably denuded; the *uncus*, however, protrudes, but much disguised. For it is almost straight, projecting horizontally, with a slight sigmoid curve, and having for its termination, instead of the usual spathulate point, three short, slightly divergent fingers. Beneath this representative of the uncus there is the long narrow *scaphium*, with shallow keel; but, from the close contiguity of the parts, and their minuteness, I could not be quite certain of the presence of the "double teeth," though once or twice I thought I discerned them.

If we compare this fine American butterfly with the still finer, closely related *P. Archesilaus* of Felder (p. 324 *suprà*), we find almost identity in the form of the uncus, but great divergence in the forms of the valve and the harpe.

Papilio Parmatus, Gray. (A. D.) (Plate XXXIII. fig. 7.)

This Australian cousin of the preceding species has a valve and a harpe equally complex, and equally hard to demonstrate; while the details of the armature seem altogether its own.

The *valve* is unusually small; and the presence of many irregular tufts of close long hairs, in unwonted places, greatly conceals and disguises the structure.

The *harpe* is, as I have said, very complicated, composed of many pieces, whose forms and positions and directions seem to have no intelligible relation to each other, or to the common object. There appears to run around the terminal portion of the valve a slender chitinous framework, which has two, if not three, projections parallel to each other, one much slenderer and longer than the other, forming a free arch. Down the dorsal side is a thin wall, rising in the middle into a tall, thin, erect, curved tooth, directed backwards. On the ventral side a ridge runs, within which, near the middle, is a semiglobular plate of deep-brown chitine, having two tall erect incurved faces, the inner forming a simple broad tooth, the outer and opposite cut into many acute serratures.

The abdominal apparatus, so far as I have been able to resolve it, seems to consist of a very small and compact *scaphium*, with the *uncus* (ill-defined) lying close upon it, and a *penis* moderately produced, reversed, terminating in a swollen extremity and a curved finger-point.

These very elegant butterflies appear emphatically and characteristically *Papiliones*; yet, in their prehensile armature, they show a manifest approach to those extra-Papilionidan families in which the valve and harpe are united to form a single complex prehensor.

Papilio Codrus, Cram. (Plate XXXIII. figs. 8–12.)

Valve parallel-sided, circular-ended, fringed with very long, badger-grey, shining hairs. A broad shelf runs obliquely across the end, and narrows down the sides. Near

the median line of the cavity, from a base that spreads like the base of a tree-trunk, runs up a narrow *harpe*, nearly to the arch, and then bends over towards the dorsal margin. It consists, on the ventral side, of three parallel laminæ, divided by deep *sulci*, but united beneath, where the whole is in union with the lining-membrane. Of these laminæ, the one next the ventral margin rises, abruptly, near its middle, to a higher level than the others, which it maintains. All three have the free edges cut into saw-teeth, on the ventral coarsely, on the others finely.

The abdominal apparatus is very abnormal. I cannot find any trace of an *uncus*, nor of a *scaphium*—unless, indeed, a minute rounded projection clothed with white hairs, in the usual place of these organs, represents either or both of them. Then, the *penis* appears to be double or even treble; for after I had removed, for examination, one organ, which corresponded, in position and form, to the penis*, there remained another which had been beside it; and this consisted of two parts—a hard chitinous thin blade which terminated in a slender spine, and a membranous investiture which ran up its side half embracing it, separating near the tip, and forming a thin yellow finger-like lobe.

All these organs, however, need fuller examination. The termination of the abdomen is profusely studded with long crowded grey hairs, under which they are almost hopelessly concealed; they are, moreover, very minute. The specimen examined was the only example of the species in my cabinet. I have represented what I saw; but I am not satisfied. The species is manifestly very anomalous.

Papilio Nireus, Linn. (A. D.) (Plate XXXIII. figs. 13–16.)

Valve approaching a trigonal form; scales of exterior slightly fringing the edge. Cavity moderately deep; a fringe of long hairs springs from the whole length of the dorsal margin, and arches over the interior.

Harpe a flattened rod or narrow plate, perhaps hollow, springing from an expanding base, and following the middle of the floor to the extremity, where it becomes spathulate (Pl. XXXIII. fig. 13). It is with ease removed entirely from the valve, when we see that the spoon-like tip, which is sometimes flat, sometimes hollowed, is studded with short stout spines, closely set over its surface (fig. 15), and that the dilated base rises into two or three conical eminences, one of which is cut into saw-teeth along its dorsal edge (fig. 14).

The *uncus* is an exceedingly slender spine with a fine-drawn point, projecting nearly horizontally, with the slightest possible curve downward. It is keeled to about mid-length. The *scaphium* is much more conspicuous, bent obliquely downward, with two stout, blunt, erect, chitinous processes, which appear to represent the normal "double teeth." The *penis* has a long finger at its upper extremity. *In situ*, all these parts are concealed by the coarse shaggy coat of scales with which the abdominal segments are clad †.

* I regret that I can say no more than this; but, when I had laid this organ on a glass slide for examination, a draught of air carried it away, and I could not find it again.

† See remarks on *P. Bromius*, at page 320, *suprà*.

Papilio Diphilus, Esp. (Plate XXXIII. figs. 17–20.)

(1. The larger race, figured by Esper, Aus. Sch. tab. xl.)

The genitalia are developed under peculiar conditions here. Looking at the ♂, we see at first no appearance of the usual valves, and the whole aspect is abnormal. The eighth segment does not protrude from under the seventh, but sends out, just at the edge of the latter, a dense arching thatch of long, horizontal, scarlet hair-scales (see Pl. XXXIII. fig. 20), under which the genital organs are widely exposed, much as in *Eurycus* and *Euryades*.

The *valves* must be searched for, and then will not be easily recognized. Each is very small, not more than ·05 inch in total length, not clad with scales externally; indeed, I think it would be correct to say, there is no valve at all, but only a naked *harpe* of valve-shape. Its outline is that of a hand-bell; the margins are thickened, and united at the summit into a rounded knob (=the handle of the bell), which is beset with minute curved spines, and bends-over towards the dorsal side *.

The *uncus* is a nearly straight wide process, semitubiform, the extremity truncate, but cut into seven obtuse teeth. The *scaphium* is seen beneath, narrow, short, with only a suggestion of the usual "double teeth." The *penis* is more normal, wiry, polished, acute, projecting beyond the surrounding organs, slightly above the horizontal.

(2. The small race.)

I received a variety from Malacca, much smaller and more elegant than the Java type as figured by Esper, pl. xl., and by Cramer, pl. cxxxviii.; the wings longer and narrower in proportion, the colours much brighter, and the white spot of the macular band in the hind wings longer and narrower, with other slight differences. In this, the bell-shaped valveless harpe is exactly as in the larger form, and is of the very same dimensions.

The uncus appears in this variety somewhat more truncate, shorter and less cut into points, so far as I have been able to examine it; the scaphium more keeled, and the other accessories the same. There is a pair of organs forming the floor of the anal cavity, with prominent points, the edges beset with long hairs, which I at first thought might possibly represent the ordinary valves; but so shallow that the harpes are separate from, and project above, them. But these are possibly the pair of strong angular projections to which the expanded bases of the harpes are usually attached. Their high position here agrees with the position of the harpes, and confirms my conclusion of *their* nature.

Papilio Polydorus, Linn. (Plate XXXIII. figs. 21–23.)

There is much resemblance between the terminal region of the body in this species and that in *P. Diphilus*, as might be anticipated; but the structure is here even more aberrant. The horizontally projecting thatch of scarlet hairs is still more copious, descending much further on each side, and even continuing, in coarser form and more irregular arrangement to the bottom. Thus, though the shining black *genitalia* can be seen, nothing can be defined till this shaggy thatch is removed; which is accordingly done in my sketch of the parts *in situ* (Pl. XXXIII. fig. 21.) Probably the protecting

* Compare it with fig. 15 of *Nireus*.

office of the ordinary valves is to some extent supplied by this thatching, the valves being almost aborted.

The *uncus* is here a stout, short, bifurcate process, the two points not quite equal *inter se*, acute, notched below. They are followed by a couple of pear-shaped organs, of highly polished, glittering, brown chitine, each terminating in an oblong knob, beset with minute spinous teeth. In fig. 21, they are seen *in situ*; in fig. 22 the right is seen interiorly, showing that it consists of a hollow shelly case, with the edges curved-over. The knob bends upward, toward the bifurcate uncus, but comes considerably short of it (as shown in fig. 21, where both the right and left knobs are seen), whereas in *P. Diphilus* the knobs close on the truncate tip of the uncus.

There can hardly be a doubt that these organs are homologous with what I have called "valveless harpes," in *Diphilus*. But, tracing them to their origin, we find that they spring from a point on each side, within the descending rami of the uncus, *i. e.* within the walls of the ninth segment; whereas the valves are appendages of the eighth, and are always outside the walls of the uncus *. Thus it is perhaps possible to consider these spinous knobbed organs the homologues of the teeth of the scaphium, which (in *P. Merope*) we have seen to be serrated. The scaphium itself I do not find in *P. Polydorus*, unless it is a shining white mass (in texture like the white of an egg boiled hard), into which the pear-shaped organs merge at their bases.

What I suppose are the *valves* proper (or their representatives), are a pair of organs (seen *in situ*, in fig. 21 below the pear-shaped bodies, with the *penis* protruding from between them) which certainly spring from the bottom of the eighth segment. Fig. 23 represents one of them, the left, viewed internally; it bears a semitubular ridge of chitine running through its midst, terminating in a minute point. This (supposed) valve is hollow, and is beset, on both margins, with long straight bristles.

If this analogy is true, it must be true also in *P. Diphilus*; but the application seems more difficult there.

It may be interesting to compare De Haan's description with mine above, every word of which, I may say, was written before I saw his. He says, "*P. Liris* and *P. Polydorus* have the hinder part of the body naked; the valves [kleppen] are very short, armed from within to the top by a hook [?, P. H. G.], and the lateral appendages [zijdelingsche aanhangsels] of *Amphrisius* † are placed under it: the spine on the back is blunt [uncus? P. H. G.]; besides this, there are also two spines present on the upper edge, and these are curved inwards; so that, altogether, the outer edge is provided with seven appendages ‡, which all rise free from one another. Between these lies the penis [roede], which, as if pressed together, has a sharp edge above and below"§.

* The harpe however, has a double basis normally first to the valve, secondly to the knob which projects from the floor of the genital cavity. This latter is, I think, situate within the ninth segment.

† These are, I presume, what I have called the harpes in this Memoir.

‡ If I understand him, I can find but six; viz. the two points of the bifid uncus, the valveless harpes (or scaphial teeth); and the two bristled valves? But I am not sure that I follow his identifications. He seems to imply a terminal point to the uncus, besides and between the two points which alone I find in *Polydorus*; and in his figures of *Liris* he represents such a point. *Polydorus* he has not figured. Possibly he did not examine both *minutely*.

§ Nat. Gesch. Ned. O. B., Papilionidea, p. 17.

Papilio Antenor, Drn. (Plate XXXIII. figs. 24–26.)

Valve of the rotundo-triangular outline common to the genus *Ornithoptera*, and nearly as large as in some species of that genus. Exteriorly of an uniform drab-white; a fringe, of dense hair-scales, projects beyond the dorsal margin, the continuation of the common clothing; the ventral margin is unfringed. Interiorly, the lining-membrane is of a rich umber-brown hue, dully shining; the contour forming a wide flat edge or shelf all round, whence it falls abruptly in a deep cavity. This is occupied by a wide bell-shaped *harpe* of glossy chitine, hollow, like the cavity which it occupies, and terminating in a rounded knob, slightly bent towards the dorsal side. This is almost exactly the figure and appearance of the (presumed) harpe in *Diphilus*, only that I cannot detect the slightest trace of serration on the knob or on any other part. The knob is spoon-shaped, hollow, with an elevated, thickened, overturned edge.

The *uncus* is nearly horizontal, straight, short, bluntly pointed, being thickened at the edges and tip. The surface, though shining, is uneven, and lacks that glittering polish which this organ usually displays. A shallow sulcus runs along the summit to the point. Below, attached to it by short white fibres, is a small *scaphium*, in which I detect no teeth. The *penis* is very minute, and scarcely visible, far within the abdominal recess.

Papilio Hector, Linn. (Plate XXXIII. figs. 27–31.)

We have here the same type of structure as in *Polydorus*, but with remarkable modifications of the organs in detail. There are, again, no proper *valves*; the posterior extremity appears as an oval opening; the area occupied by a confused set of shining black knobs, surrounded by a dense horizontal thatch of scarlet hair, which, however, is not so long as in *Polydorus*.

The *uncus* is a short spathulate point, abruptly bent perpendicularly from the middle of the transverse edge of the downsloped roof of the ninth segment. Its shape, as seen directly from behind, is shown at fig. 28.

At its point just meet the summits of a pair of organs, answering to the (suggested) scaphial teeth (see *Polydorus*, p. 330), but of very bizarre form. Sidewise they are not unlike the corresponding organs in *Polydorus*, very highly polished, like them; but when looked at directly from below, each is seen to send off a broad process of subtrigonal outline, horizontally, toward the middle of the cavity. The process is a sort of flat cushion, apparently of short close pile, throughout which are set minute slender needle-like spines vertically. The end is a thickened knob, whence descends obliquely a group of very long straight bristles (see fig. 29, the right "scaphial tooth" seen from below).

What I suppose to answer to the valves, are still further disguised here, each being a slender straight rod (fig. 30), with the point bent dorsally, nearly at a right angle, and bearing a short spine; while the dorsal margin is so beset with short straight bristles, as to give to the whole organ the appearance of a comb. The base is broadly dilated; and the pair incline towards each other, so that the summits are almost in contact.

Between them projects the very much developed *penis*, the tip forming a curved acute

spine, reaching beyond the level of all the other organs, and the preputial (?) appanage forming two ample parallel leaf-like expansions, greatly lengthened, situate on the dorsal side (fig. 31).

Professor Westwood, who figures this showy species in 'Arcana Entom.' i. pl. 3, mentions the affinity shown by its larva and pupa with those of *P. Polydorus*, on the authority of Horsfield and De Haan. And, what is much more curious and inexplicable, there is a very close resemblance between all* these organs in *P. Hector* (including, *notably*, the bent bristled expansions) and the corresponding organs in a great Asiatic Silk-moth (*Anthea Roylei*).

Clasping-Organs in Butterflies of other Families.

I subjoin a few notes made on species of other Families, chiefly the *Pieridæ*, because it is interesting to trace the gradual disappearance of a vanishing organ or set of organs.

Pieris. The valve of *P. Autodice*, of South America, a very charming microscopic object, densely clad in its snow-white hair-scales, is essentially that of a *Papilio*. The harpe is a thin sharp knife-edge, colourless, glassy, running transversely across, not far from the base, and rising into a broad tooth in the middle. The tegumen has the bird's beak-form; but I see no development of a scaphium. The penis is large and prominent.

The valve of *P. Automate* is much the same. A harpe runs obliquely from the base to the upper part of the dorsal edge—a colourless glassy ridge, with a free point. The valve, in both of these two species, is armed with a projecting semicircular hook on its margin, at, or close to, the tip.

In *P. Rapæ* the uncus is well developed; but I find no trace of a harpe, nor any structure corresponding to it or displacing it.

P. Brassicæ possesses a well-formed valve, whose outline may be described as a circle within the angle of two sides of a square, of which one is the base. The other side is the ventral, which runs up with a stiff straight edge, and terminates in a hooked point. As harpe, an acute spine of transparent chitine runs from the base nearly to the middle, and then bends up toward the dorsal side. Herold takes no notice of this little glassy rape.

Callidryas. *C. Eubule* has a very curious valve, armed as elaborately, and as singularly, as that of many a *Papilio*. Its outline is somewhat pear-shaped, having a large hook at the extremity, and a broad shoulder on the dorsal side, each of which rises into an upturned black chitinous tooth. Through the middle of the valve runs a wide and deep depression, in which the floor is so thin as to be translucent. In the very centre there is a curious, oblong, free body, of orange hue, studded with a score of erect, blunt, black spines, equally thick throughout, looking like needles carelessly stuck in a pincushion, or, like the shell of a sea-urchin; it is connected, by a projecting arm, with the dorsal margin. There is a beak-like uncus, little hooked, beneath which projects a conical scaphium,

* Except the uncus. The form of the tegumen in *A. Roylei* may be imagined by supposing a normal uncus, only with the terminal half divided into two divergent spines, and the interval between these filled up, to a line stretched from point to point, with a downy chitinous membrane, and then bent down.

In *Polydorus*, these points remain bifurcate, as they are in the American Moon-moth (*Actias Luna*).

transparent, and of extreme tenuity. The penis is of unusual length and slenderness, resembling a very fine copper wire.

In *C. Statira*, the valve is still more remarkable. Here the pear-shape is lost; for the extremity runs into a long, sharp, curved spine, and the dorsal shoulder has two wide semicircular excavations, on the eminence between which stands, attached by one angle, a triangular plate, the outer edge of which is notched into a dozen saw-teeth. This, I presume, is a harpe, and replaces the pincushion of *C. Eubule*. The tegumen projects in a long shallow *channel*, which can hardly be called an uncus, though it replaces one; beneath this is seen a minute scaphium, which simulates the form of an uncus. The penis is long, arching, and wiry, much as in *Eubule*.

Gonepteryx. The valve of *G. Rhamni* is small, but well made, rotundo-triangular, oblique, terminating in three horny points, of which the dorsal one is a rather long, slender, acute spine, which leans across the valve, so as to project beyond the ventral edge. This represents, but is not, a proper harpe. There is a small well-formed uncus, which, strangely, is translucent white, and a large penis, but no trace of a scaphium.

In the fine *G. Leachiana* of Brazil the valve is much like this, with very wide fringes of yellow hair-scales. The terminal point is long, slender, upcurved; and the two dorsal points both belong to that which supplants a harpe. There is a proper uncus, small, hooked, and a scaphium, very minute but apparently normal, beneath it. The penis, in this species, is long and prominent; its terminal expansion takes the singular form of two triangular lobes, looking exactly like the anal and dorsal fins of a mullet.

G. Clorinde, of Paraguay, has a similar valve. The uncus is a large blunt hook, polished white, like ivory, which bears beneath it a perfect little scaphium, in which, I believe, I can trace the "double teeth," though excessively minute.

Hebomoia. *H. Glaucippe* is well armed. The valve is an oblique trapezoid, ending in two stiff slender spines; the ventral margin semioval in outline, furnished with a broad white fringe. Its long very slender harpe runs transversely across the base, which throws up an elevated tooth at the dorsal end, and terminates ventrally in a more or less produced hook. It is quite papilionine in aspect, though no part, I think, is serrated. There is a long black uncus nearly horizontal, but bent down at the point. This is furnished with an ample scaphium of a polished brown hue, quite dark in parts; it has a long keel, projecting beyond the hook of the uncus, with long and deep rami, and a stout, horizontal, decurved black tooth on each side.

Terias. The valve of *T. Hecabe* is semicircular, running off to a tooth-like point at the vertex. The concavity is deep, almost hemispheric; and the margins are very broadly turned over, their inward edges elaborately furnished with spines, long, slender, sharp, arching over the cavity. On the dorsal side of the terminal tooth rise two of these spines, and a third on the ventral side, while the ventral point of the basal side runs off into a stout and sharp hooked point. There seems to be no harpe.

The uncus may easily escape recognition. Not only is it exceedingly minute, but it *seems* to be replaced by a projection with two points, the upper curved downward, the lower, longer, curved upward; but the former is the uncus, the latter its scaphium.

Colias. Here the genital armature is become very aberrant. *C. Edusa* has a short, thick, obtuse uncus, and no valves nor harpes, but fixed side pieces in place of valves, in which I can detect little analogy with *Papilio*.

Morpho. In *M. Menelaus* I find valves much as in *Papilio* but without harpes, an uncus broadly triangular but with a good hooked beak-like point, very deeply keeled, and a projecting penis. The tooth on each ramus of the uncus is more than usually separate and strong. I see no trace of a scaphium.

Nor in *M. Epistrophis*, in which for a while I fancied I did see a rudiment of the organ far up in the cavity; but very precise and repeated observation under a high power, with light thrown well into the spot, convinced me that I was looking into the anal orifice, and that there was not the least trace of a scaphium.

In this species there are well-developed valves, but small, and of delicate texture, of which the tip, preceded by a pointed fringe of very long silver hairs, is of hard, dark chitine, turned up at an angle, *with a serrated edge*, of which the teeth are large, and *cut into minute toothlets* along their sides. Here, then, we have one of the most peculiar characteristics of a harpe transferred to the valve.

Dynastor. But in the fine *D. Darius* the transition is complete. Here is a narrow, parallel-sided but very deep uncus, and a pair of horny stout organs in the place of valves, and having much of their outline, but bearing along the thickened dorsal margin a double row of strong spinous teeth, black and glittering, most formidable to behold. The valve with its harpe has become what Dr. White would call a true *harpago*, distantly like his beautiful figure of the organ in *Argynnis Laodice* (op. cit. pl. lv. fig. 20).

I now close this Memoir; but the work is very far from complete. It is but an instalment of the subject that I here present to the Linnean Society; a great majority of the recognized species of Papilionidæ being still untouched for this purpose. Yet I have not ceased to work at them; and if life and health be still vouchsafed to me, I hope I may, before long, contribute to science more details of these remarkable instruments, as yet unsuspected*.

Conscious I am, too, that a good deal of imperfection attaches to the observations recorded. Of not a few of the species examined and figured herein, I should be very glad to repeat the examination, if I had more specimens; and Entomologists could scarcely render me a kinder or more grateful service than by sending me examples of *male Papiliones*, however torn in the wings, or even the separated abdomens, if *duly authenticated*, of which they may possess worthless duplicates.

* At the time of this sheet going to press (March 6, 1883), I have accumulated, in MS., descriptions, with drawings, of the genitalia of fifty-six species, in addition to those herein contained, belonging to the genera *Ornithoptera*, *Papilio*, *Teinopalpus*, *Sericinus*, and *Leptocircus*.

APPENDIX.

Supplementary Note to Ornithoptera Remus.

Since this Memoir was completed, and presented, many examples of this magnificent butterfly have been sent to me from Celebes, and also of *O. Haliphron*; and I have examined more than a dozen males of each. The following notes embody my latest researches on the abdominal organs. They are illustrated by figs. 15–19 of Plate XXVII. [N.B. The small letters indicate the same organ or part in each figure.]

Uncus (*a*). When the beautiful patch of velvet-black hair-scales that adorns the dorsum of the eighth segment of *O. Remus* is carefully removed by abrasion, so as to expose the chitinous skin, we see that this is dully shining up to the accurately defined transverse line where the velvet ended. Thence it becomes brilliantly polished, and begins to project into a triangular area, of which the lateral edges are thickened, while the median portion, also thickened, forms the out- and downcurved uncus. Its curvature is not quite uniform: sometimes it is the arc of a circle, sometimes the arc of an ovoid; sometimes it is bent abruptly and perpendicularly downward from its middle.

Scaphium (*b–i*). From a level slightly below the expanding rami of the uncus, apparently in fixed immovable connection with it, spring a pair of slender rods, of similar shining chitine, each of which (*b*) is dilated near its base into a wide lamina exteriorly, which laminæ become the firm fleshy tissue of the cheeks (*c*). These together assume the form of one fourth of a globe, cleft by a deep vertical sulcus, which has a continuous floor (*d*). Each cheek has its outer ventricose side obliquely cut away behind: its surface is distinctly granulate, the granules elevated, more and more towards the point and back, into the characteristic stiff, glittering bristles (*e*).

A simple device may assist the comprehension of this form. If the thick rind of half an orange be removed bodily and set on its edge, if then about half of this be cut away slantingly behind, and then what remains be excised into a deep narrow groove mesially, we shall get the scaphium-cheeks of *O. Remus*.

From just below the groove descends vertically a long and narrow pentagonal piece (*f*) of what simulates polished ivory. It is not continuous with the part from which it seems to descend; for, by peering with a lens *under the edges* of the cheeks, we see the summit of the pentagon to be abruptly bent backwards, so as to reach connection with the under surface of the sulcus-floor, far back in the mid-roof of the arch.

Behind this narrow shining pentagon is the keel (*g*); a large plate of whitish tissue, very thin in the middle, which seems attached to the concealed side of the pentagon, but on the abdominal side thickening into broad irregular lobes (*h*), apparently of a different character from the thin central parts. The depth of this organ, and even its shape, differs considerably in different individuals. Possibly it is capable of alteration in form, and may be composed of something analogous to erectile tissue. Indeed, I have fancied that the varying direction of this curious member—sometimes more, sometimes less pendent—may itself indicate a sort of erection. May it be that it is a titillant, excitant,

provocant organ, to be applied to the ♀ vagina, before intromission? The extreme tip seems to be of peculiar structure: it may be glandular, and be the seat of sensation, the τέρψις ἐρωτική, of which the hard chitine of the penis seems incapable.

In one example the whole keel was movable, as on a hinge in the interior, whose place is indicated by the dotted curve-line in fig. 15.

The thickened edges unite behind into a very thin median ridge, which, like a groin from a roof, descends vertically, and is lost in the curtain to be presently described. A transverse horizontal section would be somewhat like fig. 19.

In *O. Remus*, and, I believe, in *Ornithoptera* generally, the uncus is soldered by its under surface to the upper surface of the scaphium-cheeks behind, the suture showing a thickened bead. So it is with some *Papilionides*, though with others there is a wide hiatus between these organs to the very base. That the fæcal outlet perforates the abdomen-wall at their point of union seems certain. In both *Remus* and *Haliphron* I have demonstrated the presence of an orifice, leading from the abdominal cavity between the uncus and the scaphium, and I have passed a fine needle through it—though, from the extreme minuteness of the parts, and their dry condition, the demonstration was not quite so satisfactory as I could wish. Still I can find no anal orifice *possible* anywhere else than here.

The tissues of the scaphium become attenuated and expanded behind, arching around as a great concave membrane (fig. 15), which limits the genital cavity, and shuts it off from the abdomen as by a falling curtain. It is strengthened by slender ribs of chitine, which run down vertically from the cheeks of the scaphium and from the groin of the keel, somewhat like the nervures in the membrane of the wings, and end in insensible points, near the penis.

Penis. All my examinations still leave much obscurity on the form and conditions of the intromittent organ. Its usual appearance is that of a semitube, or gutter, of brown chitine, whose upper (normally and structurally the *lower* or ventral, for the organ is reversed) side is widely open, which projects from the curtain outward to near the tip of the scaphium-keel. But these gaping sides approach each other in various degrees in various individuals, the organ at times being nearly flat, especially towards the extremity. It is then seen to have angular enlargements at intervals, which, when the sides approximate, appear as sharp projecting ribs. The tip is bevelled off to an acute or subacute point, from each side of which a ridge passes down into the hollow (fig. 20). [These characters were precisely repeated in examples of *O. Haliphron*.]

But I have seen specimens in which the trough was more than filled with a substance which, though it was not white, I suspect to have been homologous with that pulpy matter which I have repeatedly described—the more, since in this case too a portion of it was extruded to some distance from the extremity.

It is difficult to imagine how an open trough can be efficient for the conveyance of the semen into the ♀ vagina. But I venture to suggest, though I have no proof, that in life the tube may be completed by an excessively subtle film, which, in drying, falls on the opposite chitine-surface, so as to be no longer distinguishable.

The falling curtain of the scaphium-base forms below its middle an enveloping sheath for the penis, which sheath then runs back around it to the very origin of the organ. This sheath is close, yet wholly free, allowing independent action to the penis, while it is attached on each side, by a slender ligament, to the floor of the cavity.

Tracing back the organ to its origin, we see that it is fastened by muscles to a thin but wide ridge of chitine, that springs from the bottom of the seventh segment, and stands up erect transversely, yet considerably hollow, the concavity backward. This, I presume, gives the point of resistance for the *retraction* of the organ after coition. The penis, behind this attachment (*i. e.* thoraxwards) enlarges into a thick and long fleshy bulb, which seems free in the hollow of the sixth segment, and bends back upon itself.

The eighth segment at its bottom gives rise to a hollow shell-like plate of firm polished chitine, much larger than that of the seventh just mentioned. This and its fellow form the floor of the genital cavity, surrounding and closing the bases of the valves. To the upper edge of this plate the penis is affixed by a muscular or tendinous cord stretched in the contrary direction to that of the seventh segment. I conjecture that this *projects* the organ in coition, as the former *retracts* it, and that both limit its action to the median line of the body.

Hinge-knobs. Within the plate last described, nearly close to it, and nearly parallel with it, but quite free from it, is that curious piece, on each side, which I have called a knob, but which (here, in *Remus*, certainly) is hollow—a very firm and stout chitinous shell, to which the ventro-basal edge of the valve is closely articulated, and from which the root of the harpe springs.

The small italic letters denote:—*a*, the uncus; *b*, the chitinous lamina of the scaphium; *c*, its cheek; *d*, the sulcus; *e*, the aristæ; *f*, the pentagon; *g*, the keel; *h*, its lobes; *i*, its groin.

I add some results from late examinations of a few species of *Papilio*, as chiefly shedding light on the structure and relations of the scaphium.

P. Ascalaphus. The uncus, scaphium, curtain, and penis, can all be resolved into the *Remus* type. The cheek, instead of being erect, leans horizontally outward, making the sulcus much broader; the front edge of the cheek is diminished to a slender acute tooth of black chitine; and its hinder portion (= the sulcus side in *Remus*) is here the semi-globose "boat-gunwale" of brown chitinous membrane, or thin horny plate, so corrugated as to make strong oblique ridges, sloping inward and forward, on each side of the shallow sulcus. The keel, though somewhat changed in form, seems homologous; but the pentagon appears quite wanting.

In *P. Mayo*, and in *P. Memnon*, the general structure is the same; the differences of detail are slight and unimportant.

P. Agamemnon. The back of the upper part of the scaphium is elevated, skull-like, and is thickened into a ridge, where the under surface of the uncus-base is attached to it, I think, organically, as may be seen when the uncus is forced off. This ridge descends obliquely on each side, and forms the lateral margin of the curtain, reaching below the

penis. From the lower edge of each cheek descends a prominent high ridge, which (and its fellow), the intervening membrane being arched, embrace without contact the penis, sending forward on each side that singularly elegant heart-shaped bundle of white flossy filaments which I have described above (see p. 314 *suprà*, and Pl. XXXI. fig. 7). These heart-shaped bundles unite into one beneath the penis, and merge into a horizontal floor of the sheath, which runs back into the cavity of the abdomen. Another less delicate bunch of similar floss is given off on each side from the outer part of the curtain.

P. Anchisiades. The scaphium-sides go back into the ridge of the curtain (as in *Agamemnon*), and sheathe the penis. The scaphium-keel is slit vertically at the front, the slit expanding upwards. It is equivalent to the same part in *O. Remus*; but there is no pentagon, it seems quite aborted. The cheeks are rounded, polished, light brown, and thus chitinous, with a tuft of very short and fine aristæ, seated on the inner curve, to be detected only by very careful focusing against the light, but then indubitably.

P. Macedon. Here, again, as I find by several examples, the scaphium is much the same as in *O. Remus*, only that the front portion of the cheek is hardened and pointed. and so excised as to form the principal tooth. Behind this is a ridge, which runs in an inner line; the aristæ are set from the interior side of the tooth, all along the edge of this secondary ridge. Viewed in front, the appearance much resembles that of *O. Remus*; but the pentagon seems reduced to a mere line, not (visibly) split. The three teeth which I had described and figured, at the point of the united cheeks (see p. 319 *suprà*, and Pl. XXXII. fig. 3), now no longer appeared; their semblance was probably illusory. The descent to the curtain is normal.

These repeated observations make it highly probable that throughout the genus *Papilio*, as in *Ornithoptera*, the scaphium has consimilar relations with the surrounding organs, that it is constructed on a common plan though subject to many variations in details, and that it is throughout composed of three distinct portions, which probably possess distinct functions.

DESCRIPTION OF THE PLATES.

[The figures of the valves have been drawn to about six diameters each, and the others enlarged proportionally but not to scale.]

Plate XXVI.

Fig. 1. *Ornithoptera Arruana.*—The interior of the right valve with its harpe *in situ*, magnified 6 times.
Fig. 2. *O. Arruana.*—The harpe, separated and viewed as a transparent object, further magnified.
Fig. 3. *O. Arruana.*—The whole genital apparatus, seen from the right side, the right valve having been removed.
Fig. 4. *Ornithoptera Pronomus.*—The disk-like extremity of the right harpe, viewed transparently, magnified about 40 diameters.
Fig. 5. *Ornithoptera Richmondia.*—The disk of the right harpe, magnified about 40 diam.
Fig. 6. *Ornithoptera Haliphron.*—The interior of the right valve with its harpe.
Fig. 7. *O. Haliphron.*—The ultimate segments of the abdomen, and the contained organs, viewed from the right side: the right valve removed; the left with its harpe, *in situ*, represented in faint outline. The uncus, scaphium, and penis; the last surmounted by the unknown white substance.
Fig. 8. *Ornithoptera Darsius.*—The interior of the right valve, with its harpe.
Fig. 9. *O. Darsius.*—The harpe, viewed in the same aspect, further magnified.
Fig. 10. *O. Darsius.*—The same, viewed sidewise.
Fig. 11. *O. Darsius.*—The extremity of the penis viewed nearly in front, and with most of the white matter removed.
Fig. 12. *Ornithoptera Rhadamanthus.*—The scaphium and uncus seen from above.
Fig. 13. *O. Rhadamanthus.*—The interior of the right valve with its harpe.
Fig. 14. *O. Rhadamanthus.*—The right harpe further magnified.
Fig. 15. *O. Rhadamanthus.*—Teeth of harpe, viewed laterally, and more highly magnified.
Fig. 16. *O. Rhadamanthus.*—The scaphium and uncus, together with the penis, seen from the right side.

Plate XXVII.

Fig. 1. *Ornithoptera Heliacon.*—The interior of the right valve, with its harpe.
Fig. 2. *O. Heliacon.*—Disk of same harpe, further magnified.
Fig. 3. *Ornithoptera Heliaconoides.*—The interior of right valve, with its harpe.
Fig. 4. *O. Heliaconoides.*—The harpe, further magnified. The outlines around the central figure represent the forms of the teeth opposite to them when these are viewed to advantage.
Fig. 5. *Ornithoptera Brookeana.*—The interior of right valve, with its harpe.
Fig. 6. *O. Brookeana.*—The marginal teeth of the latter, more highly magnified, and viewed nearly in the plane of the harpe, so as to show them in elevation.
Fig. 7. *O. Brookeana.*—The scaphium, viewed vertically from above.
Fig. 8. *O. Brookeana.*—The scaphium, seen from the right side. The left valve and its harpe are indicated in faint outline.
Fig. 9. *Ornithoptera Amphrysus.*—The interior of the right valve with is harpe, magnified about 7 times.
Fig. 10. *O. Amphrysus.*—The abdominal organs, seen from above.
Fig. 11.—*O. Amphrysus.*—The abdominal organs, seen from the sides, both valves having been removed.
Fig. 12. *Ornithoptera Remus.*—The right valve and harpe.
Fig. 13. *O. Remus.*—The harpe, more magnified.
Fig. 14. *O. Remus.*—The same, in outline, flattened.

Fig. 15. *O. Remus.*—The end of the abdomen, both valves removed, and the walls of the segments in part broken away, to show the scaphium-curtain.

Fig. 16. *O. Remus.*—The uncus and scaphium, from above.

In figs. 16, 17, 18, and 19 the small letters have the following signification :—*a*, the uncus; *b*, the chitinous lamina of the scaphium; *c*, its cheek; *d*, the sulcus; *e*, the aristæ; *f*, the pentagon; *g*, the keel; *h*, its lobes; *i*, its groin.

Fig. 17. *O. Remus.*—The same, from the right and somewhat from above.

Fig. 18. *O. Remus.*—The scaphium, from the front.

Fig. 19. *O. Remus.*—The scaphium and its keel, from beneath.

Fig. 20. *O. Remus.*—The penis, extracted.

Plate XXVIII.

Fig. 1. *Papilio Memnon.*—The interior of the right valve, with its harpe *in situ*.

Fig. 2. *P. Memnon.*—The terminal portion of harpe, shown laterally, more magnified, and viewed as a transparent object on the stage of the microscope.

Fig. 3. *P. Memnon.*—The abdominal organs. The right valve having been detached, the left and its harpe indicated in outline.

Fig. 4. *Papilio Mayo.*—The interior of the right valve, with its harpe *in situ*.

Fig. 5. *P. Mayo.*—The harpe detached, and more magnified.

Fig. 6. *P. Mayo.*—The abdominal organs *in situ*, from the right, the valves having been removed, and the segments denuded of hair-scales.

Fig. 7. *P. Mayo.*—The scaphium, more magnified, seen from the front.

Fig. 8. *P. Mayo.*—The scaphium, seen from the right.

Fig. 9. *Papilio Erechtheus.*—The interior of the right valve and its harpe.

Fig. 10. *P. Erechtheus*—The harpe, more magnified, and viewed from the ventral side.

Fig. 11. *P. Erechtheus.*—The uncus and its abdominal origin, denuded of scales, viewed vertically from above.

Fig. 12. *P. Erechtheus.*—The same, seen laterally from the right.

Fig. 13. *P. Erechtheus.*—The organs *in situ*, with the right valve removed, the left with its harpe, delineated in faint outline.

Fig. 14. *Papilio Rhetenor.*—The interior of the right valve, with its harpe *in situ*.

Fig. 15. *P. Rhetenor.*—Expanded extremity of harpe, further magnified.

Fig. 16. *P. Rhetenor.*—The abdominal organs.

Fig. 17. *Papilio Deiphontes.*—The interior of the right valve, with the harpe *in situ*.

Fig. 18. *P. Deiphontes.*—The harpe removed from its attachment, viewed from the ventral side, and further magnified, the terminal portion alone being depicted.

Fig. 19. *P. Deiphontes.*—The uncus, scaphium, and penis *in situ*, viewed from the right side, both valves being removed.

Fig. 20. *Papilio Schmeltzi.*—Interior of right valve, with the harpe *in situ*.

Fig. 21. *P. Schmeltzi.*—Interior of left valve, with the harpe.

Fig. 22. *P. Schmeltzi.*—The extremity of the right harpe, showing the teeth, magnified 140 diameters.

Fig. 23. *Papilio Polymnestor.*—The interior of the right valve, with the harpe *in situ*.

Fig. 24. *P. Polymnestor.*—The harpe further magnified.

Fig. 25. *Papilio Protenor.*—The interior of the right valve, with the harpe *in situ*.

Fig. 26. *P. Protenor.*—The harpe further magnified.

Fig. 27. *Papilio Ascalaphus.*—The interior of the right valve, with the harpe.

Fig. 28. *P. Ascalaphus.*—The harpe further magnified.

Plate XXIX.

Fig. 1. *Papilio Helenus.*—The interior of the right valve, with the harpe *in situ*.
Fig. 2. *P. Helenus.*—The harpe, viewed from the side.
Fig. 3. *P. Helenus.*—Abdominal organs, the right valve being removed.
Fig. 4. *Papilio Menestheus.*—The right valve, with the harpe *in situ*.
Fig. 5. *P. Menestheus.*—The harpe, further magnified.
Fig. 6. *P. Menestheus.*—The abdominal organs.
Fig. 7. *Papilio Pammon.*—The interior of the right valve and its harpe.
Fig. 8. *P. Pammon.*—The harpe, further magnified.
Fig. 9. *P. Pammon.*—The abdominal organs; the segments denuded of clothing-scales, and both valves removed.
Fig. 10. *Papilio Agavus.*—The interior of the right valve, with the harpe and its affixing base *in situ*.
Fig. 11. *P. Agavus.*—The left valve. (See p. 302, note.)
Fig. 12. *P. Agavus.*—The harpe of the same removed, and further magnified.
Fig. 13. *P. Agavus.*—The abdominal organs.
Fig. 14. *Papilio Machaon.*—The interior of the right valve, with the harpe *in situ*.
Fig. 15. *P. Machaon.*—The harpe removed and further magnified.
Fig. 16. *P. Machaon.*—The abdominal organs, viewed from the right side; both valves removed.
Fig. 17. *Papilio Arcturus.*—The interior of the right valve with its harpe.
Fig. 18. *P. Arcturus.*—The harpe, further magnified.
Fig. 19. *P. Arcturus.*—The teeth of the same, with the grooves, still more magnified.
Fig. 20. *Papilio Merope.*—The interior of the right valve, with its harpe.
Fig. 21. *P. Merope.*—The harpe, more magnified.
Fig. 22. *P. Merope.*—The uncus (denuded) and the scaphium, viewed vertically.
Fig. 23. *P. Merope.*—The abdominal organs, viewed from the right side. The edge of the tegumen denuded, the right valve removed.
Fig. 24. *Papilio Brutus.*—The interior of the right valve, with the harpe.
Fig. 25. *P. Brutus.*—The harpe, more magnified.

Plate XXX.

Fig. 1. *Papilio Homerus.*—The interior of the right valve, with its harpe.
Fig. 2. *P. Homerus.*—The harpe removed and further magnified.
Fig. 3. *P. Homerus.*—The abdominal organs, viewed from the right side; both valves removed and the edges of the segments in part denuded.
Fig. 4. *P. Homerus.*—The scaphial teeth, seen from the right, and further magnified; the left double tooth in faint outline only.
Fig. 5. *Papilio Ulysses.*—The interior of the right valve, with the harpe.
Fig. 6. *P. Ulysses.*—The extremity of the harpe, viewed at a different angle, and more magnified.
Fig. 7. *P. Ulysses.*—The abdominal organs, viewed from the left side, partly denuded, and both valves removed.
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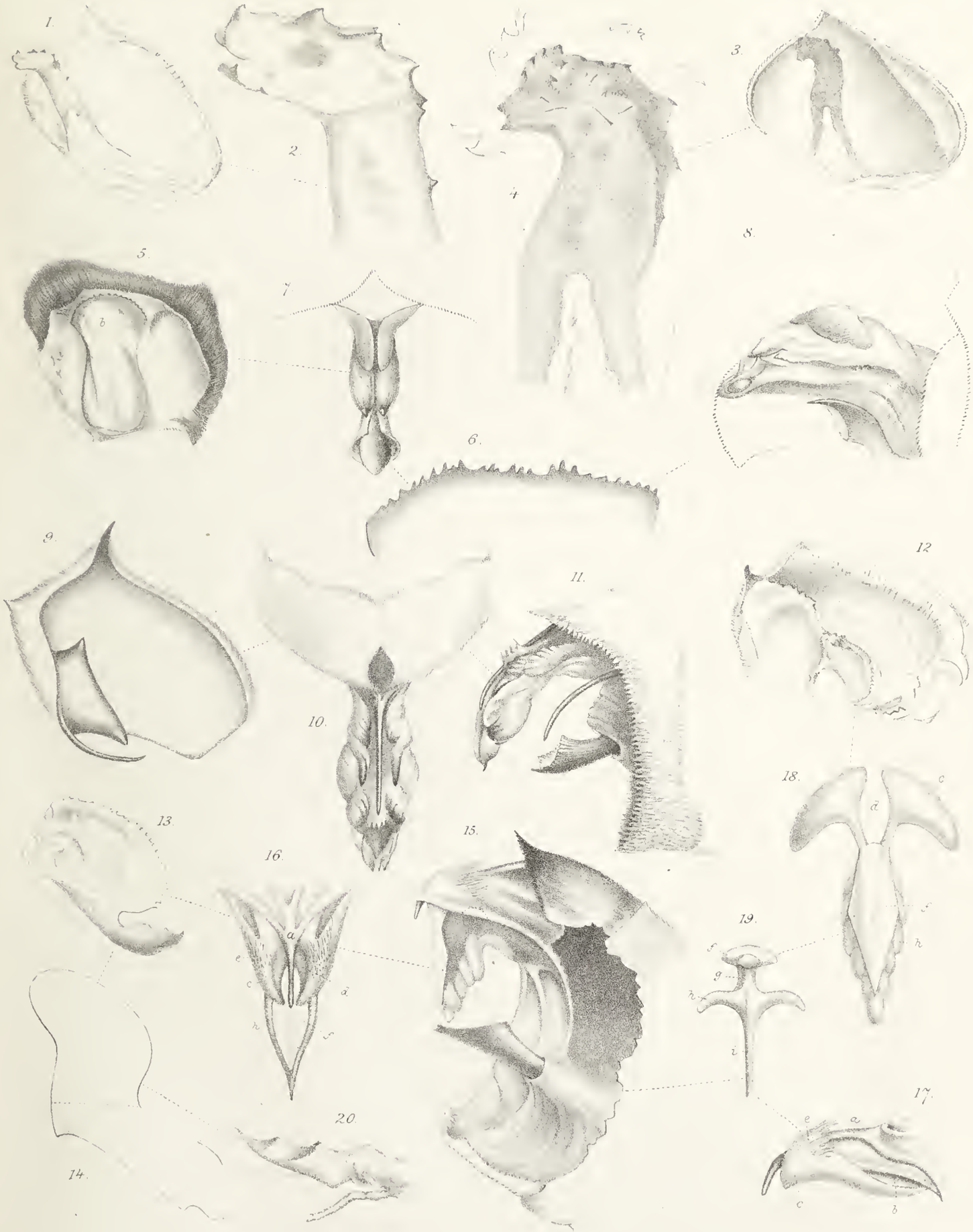

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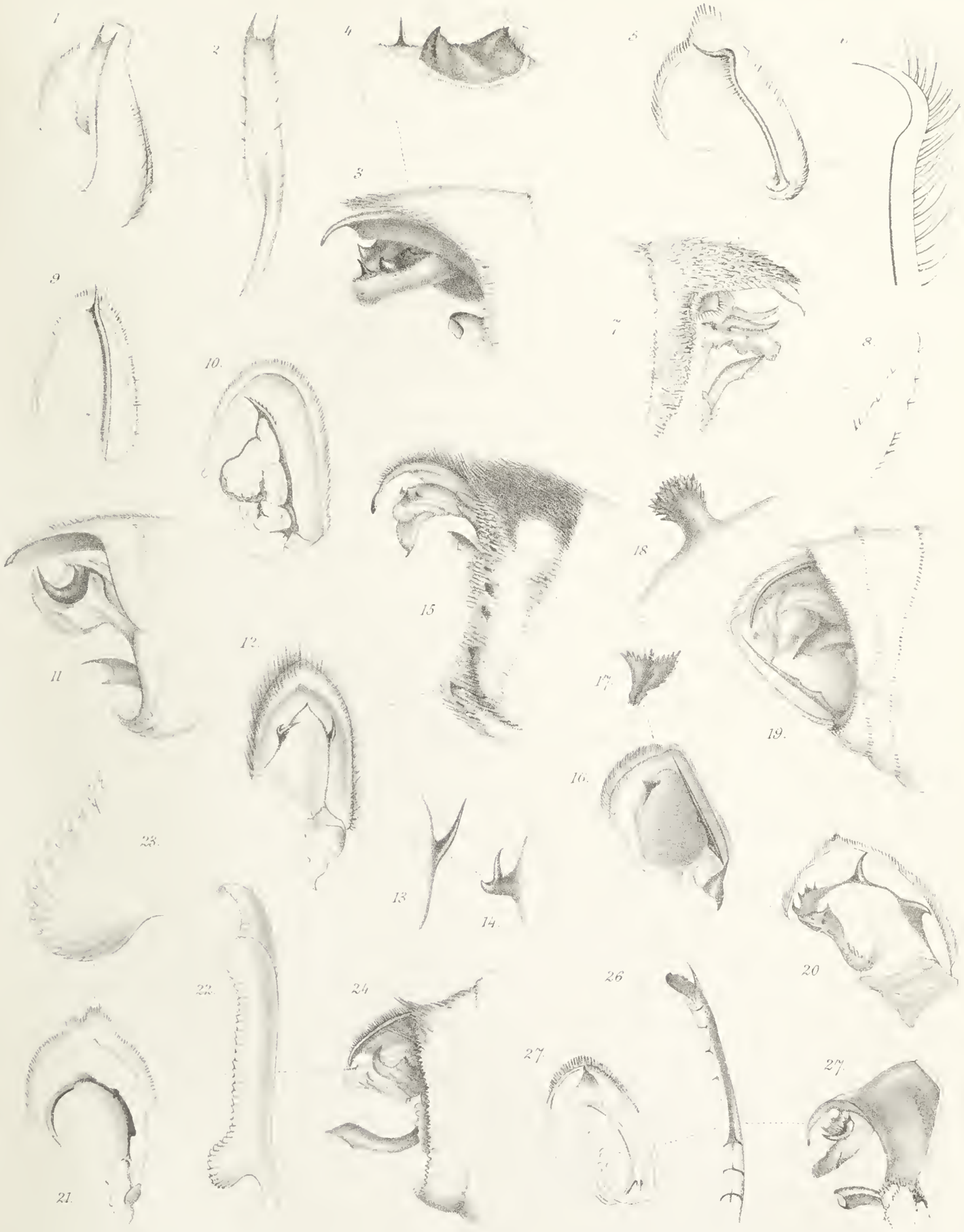

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