&c. Dr. Alix* has described how that, in the common Swan (*Cygnus olor*), there is no long flexor tendon to the small hallux. I have not examined that species; but there is undoubtedly a small one in *C. nigricollis*, *C. atratus*, and in all the other Anserine birds I have examined, as above mentioned. However I have found this tendon to the hallux wanting in

Parra africana, *Pygosceles papua*,
Chauna derbiana, *Podiceps minor*.

Professor C. Sundevall has shown† that in the Passeres and in *Upupa epops* the tendons of the *flexor longus hallucis* and the *flexor perforans digitorum* are quite free from one another, not being united by any vinculum. In all the Passeres which I have examined my observations agree with these generalizations. However, the same condition maintains in *Botaurus stellaris* and almost in *Ardea cinerea*, where the vinculum is scarcely more than a single fibre (*vide* fig. 9).

DESCRIPTION OF FIGURES.

In all the figures the numbering refers to the digits I, II, III, IV, representing the hallux, second, third, and fourth digits respectively. In all, the deep plantar tendons are alone represented, and these from their plantar aspect, the hallucial tendon being the outer of the two at the heel-joint.

Fig. 1. Left foot of *Gallus bankiva*; V, vinculum running downwards from the outer hallucial tendon to the inner digital common tendon.
2. Right foot of *Apteryx mantelli*.
3. Right foot of *Tinnunculus alaudarius*.
4. Right foot of *Buceros rhinoceros*.
5. Right foot of *Momotus lessoni*.
6. Arrangement of the tendons in the left foot of *Trogon puella*.
7. Right foot of *Crotophaga sulcirostris*.
8. Right foot of *Megalæma asiatica*.
9. Right foot of a Passerine bird.

May 4, 1875.

E. W. H. Holdsworth, Esq., in the Chair.

The following report on the additions to the Society's Menagerie during the month of April 1875 was read by the Secretary:—

The total number of registered additions to the Society's Menagerie during the month of April 1875 was 157, of which 14 were by birth, 72 by presentation, 54 by purchase, 11 by exchange, and 6 were received on deposit. The total number of departures during the same period by death and removals was 94.

The most noticeable additions during the month were:—

1. A Syrian Bulbul (*Pycnonotus xanthopygos*, Hempr. et Ehr.), presented by E. T. Rogers, C.M.Z.S., April 12th. This species is new to the Society's collection.

2. A collection of small Finches from South America, purchased April 19, amongst which are examples of several species (*Spermophila*

* Essai sur l'appareil locomoteur des Oiseaux. Paris, 1874, p. 464.

† Methodi naturalis avium disponendarum tentamen (Stockholm, 1872), and elsewhere.

cærulescens, S. aurantia, S. lineola, and *S. hypoleuca*) not previously exhibited.

3. An albino of the Common Macaque (*Macacus cynomolgus*) or of the Philippine form of the species (*M. philippinensis*), brought from Samar, Philippines, and presented by Mr. J. Ross, April 23rd. We have now a pair of these albino Monkeys in the Menagerie.

Mr. Sclater exhibited and made remarks on the skin of a chick of a Cassowary (supposed to be *Casuarius picticollis*, Sclater, P. Z. S. 1875, p. 84, Plate XVIII.) which had been transmitted to him for examination by Dr. George Bennett, F.Z.S., of Sydney. The bird had been obtained alive from the natives in Milne Bay, New Guinea, by Mr. Godfrey Goodman, Staff-Surgeon, R.N., when on the 'Basilisk' in 1873. It had died on board; and its skin had been preserved by Mr. Goodman.

The bird was still in the first down-plumage, and was generally of a pale buffy brown with the head above rufescent. The back was dark with one median and on each side two lateral broad stripes of pale brown. These stripes ran regularly parallel down the whole length of the back. The whole length of the skin from the beak to the tail was 10·5 in., of the tarsus 2·9, and of the bill from the gape 2·5.

Mr. Sclater proposed to deposit this specimen, as requested by Mr. Goodman, in the British Museum.

Prof. Newton exhibited two specimens of Ross's Gull (*Rhodostethia rossi*) received from Greenland by the Royal Museum of Copenhagen.

Professor Newton, M.A., F.R.S., F.Z.S., exhibited tracings of some unpublished sketches of the Dodo and other extinct birds of Mauritius, remarking:—

"In the summer of 1868 Mr. Hessels, an assistant in the Public Library of the University of Cambridge, informed me that, having lately been in Holland, he had there been shown the original manuscript of a journal kept during the voyage of Wolphart Harmanszoon to Mauritius in 1601–1602, which was embellished by drawings of the Dodo (*Didus ineptus*) and other birds. The text of the journal I was told had been published, but not so these sketches. I at once wrote to Professor Schlegel, acquainting him with the fact; and he replied that his attention had been already drawn to this very interesting volume, which, if I am not mistaken, belongs to a library at Utrecht. He further told me that among the birds represented were species which could be easily identified as *Aphanapteryx broecki* and *Psittacus mauritianus*, and added that he was preparing a memoir on the subject.

"I have naturally been most anxious ever since to see these sketches or copies of them; but expecting that Prof. Schlegel would shortly carry out his intention, I was careful not to interfere with his design, and contented myself with inserting a short notice of the fact in the 'Ibis' for 1868 (pp. 503–504). I have, however, waited in vain for the promised memoir. A few days ago M. Alphonse Milne-Edwards was so good as to send me tracings of the sketches, which he had obtained during a recent visit to Leyden; and I now have the pleasure of showing them to the Members of the Society present.

"The figures of the Dodo do not call for much remark; but no one can look at them without perceiving that, rough as they are, they must have been drawn by no common hand and evidently from the life. The various attitudes in which the bird is represented certainly assist us in forming a conception of what it must have been like.

"The sketch of *Aphanapteryx* would seem to have been taken from a freshly-killed bird, as it might have lain on the ground before the limner. But this also, so far as I can judge, does not add to our knowledge of this remarkable form, which we have already so well depicted by Hoefnagel.

"The remaining tracing is of more importance. I think Prof. Schlegel is clearly right in assigning it to *Psittacus mauritianus*, Owen *, which we only know from a few bones. The most extraordinary feature it presents is perhaps the frontal crest, of a shape quite unlike that found, so far as I am aware, in any other form of Parrot, rising as it does from the very base of the bill and terminating before it reaches the occiput, which appears to be flat and smooth. No sooner did I see this singular crest than it struck me that the figure of a bird given in one of the plates to Van Neck's Voyage, which has always been a puzzle to everybody, must have been intended for this species. The plate was copied in *fac-simile* for Strickland's work †; and the description of this particular figure (5) is given by him thus:—

"'5 est un oiseau de nous nommé Corbeau Indien, ayant la grandeur plus d'une fois que les Parroquets, de double et triple couleur.'

"He, it is true, says of it 'A species of *Buceros*' (p. 10, note); but no species of that genus, or any thing like it, has been seen from Mauritius, and I cannot help thinking that the figure must refer to *P. mauritianus*. If the sketch I now exhibit can be trusted as to the shortness of the bird's wings, it is very suggestive.

"Professors Owen (*loc. cit.*) and A. Milne-Edwards (Ann. Sc. Nat. ser. 5, vi. pp. 91–111) have pointed out several osteological characters which distinguish this Parrot; and the latter has shown that it cannot be referred to any of the established genera or subgenera of *Psittaci*. I would therefore propose the name of LOPHOPSITTACUS for the group of which it is the type—the only known external character that we can as yet depend upon being that afforded by the singular frontal crest.

"In conclusion, I have to add that Strickland states (p. 13) that in the published accounts of Harmanszoon's voyage no mention of Dodos occurs. It is, however, evident that there was some one of his company well employed in taking notes; and it is only to be hoped that Prof. Schlegel will not much longer delay to print them."

The following papers were read:—

* Ibis, 1866, p. 168.

† 'The Dodo and its Kindred,' pl. ii.

1. On the Colouring-matters of the Shells of Birds' Eggs. By H. C. Sorby, F.R.S., F.L.S., F.Z.S., &c., Pres. R.M.S.

[Received April 30, 1875.]

Table of Contents.

Introduction.

Any one examining a large series of different kinds of birds' eggs could not fail to be struck with the almost unlimited variety of their tints, and might readily be led to suppose that nothing definite could be made out from them. I have, however, found, by employing the same kind of spectrum method of inquiry which has led to such definite results in the case of plants, as shown in my various published papers, especially in one on comparative vegetal chromatology*, that all this apparent confusion is due simply to a variation in the relative and total amount of a limited number of definite and well-marked substances. So far as I have been able to ascertain, they have never been investigated by the spectrum method, and little more has been done than to offer such crude suggestions as that the redder colours are due to altered blood, which passes through the swollen vessels of the oviduct †, and that both the redder and greener colours are due to bile-pigments ‡ and are perhaps derived from the fæces in the cloaca §.

As I shall show, there is indeed good physical evidence to prove that the characteristic colouring-matters of eggs are closely connected either with hæmoglobin or bile-pigments, but not in such a manner as would agree with the above-named rough, almost mechanical theories, which were formed before the application of the spectrum method of inquiry made it possible to identify or distinguish organic colouring-matters of the kind now under consideration. So far as I am able to judge from what is now known, the colouring of eggs is due to definite physiological products, and not to accidental contamination with substances whose function is altogether different.

* Proceedings of the Royal Society, 1873, vol. xxi. p. 442.
† Leuckart, 'Handwörterbuch d. Physiologie,' vol. iv. 894.
‡ Naumannia, 1858, p. 393.
§ Blasius, Zeitsch. für wiss. Zoologie, xvii. p. 480.

Hitherto I have been able to distinguish seven well-marked substances. One of these is identical with a colouring-matter met with in nearly all groups of plants, from the lowest to the highest; but I have not yet been able to identify any of the rest with any found elsewhere. But, at the same time, I must admit that our knowledge of animal colouring-matters is far too limited to make such negative evidence of much value. All these seven coloured substances found in the shells of birds' eggs are insoluble in water, but soluble in absolute alcohol, either when neutral or when a small amount of free acid is present. They are also sometimes soluble in chloroform or carbon bisulphide. Absolute alcohol, however, is in every respect the most convenient and best solvent. Some are extremely permanent, and resist the action of powerful reagents, whereas others are of such unstable character that they are not only rapidly changed by acids or oxidizing reagents, but are even partially decomposed by evaporating their solutions to dryness at a gentle heat. In these general peculiarities they resemble bile-pigments more than any other group of colouring-matters, but do not actually agree with any that have passed under my notice. Some of them furnish us with a number of most interesting facts in illustration of the probable existence of a connexion between optical properties and chemical or molecular constitution; and the spectra of some of them throw much light on the theory of the arithmetical relations between the wave-lengths of the centres of absorption-bands, as I have shown in a paper read before the Royal Microscopical Society *; but on the present occasion I forbear to enter into such questions, and will confine myself as much as possible to the zoological aspect of the subject. At the same time it is absolutely necessary to enter into a certain amount of chemical and optical details, since otherwise the characteristic peculiarities of the different substances could not be established.

Method of Study.

In the first place, it may be well to remark that very little indeed can be deduced with certainty from mere general colour. Some important and reliable information may be learned from the spectrum of the light reflected from the eggs themselves or transmitted through broken fragments; but in order to study colouring-matters in a satisfactory manner, it is requisite to obtain them in solution, so that they may be more or less separated from one another, their spectra seen to greater advantage, and the effect of various reagents determined. In the shells of eggs the coloured substances are so intimately associated with carbonate of lime that they cannot be dissolved out; and even when this has been removed, they are often so firmly enclosed in other insoluble organic substances, that it is difficult or impossible to dissolve them out completely. In the majority of cases it is best to remove the earthy carbonates by means of somewhat dilute hydrochloric acid, added gradually until no further effervescence takes place. The character of the residue varies much in different cases. Sometimes we obtain a

* Monthly Microscopical Journal, vol. xiii. p. 198.

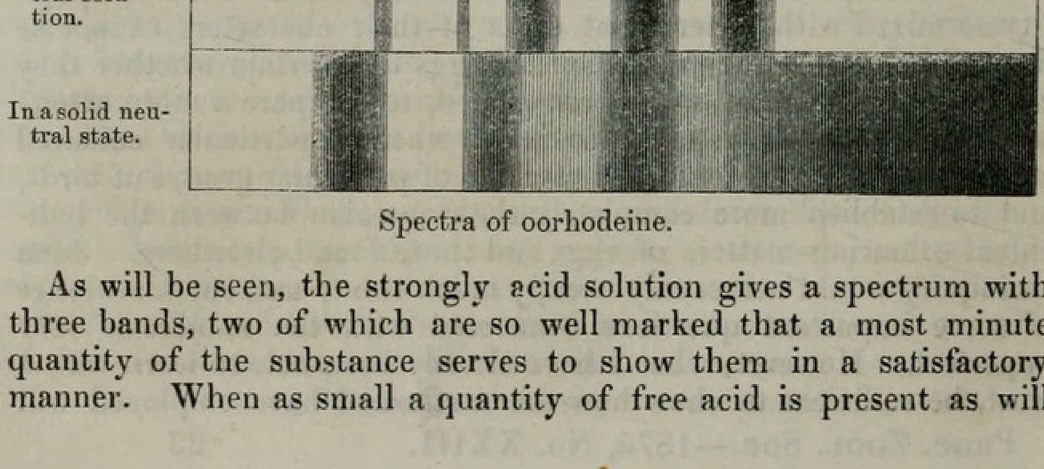
coloured membrane, occasionally like dark morocco leather, whilst in other cases the membranous part is very pale, and the colour chiefly occurs in detached skin-like flocks, or as minute particles disseminated through the liquid. By far the greater portion of these can easily be removed by filtration; but still in very many cases an appreciable quantity of the colouring-matter remains in the liquid, in such a state of unstable solution that nearly the whole is deposited in an insoluble form on evaporating at a gentle heat. In any case the insoluble coloured residue should be washed with water on a filter, abstracting from it any considerable portions of pale or colourless membrane; and after removing the greater part of the adhering water and the portions of the filter to which no colouring-matter is attached, it should be placed whilst still moist in absolute alcohol. This usually dissolves out a considerable amount of the colour; but some still remains insoluble. A portion of this is occasionally soluble in alcohol containing free acetic acid; but very often much remains undissolved until the residue is treated with alcohol containing hydrochloric acid. Sometimes even this fails to remove all, even when heated for many hours. All these different solutions should be kept separate, since they usually differ most materially; and in no case should a strong acid solvent be used unless found to be necessary, because several of the normal colouring-matters are rapidly decomposed by strong free acids. For this reason it is in some cases advisable to separate the carbonate of lime from the shell by means of acetic acid; but then unfortunately the colouring-matters are much less readily dissolved out of the residue by alcohol.

Description of the Colouring-matters.

These general remarks will I trust suffice to indicate the character of the methods usually employed; and I therefore now proceed to describe the different coloured substances hitherto met with. The number of species of eggs which I have been able to carefully study is less than I could have wished; but at the same time, in looking over large collections, I have been able to see that those which I have studied in detail represent nearly the whole of the characteristic differences. What more especially remains to be done is to find examples of eggs which will enable us to prepare in a more pure state certain colouring-matters which usually occur in small quantity so mixed with others that some of their characters cannot be determined, to examine a few special eggs to ascertain whether they contain any substance not yet recognized, to compare a more extensive series of eggs in order to learn whether particular coloured substances are or are not characteristic of particular groups of birds, and to establish more completely the connexion between the individual colouring-matters of eggs and those found elsewhere. Such an inquiry would necessarily occupy much time; and our knowledge of some important questions connected with the subject is very imperfect. However, what I have already been able to learn will, I trust, be sufficient to show how the methods I have employed will suffice to explain the more obvious peculiarities of the colours of eggs.

1. *Oorhodeine*.—This is perhaps the most important and interesting of all the colouring-matters, not only because it gives a number of most interesting spectra, of such a well-marked character that a very minute quantity can be recognized without any difficulty, even when mixed with a relatively large quantity of coloured impurities, but because it occurs, in large or smaller amount, in the shells of such a great number of eggs that its entire absence is exceptional. When in a perfectly neutral condition it is almost insoluble in alcohol; so that when the washed shell-residue is digested in cold absolute alcohol very little is dissolved, until a small quantity of hydrochloric acid is added. On evaporating this solution to dryness at a gentle heat, and treating it at once with absolute alcohol, a considerable part dissolves, probably because a small quantity of acid clings to it; but if a small excess of ammonia be added, and the solution again evaporated to dryness, the neutral residue is all but insoluble in alcohol. These peculiarities enable us to separate oorhodeine from most of the other colouring-matters, and to obtain it approximately pure. It gives spectra with extremely well-marked absorption-bands, which differ in number, character, and position according to the conditions in which it occurs. The more important of these spectra are shown by fig. 1, in which, as well as in all the other figs., they are given, not as seen with a *prism*, but as they would appear in an *interference* spectroscope, since in that case alone do we see the true relations of the different parts. To any one accustomed only to an ordinary spectroscope the blue end will therefore appear abnormally contracted and the red end expanded unusually. The numbers given at the top represent millionths of a millimetre of wave-lengths of the light.

Fig. 1.



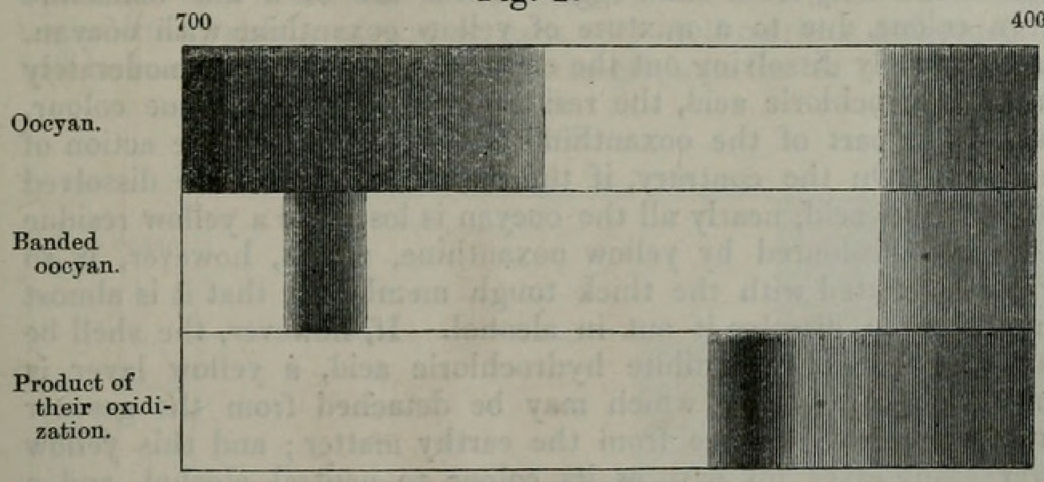
Spectra of oorhodeine.

As will be seen, the strongly acid solution gives a spectrum with three bands, two of which are so well marked that a most minute quantity of the substance serves to show them in a satisfactory manner. When as small a quantity of free acid is present as will enable the alcohol to dissolve oorhodeine, the spectrum shows the five absorption-bands given in fig. 1, and the general colour is brownish-red. This is the spectrum of the almost neutral modification when in a state of *solution*. When in a free *solid* form, as in the shell, or as found in the washed dry skin-like residue after removing the carbonate of lime by an acid, the spectrum is most materially different, as will be seen from the woodcut. Only three bands are distinctly visible, and they lie nearer to the red end, whilst there is far more of general absorption at the blue end. The result of this is that the general colour is a peculiar brown-red.

Oorhodeine is of such a very permanent character that it resists the action of very powerful reagents. I have been able to destroy it, but have not yet succeeded in changing it into any other coloured substance.

2. *Oocyan.*—In most cases this is readily soluble in neutral alcohol, and can thus be separated from oorhodeine. It is, however, often associated with yellow substances that cannot easily be removed; very commonly, therefore, the solution is of a somewhat green-blue colour, but in many cases the yellow impurity is far more easily decomposed by the action of light or by weak oxidizing reagents, and can be removed by this means, so as to enable us to determine the true colour and spectrum of the oocyan itself. When dissolved in alcohol, it is of a very fine blue colour. The spectrum shows no detached bands, but a strong general absorption of the entire red end and of a small portion of the extreme blue, as shown in fig. 2.

Fig. 2.



Spectra of the oocyans, &c.

3. *Banded Oocyan.*—This also is of fine blue colour, but differs from the former species in giving a spectrum with a well-marked detached absorption-band near the red end, as shown in fig. 2. It is also far less soluble in neutral alcohol, so that it is left in the shell-residue after having been digested for some time in cold neutral alcohol, and can subsequently be dissolved out by alcohol, to which a minute quantity of hydrochloric acid has been added. The solution must, however, be examined at once, since banded oocyan is rapidly decomposed by strong acids.

Both these different kinds of blue colouring-matter are evidently in a state of very unstable equilibrium. Sometimes the greater part of the colour is lost by merely evaporating their solutions to dryness at a gentle heat; and several very interesting products can easily be obtained by acting on them with reagents.

On adding a moderate excess of hydrochloric acid to a solution of oocyan, no other immediate change occurs than the destruction of some of the yellow substances that may be present; but in the case of *banded* oocyan, two new faint bands are developed in the orange and yellow end of the green, and it is gradually changed into a new modification, or perhaps even into a new substance, characterized by giving a spectrum with two bands, quite unlike that of the original. On adding to the solution of banded oocyan a little hydrochloric acid and nitrite of potash, it is rapidly decomposed into an orange-coloured substance, giving a spectrum with a simple well-marked absorption-band between the green and blue, as shown in the fig. In the case of oocyan this same substance is also produced; but there is an intermediate red compound formed, characterized by giving a spectrum with two bands (one in the orange, and the other at the yellow end of the green), which, however, do not correspond to those of the product of the action of acid on the banded oocyan.

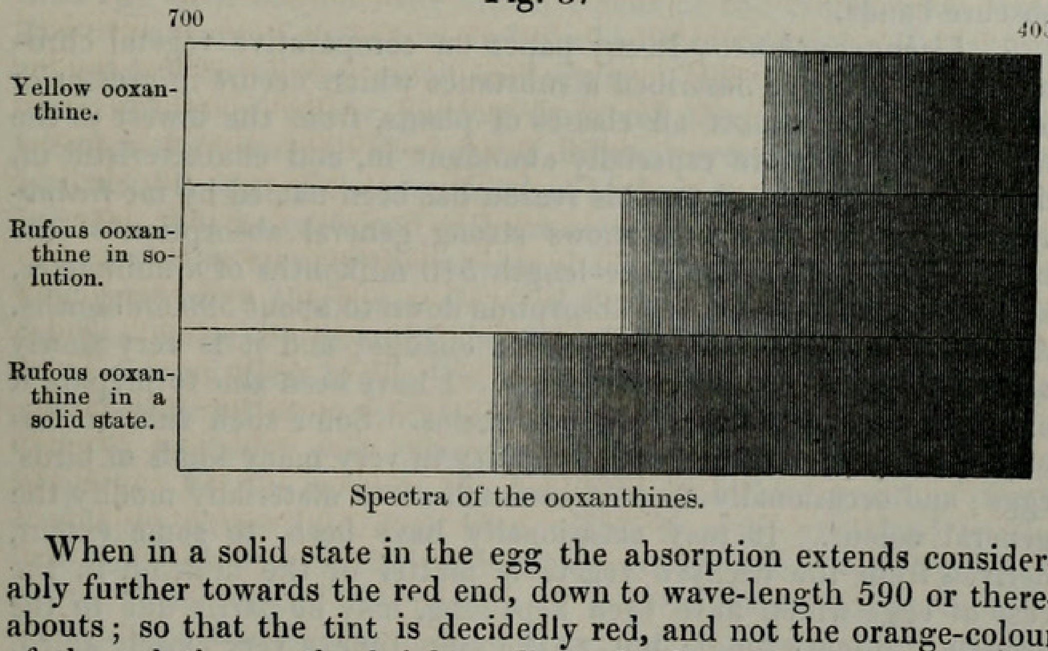
It will thus be seen that these two blue colouring-matters (oocyan and banded oocyan) differ in very important particulars, but are obviously closely related, since they both yield the same well-marked product when oxidized.

4. *Yellow Ooxanthine.*—This substance may be best obtained from moderately fresh Emu-eggs. These are of a fine malachite green colour, due to a mixture of yellow ooxanthine with oocyan. On completely dissolving out the carbonate of lime with moderately strong hydrochloric acid, the residue is of deep green-blue colour, and a large part of the ooxanthine is decomposed by the action of the acid. On the contrary, if the carbonate of lime be dissolved out by acetic acid, nearly all the oocyan is lost, and a yellow residue is obtained, coloured by yellow ooxanthine, which, however, is so firmly associated with the thick tough membrane, that it is almost impossible to dissolve it out in alcohol. If, however, the shell be partially dissolved in dilute hydrochloric acid, a yellow layer is formed on the surface, which may be detached from the greener part below, not yet free from the earthy matter; and this yellow layer easily gives up part of its colour to neutral alcohol, and a further quantity to alcohol containing a little acetic acid. These solutions are of a clear yellow colour, giving a spectrum with no detached bands, absorbing the whole of the blue light, and strongly transmitting nearly all the green and the whole of the red end of the spectrum; that is to say, light of less wave-length than 500 millionths of a millimeter is absorbed, and of greater wave-length transmitted. In a solid state, in the egg-shell, the absorption extends down to wave-length 508. Alkali and weak acids produce no immediate change in the solution; but a strong acid like hydrochloric rapidly decomposes yellow ooxanthine, and leaves only a pale, almost colour-

less residue of another substance, which will be described in the sequel. This change takes place immediately if a minute portion of nitrite of potash be added to the acid solution. The alcoholic neutral or acetic solution is also rapidly decolorized by exposure to direct sunlight. Hence it will be seen that this yellow substance is in a state of very unstable equilibrium, and is rapidly decomposed by oxidization, when a strong acid is present in a free state, or when exposed to bright light.

5. *Rufous Ooxanthine.*—Hitherto I have not met with this substance in any other eggs but those of the different species of Tinamou, and have studied it more especially in those of *Rhynchotis rufescens*, in which it occurs associated with much oocyan. It agrees with yellow ooxanthine in being rapidly decomposed by a strong free acid, and immediately when a little nitrite of potash is added; but it is not so easily, if indeed at all, destroyed by the action of a moderately dilute aqueous solution of hydrochloric acid; and its presence does not seem to have any effect in decomposing the oocyan; whereas yellow ooxanthine has a most remarkable influence, since, as will be apparent from what I have already said, when the carbonate of lime is dissolved out by a weak acid the whole of the oocyan disappears if the amount of yellow ooxanthine is considerable, whereas no such decomposition occurs when it is absent. Rufous ooxanthine also differs from yellow ooxanthine in absorbing light to a very considerably greater distance from the blue end. Even when dissolved in alcohol it absorbs not only all the blue, but also at least one half of the green; that is to say, all light of less wave-length than 550 millionths of a millimetre is absorbed, and all of greater wave-length transmitted, which, of course, is a very well-marked difference, as will be seen on comparing the spectra given in fig. 3.

Fig. 3.



Spectra of the ooxanthines.

When in a solid state in the egg the absorption extends considerably further towards the red end, down to wave-length 590 or thereabouts; so that the tint is decidedly red, and not the orange-colour of the solution or the bright yellow of yellow ooxanthine. When mixed with oocyan, it therefore gives rise to the peculiar lead-colour of the eggs of the rufous Tinamou—and not to green, like that of the fresh eggs of the Emu.

6. *Substance giving narrow absorption-bands in the red.*—Unfortunately I have not yet succeeded in obtaining this in sufficient quantity, or sufficiently free from other substances, to be able to decide whether its true colour is blue, green, or brown; but the fact of its giving a spectrum with several narrow absorption-bands in the red would certainly indicate that, when mixed with other colouring-matters, it would cause them to have an abnormally browner tint. Small quantities of it occur in very many eggs; but I have not yet found it so abundant in any as to exercise a more important effect on the general colour than to make it somewhat more dull. Since the entire spectrum is not accurately known, I will merely give the position of the different very narrow absorption-bands in millionths of millimetres of wave-length. The most complete spectrum shows three bands. On adding excess of ammonia, that nearest the red end alone remains, whilst the addition of a small excess of a strong acid removes all but the central band—and when the excess is considerable, raises this band towards the blue end. These facts will be better shown by the following table:—

	Centre of bands.		
Most complete spectrum	668	648	628
With excess of ammonia	668		
With a little acid..............	..	643	
With much acid	..	641	

By means of these bands a very small quantity of this substance can easily be recognized. It is not readily decomposed—but, when acted upon with oxidizing reagents, may be changed into another colouring-matter, giving rise to a spectrum with one or two somewhat obscure bands.

7. *Lichnoxanthine.*—In my paper on comparative vegetal chromatology *, I have described a substance which occurs in greater or less amount in almost all classes of plants, from the lowest to the highest, but is more especially abundant in, and characteristic of, lichens and fungi, and for this reason has been named by me *lichnoxanthine*. The spectrum shows strong general absorption of the blue end down to about wave-length 510 millionths of a millimetre, and a much weaker general absorption down to about 590 millionths. Acids and alkalis produce very little change; and it is very slowly altered by strong oxidizing reagents. I have been able to prepare it artificially by the decomposition of resins. Some such substance is undoubtedly present in small quantity in very many kinds of birds' eggs; and occasionally there is so much as to materially modify the general colour. It may occasionally have been, to some extent, derived from the decayed vegetable matter of the nest, or, in the case of eggs which have been kept long, may be partly due to the growth of minute fungi; but, at the same time, a very closely allied,

* Proc. Roy. Soc. 1873, vol. xxi. p. 462.

if not identical, substance does really appear to be a normal constituent of the shell of eggs having a peculiar brick-red colour.

The various Colours of Eggs themselves.

Such, then, is a general account of those peculiarities of the colouring matters that have come under my notice, which suffice to distinguish them from one another and from analogous substances met with elsewhere; and I now proceed to a more detailed consideration of the eggs themselves. As an illustration of the method of study, suppose that we have taken portions of the brownish-red eggs of the common Grouse, of the pure brown eggs of the Nightingale, and of the pure blue of the common Thrush, separated from the black spots, kept for examination by themselves. After having, in each case, dissolved out the carbonate of lime with dilute hydrochloric acid and having washed the residues with water, they should each be digested in cold neutral absolute alcohol. Scarcely any colour would be dissolved out in the case of the Grouse—but a fine blue in all the others, which, on further examination, would be found to be oocyan, with mere traces of other substances. After having dissolved out as much as possible, by means of fresh neutral alcohol, the residue should be digested in alcohol with a small quantity of hydrochloric acid. It would then be found that the Grouse-shell would give a rose-coloured solution, containing much of the acid modification of oorhodeine. The Nightingale would also give much oorhodeine, but the colour would be modified by the presence of oocyan; the blue portion of the Thrush-egg would give a small quantity of a fine blue substance, showing the spectrum of banded oocyan, with little or no trace of oorhodeine, whereas the dark spots would be found to give a very considerable quantity of oorhodeine. We thus clearly see that the redder egg is mainly coloured with oorhodeine; the blue egg with oocyan—the brown colour of the Nightingale being due to mixture of these two, and the black spots on the Thrush-egg to patches containing much oorhodeine. All the various intermediate shades of colour, passing from red through brown to blue, whether they occur in the eggs of different species or in the more or less variable eggs of the same kind of bird, or in patches on the same egg, can thus be explained without any difficulty.

In a similar manner the various shades of green, passing from the blue-green of such eggs as those of the common Hedge Sparrow to the fine malachite green of the fresh Emu, and to the very yellow-green seen on them in patches, are all due to a variable mixture of oocyan with yellow ooxanthine.

As is, no doubt, well known, many green eggs turn blue on long keeping. In this manner the beautiful malachite green of fresh Emu-eggs passes into dark blue. This is easily explained by the fact that yellow ooxanthine is much more easily destroyed by oxidization than oocyan. A portion of a green Emu egg exposed to strong light soon becomes much bluer, and so does a mixed solution of the two colouring-matters in alcohol, the yellow constituent being destroyed and the blue left.

A few eggs are of a brick-red colour. Those of Cetti's Warbler are as good an example as any I have seen; and on carefully comparing them with the browner red eggs of the common Grouse, I found that both contained a large amount of oorhodeine, but that the tint was made more dull in the case of the Grouse by the presence of a small quantity of the colouring-matter which gives the narrow bands in the red; whereas in the case of Cetti's Warbler this was almost or quite absent, and there was present a relatively very unusually large amount of the orange-coloured substance, which I have not been able to distinguish from lichnoxanthine. To the presence of this substance we may thus attribute the brick-red tints seen in a few eggs.

Connexion between the Colouring-matters of the Eggs and the Structure of the Birds.

My studies of colouring-matters by the spectrum method soon led me to perceive that the individual species of certain groups of coloured substances are so intimately connected with their life that plants may be arranged in a kind of natural order according to the presence, absence, or relative proportion of the various coloured constituents, which order on the whole agrees remarkably with that founded on structural characters, as shown in my paper on comparative vegetal chromatology.* This naturally led me to consider whether any such connexion could be recognized in the case of birds' eggs. Much remains to be learned before any positive opinion can be expressed; but what is already known appears to be sufficient to prove that, if there be any definite connexion between the general organization of birds and the coloured substances found in their eggs, it is not of such a kind as is at all obvious to any one who, like myself, is not thoroughly acquainted with anatomical details. Six out of the seven different colouring-matters occur in variable amount in a very great variety of eggs, but there is no greater variation than is met with in the different individual eggs of the common Guillemot; so that the study of the colouring-matters cannot be looked upon as of any value in distinguishing species, or even much wider groups, except, perhaps, in one particular instance. Hitherto I have met with rufous ooxanthine only in the eggs of the Tinamous, and perhaps in those of some species of Cassowary; and though the question needs further examination, it is perhaps desirable to give a short account of what is already known.

The eggs of the black variety of the common Duck are coloured with a nearly black substance, which I have not yet obtained in a state of solution, and which may correspond to the so-called *pigmentum nigrum*; but whether it is a simple substance or a mixture remains to be determined, and therefore it would be premature to class it with the other more typical colouring-matters.

Eggs of the Tinamous.

As previously described, rufous ooxanthine when in solid form in

* Proceedings of the Royal Society, xxi. p. 442.

the shell of such redder Tinamou-eggs as those of *Crypturus obsoletus* (Wickham), absorbs the blue, the green, and some of the yellow rays, but transmits the orange and red; so that the colour is a sort of orange-red, made duller and of more leaden tint in the eggs of other species by mixture with oocyan. The result is that we obtain tints which are not so decidedly different from those due to a mixture of oocyan with oorhodeine as to lead any one to conclude at once that they were not due to the same substances. However, when the eggs in their natural state are properly illuminated by light so condensed on them sideways from a lamp that as little as possible is reflected from the surface, the spectra are seen to differ entirely. When oorhodeine is present, one or more of its absorption-bands may be seen; but when the red colour is due to rufous ooxanthine, no trace of any such bands can be recognized. My knowledge of the chemical and optical characters of rufous ooxanthine when in a state of solution were derived from the study of the eggs of the rufous Tinamou (*Rhynchotis rufescens*); and hitherto I have been able to study only the spectra of the eggs of other species through the kindness of Mr. Osbert Salvin, on whose authority I give the various names. Taking all the facts of the case into consideration, it appears to me to be almost certain that the redder-coloured constituent in all the different species is rufous ooxanthine. At all events, none show any trace of the bands of oorhodeine, and all show the same absorption of light of less wave-length than about 590 millionths of a millimetre. All that remains to be done to make this point certain is to examine the *solutions* derived from other species than that I have named, in order to be sure that the chemical as well as the optical characters are identical. In the present state of the question the following conclusions must be looked upon as only extremely probable.

No species of Tinamou yet examined contains any recognizable amount of oorhodeine. The colour of many species is due to a variable mixture of rufous ooxanthine with oocyan, the former greatly preponderating in such red eggs as those of *Crypturus obsoletus, C. pileatus,* and *Nothoprocta curvirostris.* The red and blue constituents occur in more equal proportion in the peculiar lead-coloured eggs of *Rhynchotis rufescens. Calodromas elegans,* when in a comparatively fresh state, contains so much yellow ooxanthine that it is pale green-yellow; but by exposure to light this yellow constituent is decomposed, and the shell becomes a pale flesh-colour from the small residual amount of rufous ooxanthine. Fresh-laid eggs of *Tinamus solitarius* are of nearly the same deep green as those of the Emu; and the long-kept eggs of *Tinamus robustus* are of fine blue, as though in some species there were very little rufous ooxanthine, and the colouring, as in the case of the Emu, due to a mixture of oocyan and yellow ooxanthine. It will thus be seen that all the various peculiar tints can be explained by the presence of a variable quantity of rufous ooxanthine.

I have carefully examined the spectra of many other eggs which appeared at all likely to contain rufous ooxanthine, but have not yet seen any facts which seem to indicate that it occurs in any other group of birds than the Tinamous, unless, indeed, it be in the case of the eggs of *Casuarius bennettii* and *C. australis*. If further examination should confirm these conclusions, it appears to me that the facts will be of much interest in connexion with comparative physiology, as showing that, to a limited extent, even in the case of birds' eggs, there is a connexion between the general organization of the animals and their coloured secretions, since, as will be seen, such a well-marked group of birds as the Tinamous appears to be equally well distinguished by the formation of a special colouring-matter in the egg.

Connexion between the Colouring-matters of Eggs and other Organic Products.

It would obviously be very interesting to learn what connexion there is between the various colouring-matters described in this paper and substances met with elsewhere. Perhaps further inquiry may lead to the discovery of some of them in other situations; but, with the exception of lichnoxanthine, I have not yet detected or been at all events able to identify them with confidence except in the shells of birds' eggs. The spectra of oorhodeine are so well marked that there could be no difficulty in recognizing a comparatively small quantity; and yet no trace can be detected in feathers whose general colour is practically identical with that of birds' eggs coloured with oorhodeine.

In considering the relation between the coloured substances in birds' eggs and other natural or artificial products, we are at once brought face to face with a branch of inquiry which seems to promise most valuable results, but is now so much in its infancy that the conclusions can only be looked upon as very plausible. In a paper recently read before the Royal Microscopical Society* I have shown that in some cases it is certain, and in others probable, that when a coloured constituent is common to a number of distinctly different compounds these may and do generally give spectra which are most intimately related in the *ratio* of the *wave-lengths* of the centres of their absorption-bands, but the *actual* wave-lengths differ in the different spectra. We may perhaps better understand the facts by supposing that when a substance combined with the coloured constituent is replaced by some other, the general *shape* and constitution of the ultimate molecules is so slightly changed that the general character of the spectrum is the same, but the *size* of the molcules so far altered that they are put into relation with waves of light of a different length. It appears to me therefore that, when we meet with two substances which give almost exactly the same spectra and are changed in the same manner by the addition of reagents—in fact differ from one another only in the *numerical values*, and not in the *relations* of the wave-lengths of the bands or in any other essential particular—we may look upon it as very

* Monthly Microscopical Journal, vol. xiii. p. 198.

probable that there is some important chemical or physical relation between the two compounds.

Relations of Oorhodeine.

It would be difficult to find more striking examples of such a connexion than oorhodeine and the product of the decomposition of the red colouring-matter of blood by strong sulphuric acid, discovered and described by Thudicum*. When in a nearly neutral state, dissolved in alcohol, it gives a spectrum of exactly the same character as that of oorhodeine in the same physical condition; and on adding a small quantity of a strong acid to both they are both changed in the same manner, and give new spectra which are also of exactly the same character. The spectra of their neutral modifications and also those of the very acid solutions have most remarkable and unusual peculiarities, quite unlike those of any other substances; and therefore one cannot, I think, attribute the resemblance to mere accident. The agreement is so close that a superficial observer might easily be led to conclude that they were absolutely identical, and that oorhodeine was merely Thudicum's cruentine; but when the spectra are compared together side by side with a suitable instrument, it may be seen that although the number, relative intensity, and relative position of the bands, both in a neutral and acid condition, are exactly the same, the *position* of the band is *not* the same. The difference between the spectra is exactly like what is so often seen on comparing together the spectra of the same substance dissolved in different liquids; but this explanation will not apply in this case, because I find that the position of the bands in cruentine does *not vary* with the nature of the solvent, and the difference between its spectra and those of oorhodeine occurs when they are both dissolved in the *same* solvent. In order to show the nature of the relation of the spectra, I subjoin the following tables, giving the position of the centres of the absorption-bands in millionths of a millimetre of wave-length.

Table 1.—*Dissolved in nearly neutral alcohol.*

Oorhodeine	630	602	578	539	504
Cruentine	623	596	572	534	500
Difference	7	6	6	5	4

Table 2.—*Dissolved in Alcohol with strong Acid.*

Oorhodeine	604	580	557
Cruentine	598	574	552
Difference	6	6	5

Though I feel much tempted to enter further into the purely physical part of the question, it will, I think, be better to confine myself to what bears more directly on zoological facts. Following

* Tenth Report of the Medical Officer of the Privy Council, p. 227.

out the kind of arguments made use of in my late paper in the 'Monthly Microscopical Journal,' the conclusions to which we are led by the above-described facts are that oorhodeine is in some way or other closely related to cruentine, but not identical with it, as shown not only by the well-marked difference in the spectra, but also by the difference in their solubility and power of resisting the decomposing action of powerful reagents.

In the present state of our knowledge the most plausible explanation of all the facts is that perhaps oorhodeine and cruentine contain some common coloured radical of the same chemical or physical constitution, combined with some other substance which is itself colourless, and that this second constituent is not the same in oorhodeine as in cruentine, but differs sufficiently to modify the general properties and to slightly alter the size of the ultimate molecules and so as to cause them to be related to waves of light of a little different length. It must, however, be borne in mind that I advance these views merely as being the most probable explanation of the facts. Assuming them to be true, they lead to the conclusion that the oorhodeine of birds' eggs is derived from the red colouring-matter of the blood, not by any mere mechanical exudation, but by some unknown physiological process of secretion, which breaks up the highly complex molecule of hæmoglobin into one which can be formed artificially by heating it with strong sulphuric acid; but in the living organism it combines with a second substance differing from that with which it combines when the change is effected by the action of hot strong sulphuric acid. Whether this view of the subject be in all respects true or not, it at all events appears to me very plausible and well worthy of further examination, as pointing to the source of one of the most important colouring-matters of birds' eggs.

Relations of the Oocyans.

In their normal condition the fæces of man, and probably those of many other animals, contain a yellow colouring-matter, which by oxidization yields a substance closely related, if not identical, with a product of the oxidization of the bilirubin of bile described by Jaffé* and by Heynsius and Campbell†. When extracted from fæces by alcohol without contact with the air, it gives a spectrum which cuts off the blue end without any definite band; but when exposed to the air or treated with some oxidizing reagent, the solution becomes orange-coloured, and the spectrum shows a well-marked, dark, moderately broad absorption-band between the blue and the green, having its centre at wave-length 495 millionths of a millimetre. The addition of an excess of ammonia immediately removes this band without producing any well-marked change in the colour. Now I find, on comparing this substance with the product of the oxidization of the two species of oocyan, which gives the spectrum shown by fig. 2, that there is a close agreement in general characters, but yet a well-marked difference. The band

* Virchow's Archiv, vol. xlvii. p. 262. † Pflüger's Archiv, vol. iv. p. 520.

in the product from the oocyans is about $\frac{5}{4}$ the breadth; and its centre is a little further from the blue end, being at wave-length 497; and caustic potash does not develop any band as in the other substances. On the whole, then, if we follow the same line of reasoning as that adopted in the case of oorhodeine, we are led to conclude that the product of the oxidization of the two kinds of oocyan is in some way connected with a product of the change and oxidization of the colouring-matter of bile; and thus we may perhaps be justified in concluding that there is some chemical relation between the oocyans and bile. Bilirubin can indeed easily be converted by oxidization into a blue substance; but this differs entirely from either of the oocyans, both in its spectrum and in the character of the products of its decomposition. The residual bile-product found in fæces is in all probability a representative of a much further stage of change than to the oocyans; and if it could give rise to them it would be by a process of integration, which is not at all likely. On the whole their connexion with bile is as if we had two parallel series of products depending on two distinct physiological processes—one in the liver giving bile, and the other in the oviduct giving rise to eggshell-pigments.

Conclusion.

In conclusion I would say that the chief points which I have, I think, established are that all the varied tints of birds' eggs are due to mixtures of a limited number of colouring-matters, having well-marked specific characters. Except in one particular case, there is apparently no intimate connexion between the organization of the birds and the colouring-matters secreted; but, if further inquiry should prove that on the whole these substances are formed naturally only during the development of the eggs of birds, it would, I think, be an important fact in relation to comparative physiology and chromatology, as showing that special coloured substances are secreted under special anatomical and physiological conditions, as does indeed occur in the case of many other normal and abnormal secretions.

2. On the Hyoid Bone of the Elephant. By A. H. Garrod, B.A., F.Z.S., Prosector to the Society.

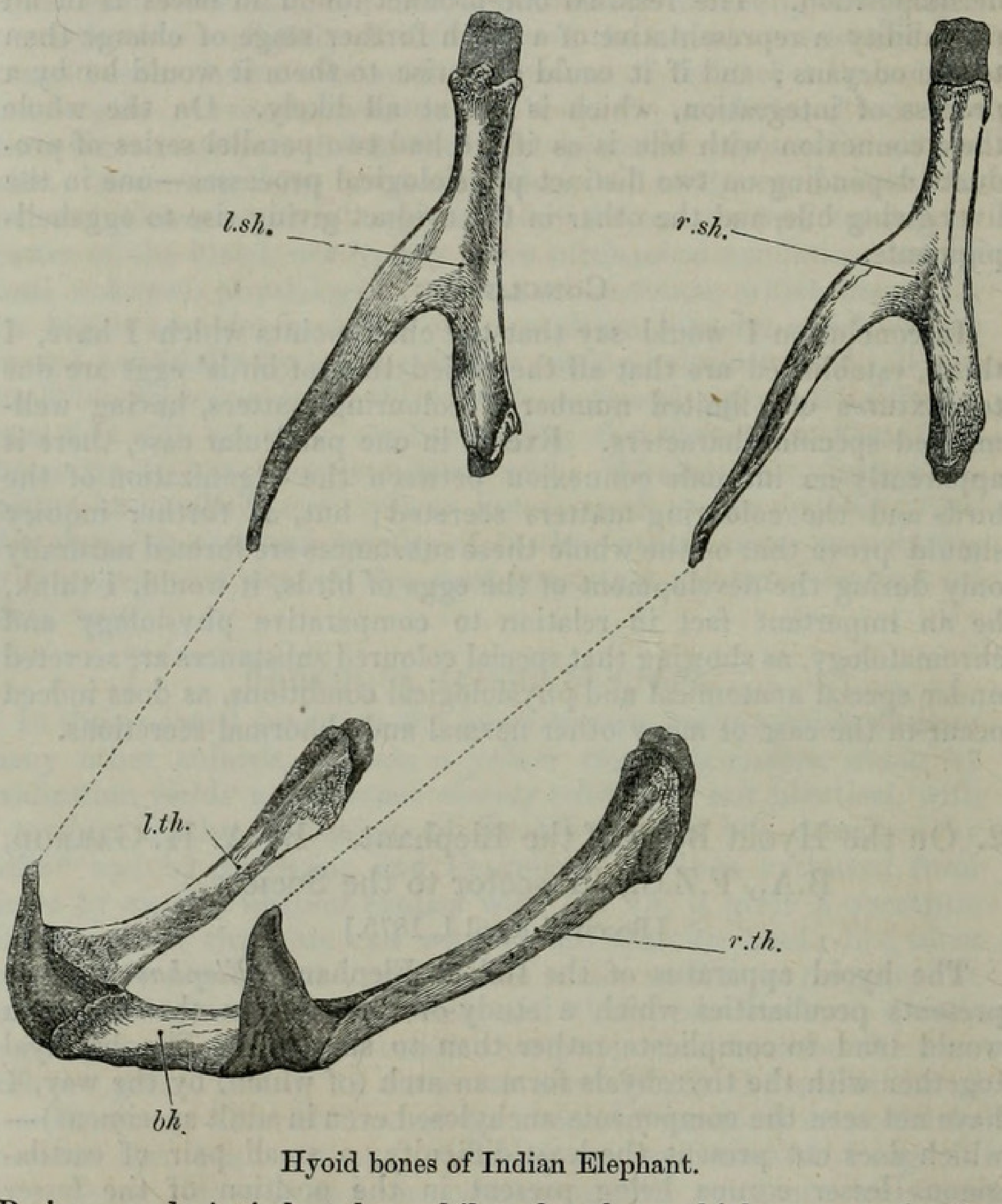
[Received April 1, 1875.]

The hyoid apparatus of the Indian Elephant (*Elephas indicus*) presents peculiarities which a study of the same in the Ungulata would tend to complicate rather than to simplify. The basihyal together with the thyrohyals form an arch (of which, by the way, I have not seen the components anchylosed even in adult specimens)—which does not present the least difficulty, a small pair of cartilaginous lesser cornua being present in the position of the lesser cornua of anthropotomy. It is the stylohyals which, as far as I can find, have not yet been correctly described. Of them Prof. Owen remarks *, "From the middle of the stylohyal a slender

* Anatomy of Vertebrata, vol. ii. p. 441.

pointed process is sent off at an acute angle." And in Prof. Flower's 'Osteology' it is said that "the stylohyals are remarkable for having a long pointed process projecting downwards from near the middle of their posterior border." Prof. Morrison Watson * enters fully into the description of the hyoid muscles, without mentioning, though evidently correctly understanding, the disposition of the bones with which they are associated.

From the above remarks it is evident that the thick short portion of each stylohyal is assumed to be the body of that bone, the pointed process being considered to be an accessory part of it. Such, however, is not the case—the slender pointed process in reality corresponding to the long body of the stylohyal in the



Hyoid bones of Indian Elephant.

Perisso- and Artiodactyla, whilst the short thick process is the posterior descending process. That such is the case I have been able to prove recently in two specimens.

* Journal of Anatomy and Physiology, November 1874, p. 131.

In the Indian Elephant the stylohyal (*s h*) is a thin bone composed, in the adult male, of a flat portion, 4 inches long, less than ¼ inch thick, and very nearly ¾ inch broad, with parallel sides, obtusely truncated at both ends, which are capped with cartilage. In the standing animal the position of this portion of the bone is nearly vertical. Above, it is closely united to the stylo-temporal region of the skull, whilst the lower end gives origin to the digastric muscle. From the middle of the *anterior* border continues onwards the body of the bone, at an acute angle with the lower portion of the above-described element, downwards and forwards. This is elongately triangular in shape, 6 inches long, ⅜ inch broad at its middle, and tapering to a point in front, where it gives attachment to a hardly specialized stylohyoid ligament and serves for the origin of the stylo-glossus muscle. The interval between the tip of this stylohyal and the lesser cornu (cartilaginous) of the hyoid bone is 5 inches, or a little less than the length of the process itself. As it descends in its downward and forward course, this tapering stylohyal curves slightly on itself, turning a little outwards.

The accompanying figure (p. 366) will explain the condition.

The descending digastric process, as it may be termed, may be compared to the posteriorly directed process of the stylohyal in the Ungulata. It differs from it, however, in one essential particular, which is that in the latter it does not give origin to the digastric muscle, but only to the stylohyoid; whilst in the Elephant the digastric arises from its lower end only, and the stylohyoid from the angle formed at its junction with the body of the bone.

In the Elephant therefore the deficiency of the lateral intermediate elements of the hyoid apparatus permit of a much greater movement of the base of the tongue than in the Ungulata, whose nearly rigid stylohyals, epihyals, and ceratohyals can allow of little more than an antero-posterior movement of the base of the tongue, in part of the circle of which the hyo-cranial attachment is the centre.

3. Notes on two Pigeons, *Ianthœnas leucolæma* and *Erythrœnas pulcherrima*. By A. H. Garrod, B.A., F.Z.S., Prosector to the Society.

[Received April 1, 1875.]

Since my communication to the Society "On some Points in the Anatomy of the *Columbæ*"*, specimens of two species of this group have died in the Gardens, which deserve a passing note.

Ianthœnas leucolæma.—The genus to which this bird belongs has been, by different authors, placed sometimes in the Columbine and at others in the Carpophagine section of the family—the number of the rectrices (12, and not 14) having made its position uncertain, as its general appearance tends to that of the Fruit-eaters.

* P. Z. S. 1874, p. 249 *et seqq.*

From the paper above referred to, the definition of the Columbinæ, containing the genus *Columba*, may be thus stated :—

Columbinæ. Columbidæ possessing an ambiens muscle, intestinal cæca, an oil-gland, 12 rectrices, and no gall-bladder.

Whereas *Carpophaga* possesses the ambiens muscle, an oil-gland, a gall-bladder, and no intestinal cæca.

In *Ianthœnas leucolæma* the ambiens muscle and the oil-gland are present, as are the intestinal cæca*. The gall-bladder is absent. This bird must therefore, together with *Columba*, *Turtur*, *Macropygia*, and *Ectopistes*, be placed in the Columbine and not in the Carpophagine division. The intestines are 47 inches in length, of average diameter; and the gizzard is typical in structure, having simple plicated pads.

Erythrœnas pulcherrima.—This species is truly Ptilonopine in all its characters. As in *Ptilonopus*, the ambiens muscle is wanting, as are the cæca to the intestine. The gall-bladder is present; and the oil-gland is very small. The gizzard presents the peculiarities of that genus, although the four pads are not so regularly constructed, minor plications existing. There are 14 rectrices; and the intestines (which are capacious, as in all fruit-eating birds) are 16 inches in length.

4. On the Genus *Scotophilus*, with Description of a new Genus and Species allied thereto. By G. E. Dobson, B.A., M.B., F.L.S.

[Received April 17, 1875.]

In 1820 the genus *Scotophilus* was founded by Dr. W. E. Leach † on a single immature specimen of a Bat which belongs probably to the species now generally known as *Nycticejus temminckii*, Horsf.‡ That specimen was also made by Dr. Leach the type of his *Scotophilus kuhlii*; and this name would take precedence of Horsfield's if it were possible to determine decisively the adult form from an examination of the immature animal.

The specimen in question (which is preserved in alcohol in the British Museum) still retains the deciduous milk-teeth, which, in the case of the upper incisors, are two in excess of those found in all adult individuals belonging to this genus. It would therefore be quite impossible also to distinguish the genus as defined by Leach from Keyserling and Blasius's subgenus *Vesperus* §.

The question therefore arises, whether this genus, so very imperfectly defined, and founded on a specimen of an animal so immature that the species to which it belongs cannot be determined, should not be rejected altogether.

* These are extremely slender, and require special precautions to be taken for their demonstration.

† Trans. Linn. Soc. 1822, xiii. p. 71.

‡ Horsfield, 'Zoological Researches in Java,' 1825.

§ *Vesperus*, subgenus of *Vesperugo*, Keys. & Blas. (Wiegmann's Archiv, 1839, p. 312).

It has been suggested, however, by Dr. W. Peters, who has pointed out these facts*, that the name *Scotophilus* should be retained for those Bats inhabiting the Eastern Hemisphere, hitherto known as *Nycticeji*, which differ in many important respects, requiring generic separation, from the genus represented in the New World by *Nycticejus crepuscularis*, Le Conte, which possesses, numerically, the same dentition.

I have adopted Prof. Peters's suggestion, because zoological literature is thereby spared the burden of a new generic name. It still remains, however, to supplement the very imperfect and misleading original definition of *Scotophilus* by one from which the characters of this genus may be known and its members readily recognized. This is especially necessary; for since a large number of species representing very different groups were included by Dr. J. E. Gray under the common generic title *Scotophilus*†, this name has been indifferently applied, by English and American zoologists especially, to almost every species of Bat belonging to the family *Vespertilionidæ* of which the dental formula was known or suspected to represent less than thirty-eight teeth.

Scotophilus.

Muzzle short, obtusely conical, smoothly rounded off, naked: nostrils close together, opening by simple lunate apertures in front or sublaterally, their inner margins projecting: ears longer than broad, generally considerably shorter than the head, with rounded tips, the outer margin terminating behind the angle of the mouth in a distinct convex lobe; tragus tapering, generally subacutely pointed and curved inwards.

Tail shorter than the head and body, contained, except the terminal rudimentary vertebra, within the interfemoral membrane: calcaneum weak; wings attached or close to the base of the toes. Fur generally short and nearly confined to the body; wing- and interfemoral membranes very thick and leathery.

Skull thick, with prominent crests: occipital and sagittal crests often forming at their junction behind a thick projecting process from which the skull slopes evenly downwards and forwards to the end of the nasal bones in front; occiput concave, with prominent occipital crest; facial bones much shortened in front of infraorbital foramina, which are large and well defined; the bony palate very narrow behind last upper molar, extending backwards as far as the middle of the zygomatic arches; basioccipital between cochleæ broad; cochleæ partially concealed by the tympanic bullæ; paroccipital and mastoid processes well developed, prominent.

Dentition.—Inc. $\frac{1.1}{6}$; C. $\frac{1.1}{1.1}$; Pm. $\frac{1.1}{2.2}$; M. $\frac{3.3}{3.3}$.

An additional external incisor, on each side, above, in the young. Upper incisors long, unicuspidate, acute, close to the canines by their

* Monatsb. Akad. Wissensch. Berl. 1866, p. 679.

† "Revision of the Genera of Bats," Mag. Zool. & Bot. ii. pp. 497, 498 (1838).

bases; upper premolar large, exceeding the molars in vertical extent, and quite close to the canine: last upper molar consisting of a transverse plate only; first lower premolar small, *crushed in between the canine and second premolar*, which exceeds the molars in vertical extent. All the molar teeth very strong, with acute cusps.

Distribution.—Africa, Asia, and Australia. In Africa probably not south of Port Natal: in Asia confined to the warmer parts, extending from Afghanistan to Southern China and the Philippines: in Australia probably extending throughout the whole country.

This genus, though difficult to define, and approaching *Vesperugo*, Keys. & Blas., in many points, especially through certain species of that genus, contains a very natural group of Bats of very wide distribution (as above described) throughout the tropical and subtropical regions of the Eastern Hemisphere. They are distinguished specially by possessing a single pair of upper incisors separated by a wide space and placed close to the canines; by the small transverse first lower premolar crushed in between the approximated canine and second premolar, yet standing in the tooth-row; and, generally, by their short, conical, naked muzzle, and rather short and narrow ears; by their heavy bodies and strong limbs with remarkably thick and nearly naked leathery membranes; and by their short fur, generally olive- or chestnut-brown above, and yellowish or reddish white beneath.

Owing to the wide distribution and variableness in size and colour of the species of this genus, many different names have been given to the same species*; and this variableness and a close external resemblance between different species inhabiting distant countries has caused considerable difficulty in determining species from descriptions either very imperfect or based upon general characters only, such as the colour of the fur and measurements.

It is evident, therefore, that if some characters be found by which the species may be divided into subordinate groups or subgenera, the difficulty of determining the different species will be much lessened. Such characters I have found in the form of the internal basal lobe of the ear and in that of the tragus.

The species may therefore be arranged as follows:—

A. Internal basal lobe of ear angular, inferior margin straight, forming with the ascending margin almost a right angle: tragus with a narrow prominent ridge passing across its front surface from the base of its inner margin .... (*Scotophilus.*)

 a. Upper incisors close to canines; premaxillary bones very narrow, leaving a wide space between them in front, nasal opening very large.

  α. Cingulum of the upper incisors very narrow .... *S. temminckii*, Horsf.

  β. Cingulum of the upper incisors forming a broad horizontal shoulder behind, scarcely raised above the level of the gum .. .. *S. borbonicus*, Geoff.

---

* E. g. *Scotophilus temminckii*, Horsf., = *Vespertilio belangeri*, Is. Geoff., = *Vespertilio noctulinus*, Is. Geoff., = *Vespertilio castaneus*, Gray, = *Nycticejus luteus*, Blyth, = *Nycticejus flaveolus*, Blyth.

B. Internal basal lobe of ear convex, evenly rounded: front surface of tragus smooth .... (*Scoteinus.*)
  a'. Ears nearly as long as the head; internal basal lobe commencing in a long lobule projecting backwards .... *S. emarginatus*, Dobson.
  b'. Ears much shorter than the head, internal basal lobe commencing in a short lobule.
    γ. Cingulum of the upper incisors with a small cusp posteriorly .... *S. rueppellii*, Peters.
    δ. Cingulum of the upper incisors without a posterior cusp .... *S. greyii*, Gray.
b. Upper incisors separated from the canines by a short space; premaxillary bones more developed; nasal opening small...................... (*Scotomanes.*)
    ε. Cingulum of the upper incisors with a distinct cusp posteriorly .... *S. ornatus*, Blyth.

This is not intended to represent a complete synopsis of the species of *Scotophilus*, but to indicate how the genus may be divided into groups, and to serve as a guide to determining the species. *Sc. ornatus* does not come properly under either of the first two groups; I have therefore placed this species by itself.

This very remarkable species, which inhabits the warm valleys among the hills below Darjeeling, the Kasia Hills, and Kakhyan ranges, Yunan, is distinguished from all the other species of *Scotophilus* by the peculiar pied condition of the fur*, in which and in other respects, as in the form of the ear and tragus and shape of the head and muzzle, it approaches the American genus *Atalapha*.

If the skull be compared with that of a full-grown specimen of *Sc. temminckii*, the following differences may be observed:—

In *Sc. temminckii* the superior angle of the occipital crest forms with the sagittal crest a prominent projection; in *Sc. ornatus* this projection is small, the sagittal crest is more developed in front, and the postorbital processes are larger. The frontal in *Sc. ornatus* is grooved in the centre; in *Sc. temminckii* it forms a plane surface. In *Sc. ornatus* the premaxillary bones are much more developed and the nasal opening is not half the size of that in *Sc. temminckii*; the incisors also are placed at the inner side of the premaxillaries and separated from the canines by a space. In *Sc. ornatus* the bony palate is much broader behind the last molars, and does not extend so far backwards.

In the upper jaw, the teeth (with the exception of the incisors, which are separated from the canines and have an acute short posterior cusp) are very similar in both species: in the lower jaw

* The following is a description of the colour of the fur in *Sc. ornatus*:—In males, above light chestnut, on the crown of the head a small longitudinal patch of pure white; from the back of the head, for two thirds the length of the spine, a narrow interrupted band of white extends longitudinally; at the base of the ears posteriorly a patch of white; on either side of the body two white patches, one in front of the head of the humerus, the other behind it: on the under surface a band of white round the neck connects the spots behind each ear, this is succeeded by a band of chestnut-brown, followed by a band of white and succeeded by pale brown, which extends to the root of the tail. In females the fur is much darker throughout, and the white spots and bands of less size and occasionally altogether absent in certain places.

the first premolar is less crushed in between the canine and second premolar than in any other species of the genus; it is, however, similarly flattened from before backwards, and has two short cusps arising internally from the cingulum, which are not found in the other species.

Sc. greyii (included in synopsis above) has been named but not described. I therefore add a description of this species (the smallest of the genus known), taken from an examination of the types in the British Museum, and from a specimen of an adult male, preserved in alcohol, from Port Essington in North Australia, presented by the Earl of Derby to the National Collection.

SCOTOPHILUS GREYII.

Scotophilus greyii, Gray, List of the Specimens of Mammalia in the British Museum, 1843 (not described); Voy. 'Erebus' and 'Terror,' 1844, pl. 20 (not described).

Crown of the head slightly elevated above the face-line; muzzle flat above, rather broad, glandular prominences on the sides of the face moderately developed: ears short, triangular, shortly rounded off above; basal lobe of inner margin rounded, ascending portion slightly convex, emarginate opposite the base of the tragus, and terminating in a distinct rounded lobe. Tragus broad, obtuse, with a triangular lobule near the base; inner margin straight, outer straight below, sloping inwards above from a point opposite the middle of the inner margin.

Wings to the base of the toes; postcalcaneal lobe small, but distinct, rounded, placed on the calcaneum at a distance from the ankle equal to the breadth of the foot; last caudal vertebra free.

Above chestnut-brown throughout; beneath similar, the extreme points of the hairs ashy.

Upper incisors close to base of canines, inclined forwards and inwards; lower incisors not crowded, indistinctly lobed; lower canines without internal basal cusp; first lower premolar small and blunt, crushed in between the canine and second premolar and pushed slightly inwards; posterior upper molar equal to half antepenultimate molar.

Length: head and body 1″·7, tail 1″·3, ear 0″·5, forearm 1″·38, tibia 0″·5, foot and claws 0″·35.

The following description of a new genus and species has been taken from a specimen preserved in alcohol, which had been obtained in the Bellary Hills, Southern India, by the Hon. J. Dormer, and presented by him to the British Museum.

SCOTOZOUS, nov. gen.

General characters those of *Vesperugo*, Keys. & Blas., but with two incisors only in the upper jaw.

Dentition.—Inc. $\frac{1.1}{6}$; C. $\frac{1.1}{1.1}$; Pm. $\frac{2.2}{2.2}$; M. $\frac{3.3}{3.3}$.

The upper incisors large, unicuspidate, like small canines; each incisor close to the canine by its base, but inclined forwards and inwards towards its fellow of the opposite side; first upper premolar minute, in the inner angle between the canine and the second premolar; first lower premolar not crushed in between the canine and second premolar.

SCOTOZOUS DORMERI, n. sp.

Crown of the head scarcely raised above the face-line; glands between the nostrils and eyes well developed, but not causing a depression between them on the muzzle; nostrils opening sublaterally, the space between divided in the centre by a narrow vertical band passing downwards to the lip as in *Vesperugo pipistrellus*: ears shorter than the head, triangular, with rounded tips; upper third of outer margin of the ear faintly concave, then gradually convex, again slightly concave opposite the base of the tragus, and terminating in a rounded lobe below the eye, on a level with the angle of the mouth. Tragus with a small triangular lobe near the base of the outer margin, outer and inner margins parallel as far as the upper third of the outer margin, where the outer margin slopes suddenly upwards and inwards, meeting the inner margin at an angle.

Thumb armed with a strongly curved claw; postcalcaneal lobe distinct, triangular; tip of tail projecting; wings from the base of the claws; foot rather large, first toe nearly equal to the others in length.

Fur above brown, the extreme tips ashy; beneath darker brown, the terminal third of the hairs white.

A single large and acutely pointed unicuspidate incisor on each side above, directed forwards and inwards; this tooth almost touches the canine by its base; but its summit is closer to its fellow of the opposite side, owing to its direction inwards; from the outer side of its cingulum a very small spur projects. Second upper premolar large, equal to three fourths the canine in vertical extent, and placed close to it; in the small triangular space inside, between it and the canine, a minute premolar may be seen with the aid of a lens, not visible from without. Posterior upper molar equal to half the antepenultimate molar. Lower incisors crowded; middle incisors slightly larger than the others, all distinctly trifid: lower canines without a cusp from inner margin of cingulum. First lower premolar shorter than the second premolar, but in transverse diameter rather greater, nearer by its summit to the second premolar than to the canine.

Length: head and body 1″·5, tail 1″·15, head 0″·6, ear 0″·45, tragus 0″·18, forearm 1″·25, thumb 0″·25, second finger 1″·85, fourth finger 1″·4, tibia 0″·4, foot and claws 0″·28.

5. On the Breeding of certain Grallatores and Natatores in the S.E. of Ceylon, with Notes on the Nestling-plumages of the same. By W. VINCENT LEGGE, R.A., F.Z.S.

[Received April 20, 1875.]

During the prevalence of the S.W. monsoon in the month of June last year I made a trip to the S.E. coast of Ceylon, a locality but little known as regards its ornithology, with the view of ascertaining whether our *Sterninæ*, which, for the most part, leave the western side of the island at that season, were to be found then on the opposite and sheltered coast, or whether they were absent from that part also, and had migrated northwards for the purpose of breeding. The reward of this determination, revealed immediately on my arrival at my headquarters, Hambantota, certainly exceeded my expectation. I looked forward to seeing immature examples of many Terns, such as *Gelochelidon anglicus, Sterna bengalensis, S. pelecanoides*, &c., wandering about the salt lakes ; but I was not prepared to find hundreds of *Sternulæ* and *Charadriinæ*, still less *Himantopus*, *breeding* on the salt-pans when, as I had conceived and others with me, they were engaged in carrying out that responsible duty thousands of miles north ! Nevertheless, in spite of my preconceptions, there they were unmistakably occupied in the business of laying eggs and hatching young in a temperature of 87° Fahr. (in the shade), as if there were no such thing in existence as a delightful Central-Asian climate to do all this in. And as therefore this is the first record of the breeding in Ceylon of these birds, I propose to give the result of my discoveries in the following notes.

1. ÆGIALITES CANTIANUS, Latham.

This Sand-Plover, together with *Æ. mongolicus* (for the most part in winter dress* and not breeding), was the most abundant of the *Charadriinæ* met with during my explorations. But before remarking on its nesting, I will describe the habitat of this and other Waders in this part of Ceylon.

A chain of shallow lakes or salt-pans, from which the Government of Ceylon annually obtains quantities of salt, fringe the coast in this flat district for many miles to the north of Hambantota ; they are situated at about ¼ of a mile from the sea shore, being separated from the beach by a narrow belt of jungle through which there is no communication with the outer salt water. The salt-pans (or lēways † as they are termed in Ceylon) are of great extent, many of them being more than 10 miles in circumference ; but in the hot weather they become partly dried up (at which time the annual salt-"collections" take place), leaving around them a wide belt of foreshore consisting of a mixture of mud and sand, covered in many parts by tracts of

* These must undoubtedly be birds of the previous year, not yet arrived at sufficient maturity to breed.

† Pronounced *Layroy*.

shell-fragments. In places these gravelly shell-wastes are worked into little mounds and hollows by the feet of cattle driven along the shore of the Lĕways to their feeding-grounds. In these spots I invariably found the *Æ. cantianus* nesting. On the top of a little mound 6 inches high there would be a small hollow worked out and bottomed with a number of little shell-fragments, just large enough to contain three eggs. This was the general number of eggs, and was never exceeded; in some I found two, and in others, where the clutch was incomplete, only one. The eggs I procured were not all of the same type, differing both as regards ground-colour and character of marking. As a rule the ground was olive-grey, covered in some instances nearly uniformly with small irregular blots of dark sepia over indistinct spots of bluish grey, with here and there streaks and pencillings of a deeper hue; in others, of the same ground, the markings were most numerous at the obtuse end and the egg covered with longer streaks and scratches. A larger type than this was stone-yellow, with the markings consisting almost entirely of streaked blotches and zigzag pencillings of rich sepia*. The largest measured 1·24 inch by 0·91, and the smallest 1·2 by 0·86. My eggs were all taken between the 27th of June and 14th of July, and were in most instances far advanced in incubation, besides which a fair proportion of nestlings were observed, showing the early part of the former month to be the commencement of the breeding-season. All the old birds had already lost the black frontal band, which I had found perfect in birds shot the previous year in the same district as early as the 17th of March, thus reducing the breeding-dress to a duration of only four months.

The plumage of the nestling (which I found running along the sand with the parent birds) is fulvous above, with black lines and spottings on the crown and nape, and a velvety black streak down the centre of the back, on either side of this streak the back is marked with black spots; tail black; the nuchal markings sweep round below the ears in a circle; beneath the down is white; bill black; legs and feet sickly olive-green.

The various devices resorted to by the old birds to attract attention and draw away the intruder from the nests were most interesting to witness. They consisted in the bird flying off to the right hand in front and then circling away across me to the left and making a circuit in rear until it came round to where it rose; this movement it would perform uttering the ordinary note, "chit-ek," "chit-ek." On alighting it would run off, supplementing this sound with a short whistle; and if successful in inducing me to follow it, it would squat on the ground for a moment and continue off with a low harsh cry. Were, however, its powers of persuasion not sufficient to draw me away in pursuit of it, it would rise and make the same circuit as be-

* I should have been disposed to take these for the eggs of *Æ. mongolicus*; but I never could detect any other species in proximity to the nest but *Æ. cantianus*, whose actions and deportment on the approach of man could not be mistaken. I will not, however, undertake to pronounce positively that they were not the eggs of the former bird.

fore, always alighting to my right hand about 30 yards from where I stood. These movements were performed while I was in actual search of the nest; when approaching the vicinity of a nest for the first time, however, my attention was always drawn to the bird running along with its wings trailing on the ground.

2. Sarciophorus malabaricus, Bodd.

I include a notice of this Plover, as I found its eggs. It is resident in Ceylon, and in the district in question breeds on low sandy ground not far from the shores of the Lēways. A nest I found on the 1st July was a slight hollow scraped in the ground and containing no materials for a lining. The number of eggs was four, of a rich stone-yellow, blotched throughout with several shades of rich sepia over a number of light inky spots; the markings, which were most numerous at the obtuse end, were elongated in the direction of the axis. In shape they were pyriform, and measured 1·46 inch by 1·12.

The young would appear to be led away from the nest as soon as they are hatched, as, on resorting one morning to a nest which the previous evening had contained four eggs, I found but one left, while the young from the remaining three were nowhere to be found in the vicinity of the spot, all traces of broken shells having been likewise removed.

3. Himantopus candidus, Bonn.

This species was abundant, and is in the breeding-season one of the most noisy birds imaginable. Before its nest or young are approached within a third of a mile it rises into the air, and, balancing itself with regular beating of the wings, utters loud cries for the space of several minutes, sallying off to a little distance and repeating its alarm-note with the view of drawing you away. It remains in the air thus for half an hour at a time, until it becomes a nuisance with its noise, keeping well out of shot all the while. I found that it commenced to breed in May, nesting generally on a gravelly bank on the shores of the Lēway and near the water. The nest is merely a slight hollow, resembling those of other waders. The eggs, which are either two or three in number, are stout, pyriform in shape, and of an olivaceous stone-yellow ground-colour, blotched openly all over with large dark sepia blots, upon others of an inky grey hue. The markings are largest at the obtuse end. Axis 1·63 inch; diameter 1·26.

On the 28th I discovered three nestlings on the end of an embankment jutting out into one of the Lēways: one of them concealed itself between two stakes; and the other two took to the water, swimming with great ease and speed. The lake was not less than 200 yards in breadth at the spot; and I watched the little fugitives across it. One captured nestling was placed alive in a leathern bag which my servant was carrying; but the mouth not being properly closed, in a few minutes it escaped, and ran with incredible speed along the embankment, dodging my servant with great adroitness, and giving him as much as he could do to recapture it. It has the head mottled buff and black, descending down the nape to a point; upper part of hind neck white ; lower part, interscapular region, scapulars, and wing-coverts dark olivaceous green, tipped fulvous ; back buff, with black velvety bars ; tail barred black and buff ; tips of quill-feathers white ; forehead and all beneath white ; legs and feet greenish olive, toes above plumbeous.

A full-plumaged nestling, shot on the 14th July, had attained a length of 13·22 inches ; wing 8 ; tarsus 4·1 ; hind toe and claw 1·7 ; bill at front 2·2 : iris salmon-colour, slightly mottled dark ; bill blackish olive, dusky at base of upper mandible, and yellowish beneath ; tibia and tarsi brownish yellow, dusky bluish grey at joints ; feet and sides of tarsi brown ; crown and nape brown, fading on the hind neck into light brown, and deepening into blackish brown on the interscapular region and scapulars, where the feathers are edged with buff ; primaries as in adult ; wing-coverts and tertiaries conspicuously margined with buff.

4. Sternula sinensis, Gmel.

Great numbers of this Tern, as identified for me by Mr. Howard Saunders, breed on the foreshores of the Lēways. As far as I am able to judge without examples from other parts of the world for comparison, I procured three races of *Sternula* on the breeding-grounds.

They may be classed as under :—

a. With one blackish primary, from 7·25 to 6·9 inches in length, the bill long and not exceeding 1·3 ; vent and shorter under tail-coverts light iron-grey ; feet clear orange.

b. With two blackish primaries, from 7·2 to 6 8 inches in length ; bill slightly shorter than *a*, not exceeding 1·2, and with the gonys deeper and the under tail-coverts pure white ; feet smaller than *a*, *those of the females dusky orange*.

*c**. With black quills and shafts and finely attenuated bill, dusky orange with black tip, and legs and feet yellowish brown.

It seems reasonable to suppose that *b* is very closely allied to, but a different species from, *a*, which Mr. Saunders identifies as *S. sinensis*, although its distinctive characteristics are rather trivial. The note of *S. sinensis* was a peculiar *Palæornis*-like pipe, while that of the other variety was a harsh Tern-like cry. A further reason for the existence of two species would be the great variety in size and character of marking displayed in many of the eggs which I took. The nests were found on the perfectly level earthy-sand foreshore, and consisted of the smallest perceptible hollows, appearing as if they were stamped out by the bird's feet, and containing no foundation or bottom of any other substance than the bare earth. They were as a rule a long distance from the water, and were never closer to each other than 10 or 12 feet, and very seldom as near as this.

* An example of this type, now in the possession of Mr. Howard Saunders, and the *only one* procured, corresponds mainly with a bird shot at Colombo in December 1869 and identified by Lord Walden as *S. minuta*, the latter differing in its black bill and brownish red feet. A reddish line seems to be a mark of the winter dress in some Terns, those of *Hydrochelidon leucopareia* being quite red in winter against reddish black in summer.

The number of eggs was either two or three, the latter being the prevailing figure; they were not arranged, as those of Grallatores, point to point, and, when in twos, were neatly placed side by side. The eggs I procured divide themselves into four distinct types :—

1. Ovals somewhat pointed at the smaller end, but not obtuse enough at the major end to be pyriform, of a pale olive-green ground-colour, uniformly blotched, the markings as a rule running diagonally across the surface, with one or two shades of umber and dark purple-brown over spottings of bluish grey.

Dimensions—axis ranging between 1·43 and 1·38 inch; diameter between ·92 and ·94 respectively, the shortest egg being the stoutest.

2. Pointed ovals, of a stone-grey or yellowish grey ground-colour, marked with the usual blotches of faded blue or bluish grey, and blotched throughout with sepia and reddish brown, for the most part in small markings, but in large spots at the major end in some. In one or two there are small dottings of dark sepia and a few dark streaks of the same.

Dimensions—axis ranging from 1·38 to 1·23 inch, diameter from ·98 to ·92.

3. Short stumpy ovals, of a yellowish grey ground, faintly blotched or clouded with faded bluish grey, and marked sparingly over this with dull umber-brown or rich sepia, confluent somewhat round the centre in some.

Dimensions—axis ranging between 1·36 and 1·18 inch, diameter between ·99 and ·97.

4. Pointed ovals, of a greenish grey, whitish, or stone-yellow ground, handsomely marked with bold blotches of rich sepia, mostly round the obtuse end, and over large spots of faded bluish grey.

The ground-colour varied in this type more than in the others.

Dimensions—axis ranging between 1·37 and 1·28 inch, diameter between 1·0 and ·96.

On our interfering with the nests some of the birds showed great courage and alarm, swooping close to our heads with loud screams; and from this I am able to identify * both varieties 1 and 2 as belonging to the larger bird with the one black primary.

We found nests in different localities and in a variety of situations. In some the ground was stony in places; and here we found the young nestlings, able to run, most cleverly "planted" between reddish stones, they themselves so closely assimilating in colour that we could scarcely recognize them.

The chick when first hatched has the bill fleshy with a dusky tip, and the legs and feet fleshy red; the prevailing hue of the upper surface is rufous white, with three dark stripes over the vertex, and with the back striped and mottled with black. At about a week old, the rufous white turns to a sort of isabelline grey; and this again becomes tawny yellowish in the nestling flying well. At this stage

* With regard to variety 4, I will leave Mr. Howard Saunders to make his remarks thereupon; I am forwarding this paper to him in order that he may, if he wishes, append notes of his own.

the plumage is as follows. Bill dusky above, fleshy yellow along edge of upper mandible, as is also the lower mandible, except the tip, which is dusky; legs and feet dingy yellow; iris brown, as in the adult. A black spot immediately in front of eye; lores and forehead cinereous grey, becoming darker on the vertex; nape and behind eye blackish, edged, except on the latter part, with tawny fulvous; hind neck, scapulars, and tertials yellowish tawny, with broad blackish oval marks, inside which the centre of the feather is dusky; wing-coverts slate-grey, the median edged fulvous buff with an adjacent blackish border. Quills dark silver-grey, the first two darker on the inner webs (probably the young of *b*); tail pale slate-grey, tipped broadly with tawny yellow, with an adjacent black cross ray; beneath white. At this stage the wing measured 4·5 inches, and the tail was short and rounded. This example was shot on the 1st July. By the 13th there were numbers of well-grown birds about, with a wing of 6·2 inches, the bill measuring at that time 0·9 inch at front; the tarsi and feet were then dusky yellow, with the joints and outer edge of webs brownish. The bill was brownish yellow above, with the gape and base of lower mandible dingy yellow. The grey of the lores and forehead and the black of the nape had deepened, the vertex was less edged with fulvous than the above-described nestling; the back and scapulars were much the same, except that the tawny hue was leaving the centres and edges, which were both becoming whitish. On the radius the feathers were darker, as were also the quills, especially the inner webs of the first (*in the example now before me*); the outer tail-feather was white; and the remainder had an arrow-headed subterminal spot, of larger size than in the young individual.

Besides the above-mentioned species, *Hydrochelidon leucopareia*, *Gelochelidon anglicus*, and *Sterna bengalensis* were very abundant, and all in *winter plumage*. The year before I had shot an example of *G. anglicus* with the black hood in the same district as early as the 18th of March. It is very abundant in this part of the island; and last month, among numbers of winter-plumaged birds, I now and then recognized one with the summer hood. *Sterna pelecanoides* was also common in the Hambantota district; it breeds on certain rocks off our coasts, as I am informed by Mr. Nevill.

Trincomalie, Oct. 20, 1874.

June 1, 1875.

Dr. Günther, F.R.S., V.P., in the Chair.

Mr. Sclater made some remarks on the most noticeable objects he had seen during a recent visit to the Zoological Gardens of Rotterdam, the Hague, Amsterdam, Antwerp, and Ghent.

At Rotterdam the specimen of *Cryptoprocta ferox*, observed on the occasion of his previous visit in 1873 *, was still alive and

* See P. Z. S. 1873, p. 473.