THURSDAY, APRIL 3, 1879

COLOUR IN NATURE

The Colour Sense: its Origin and Development. An Essay in Comparative Psychology. By Grant Allen, B.A. (London: Trübner and Co., 1879.)

THIS interesting and suggestive work deals with the whole question of colour in nature, and more especially with its manifestations in the organic world and the complex colour reactions between plants and animals. It traces the origin of the colour sense in insects to their visits to primeval flowers in order to feed upon the pollen, and in birds to their seeking for fruits, whose seeds they dispersed and whose colours were developed to attract them. It thus attempts to show that the very existence of most of the brilliant colours of the organic world is due to the influence of the colour sense in animals. The author adopts, with some reservations, Mr. Darwin's theory of sexual selection to account for the colours of most animals, and he endeavours to show that only those groups display beautiful colours in which a taste for colour has been aroused by the influence of flowers, fruits, or brilliant insects, their habitual food. All these subjects are treated in a very thorough manner, with a wealth of illustration, a clearness of style, and a cogency of reasoning, which make up a most attractive volume; and though we may not agree with all the author's conclusions, and may even doubt the accuracy of some of his facts, we cannot but admit that he has placed the whole subject before us in a way that must engage the attention both of the man of science and the general reader. We will now proceed to give an outline of the whole work, dwelling here and there on the more interesting points, and especially on those where we venture to differ from the conclusions arrived at.

After an introductory chapter, the contents of which are above indicated, an excellent account is given of the nature of light, and of those peculiarities of the æther-waves which produce in us the sensations of light and colour. The third chapter deals with the organ of vision, giving an account of its earliest appearance and progressive complexity in the animal kingdom, and of the structure of the eyes of the higher animals, and the relation of their parts to the perception of light and of differences of colour. One of the most important facts here brought out is, that the complex mechanism required to produce vision has been several times independently evolved—the eye of the bee, of the cuttle-fish, and of the eagle have each apparently been separately developed from unlike remote sightless ancestors.

The next chapter is a long and very interesting one, on "Insects and Flowers." It deals with the origin and development of these two classes of organisms and their actions and reactions on each other. It is full of interesting facts; and the discussion of the mode of origin of the colours of flowers by a reference to the conditions under which colour appears normally in living plants is especially instructive; the generalisation being arrived at that the leaves which create or store up energy for the plant are green, while whenever leaves lose this function and become expenders of energy they lose the green tint and acquire various other colours; growing shoots, young leaves, buds, stamens and stigmas, and their protecting scales, are almost always variously coloured. The rudiments of colour being thus always ready in the floral organs, it is not surprising that flowers have been separately developed in monocotyledons and dicotyledons, and also probably many times over in each of these divisions.

In this part of his work the author exhibits his tendency to trust far too much to negative evidence, especially to that afforded by geology. He speaks of the carboniferous epoch as presenting a green jungle of ferns and club-moss, "in which there is no trace of bee or moth or joyous butterfly;" while "scarlet berry and crimson blossom, gorgeous bird, and painted insect were all equally absent from the unvaried panorama of green overhead and brown beneath." As the flora preserved to us in the coal-measures was almost certainly that of swamps only, we cannot possibly tell what existed on the uplands and mountains of that period. The enormous differentiation of flowering plants, and the comparatively little change they seem to have undergone during the whole tertiary period would lead to the inference that they may have already existed in some variety during the carboniferous epoch; while the actual discovery of a butterfly in the lower oolite, and of a well preserved wing of what appears to be a large moth in the carboniferous shales of Belgium,[1] renders it quite possible that coloured flowers and gay butterflies *were* then in existence. The statements as to the time when the different orders of insects first came into being (quoted at p. 68) are quite worthless when we consider how rare must be the conditions leading to the preservation of winged insects, and they are already contradicted by well-known palæontological facts. Another statement that seems equally open to doubt is, that even in early tertiary times there were no orchids (p. 97), a statement founded on the generalisation that entomophilous monocotyledons are later productions than entomophilous dicotyledons, because the perianth of the former is usually less specialised. But surely in orchids the perianth is more highly specialised than in any existing flowers whatever; and if we take into account the world-wide distribution of these plants, their immense richness in genera and species, and their wonderful complexity of structure, we must consider them as among the most ancient instead of the most recent of flowers. They are also exceptions to the general rule of the size of the flower being in inverse proportion to its special adaptation to insect fertilisation; of which the large but simple lilies and tulips as contrasted with the small but complex labiates, are quoted as examples.

The next chapter, on the colour sense in insects, sets forth both the direct and the indirect evidence on this question; such as Sir John Lubbock's experiments on bees and wasps, the mimicking insects which deceive other insects, the clear relation of coloured flowers to the visits of insects, the fact of insects often visiting hundreds of the same species of flower in succession, &c. This chapter concludes with a striking picture of the vast effect which has been produced on the appearance of external nature by insect agency, "which has turned the

[1] *Breyeria borinensis*, "Annales de la Société Entomologique de Belgique," t. xviii. Pl. v. (Photograph).

whole surface of the earth into a boundless flower-garden," supplying insects from year to year with pollen or honey, and itself gaining in return a renewal of life by means of the baits that it offers for their allurement. "If," adds Mr. Allen, "any man can seriously doubt that these changes are really due to a colour sense in the little creatures which live upon the beautiful flowers; if he can imagine that the plant has produced its gorgeous petals for no other purpose than that of suicidal wastefulness; that the *Mantis* has grown into the perfect semblance of a leaf from pure wanton causeless mimicry; that the lurid red of fly-fertilised blossoms bears its likeness to the mangled flesh of animals by a simple freak of creative power; then the whole science and philosophy of the last hundred years have been thrown away upon him, and he may return at leisure to the blind and hopeless chance of the eighteenth century atheists."

The relation of birds and mammals to fruits is next discussed, and this is shown to be in many respects parallel to that of insects and flowers, only those fruits being conspicuously coloured which are edible, and the dispersal of whose seeds is effected by the birds or other animals which eat them. The whole of this subject is very well treated, but the evidence that fruits in general have been modified both in edibility and attractiveness in relation to the animals which feed upon them, is by no means so clear as in the case of flowers. With regard to small and hard-seeded fruits, such as our strawberries, currants, and raspberries, our hips and haws, our yews and cranberries, this is no doubt the case, since they are carried away by birds and vegetate after passing through their bodies. It is also the case with such fruits as the nutmeg, whose bulky seeds pass undigested through the stomachs of the great fruit pigeons, but whether the same rule applies to most of the larger fruits may be doubted except when they have hard, stony seed-coverings, as in the case of plums and apricots, which evidently protect the seeds from being eaten, or, if eaten, from being digested. But the majority of the larger fruits are eaten by mammals, and it is doubtful whether their seeds can survive the process. Such are oranges and shaddocks, and gourds of various kinds, while many large bright-coloured fruits of the tropics do not seem to be eaten at all. Many of these are very round and smooth, and may get dispersed by mere rolling down hill, as occurred with the mango in Jamaica,[1] or by being accidentally disturbed by the feet of animals. It is to be observed, too, that the fruits of trees are usually so abundant that, if eatable, there is no danger of their not being eaten even if uncoloured, as in the case of our acorns, beech-nuts, and chestnuts. An immense number of the tropical fruits eaten by monkeys and parrots are not coloured, and the half-developed seeds are often alone eaten; while in others, as the jack-fruit, bread-fruit, and durian, the large seeds are as eatable as the pulpy mass, and the edible nature of the fruit must be injurious rather than otherwise as leading to the destruction of seeds. This need be no difficulty when we consider that with forest trees, which live for several centuries, there is only vacant space for young trees at long intervals, and thus no rigid selection of seeds takes place tending to secure them from being destroyed as food for animals.

[1] See Sir Joseph Hooker's lecture at the Royal Institution on "The Distribution of the North American Flora."

On account of the fondness of most birds and other animals for the very same fruits which we like best, Mr. Allen maintains the general community of taste in all animals. I have, however, usually found monkeys eating fruits which were very disagreeable to me, and the theory is hardly consistent with the fact that many nauseous fruits are bright-coloured. Thus the *Citrullus colocynthus* of Palestine has a beautiful fruit of the size and colour of an orange, but, according to Canon Tristram, "nauseous beyond description to the taste,"—while the *Solanum sanctum*, generally called the "Dead Sea apple," is almost equally disagreeable, but is of a brilliant red colour. Now if these fruits are eaten by any animals their taste must be very different from ours, while if they are not, these fruits have become strikingly attractive from other causes than to induce animals to eat and disperse them. This latter view is supported by another fruit, also found in Palestine, the *Calotropis procera*, which is as large as an apple and bright yellow, but is full of thin flat seeds winged with exquisitely fine silky filaments. Here, then, the seeds having special powers of dispersal by the wind do not need the aid of animals, yet the fruit is most attractively coloured. This is one of the Apocynaceæ, which are usually poisonous, and I have observed brilliantly coloured fruits of the same order in the tropics, but some of these are known to be eatable. Taking into consideration all the facts, it seems probable that attractive fruits are more abundant among the smaller trees and shrubs of temperate lands than in the forests of the tropics, and that their colours are largely due to those adventitious causes which our author has himself so well elucidated. When their distribution has been aided by birds their colours, their edibility, and the non-digestibility of their seeds would all be increased by natural selection. The dry fruits of herbaceous plants, in which the struggle for existence is probably more severe, have no doubt often been prevented from acquiring bright colours by natural selection in order to protect their seeds, just as so many insects and birds have acquired brown or green protective tints.

A curious point in relation to this question, and one that has not been noticed by our author, is the very different characteristic colours of fruits and flowers. I have tabulated the colours of these, under four heads, taken from two books of manageable size—Hooker's "British Flora" and Mongredien's "Trees and Shrubs for English Plantations." The colours of the two classes I find to be as follows, dividing the purples between the red and blue to the best of my judgment, and taking black among fruits as corresponding to blue in flowers.

Flowers.	White.	Yellow.	Red.	Blue.
British Flora	292	228	168	123
Trees and Shrubs	160	73	62	37
Totals	452	301	230	160
Fruits.				
British Flora	2	3	33	24
Trees and Shrubs	5	11	35	21
Totals	7	14	68	45

Here we see that white and yellow which immensely preponderate in flowers are very scarce among fruits, among which red and blue (or black) predominate, the two colours which are far less common in flowers. We must conclude, either that there is not a community of taste in colour between insects and birds, or, that what may be termed the normal colours of both have been more or less intensified and utilised by natural selection in order to attract insects and birds respectively.

The next chapter, on the colour-sense in vertebrates, clearly establishes the fact of the possession of this sense by all vertebrate animals, but more especially by birds and reptiles. The evidence of such a sense in mammalia generally is very scanty, though it undoubtedly exists in monkeys; while there are good reasons for believing that it is more acute in birds than even in ourselves. Birds on the whole need to perceive colour more than any other animals, both because the insects and fruits and buds on which so many of them feed are small variously-coloured objects, and because from their habits they require to see and recognise these objects from a considerable distance. It is therefore a remarkable confirmation of the modern theory—that the cones of the retina are colour organs while the rods are only light organs, that in birds the cones are three times as numerous as the rods, while in mammals they are less numerous. Nocturnal birds, such as owls, however, have very few cones, while nocturnal mammals have none. The *macula lutea*, a central yellow spot consisting largely of cones, is found in man and monkeys only, while it exists in all diurnal birds, and these in addition have their cones furnished with variously-coloured globules, which are supposed to give a still more perfect perception of colour. The eye of the chameleon is as perfect as that of a bird, and this accords with its capacity of colour change, and the extreme accuracy with which it detects and captures insects. Mammals, on the other hand, even the insectivorous and frugivorous kinds, have very little occasion for a refined colour sense, since the great mass of creeping insects are of obscure colours, while the squirrels and allies feed on brown nuts rather than on coloured fruits. The evidence seems to show, therefore, that a tolerably perfect colour-sense has only been attained, among mammalia, in the monkeys and man, while even in these it is probably very inferior to that of birds. It seems probable, therefore, that the prevalence of colour-blindness is really an indication of the colour sense in man having been a comparatively recent development, instead of being, as Mr. Allen thinks, a disease of civilisation. An acute colour sense is certainly not of the first importance to savages; and though our author has adduced valuable evidence that most savages distinguish colours just as well as we do, it is very important to ascertain whether colour-blindness exists among uncivilised peoples to a greater or a less extent than among Europeans.

The next chapter, on the direct action of the colour sense upon the animal integuments, deals with the theory of sexual selection as advanced by Mr Darwin, and endeavours to support it by a variety of general considerations. Many of these arguments are very weak, and are often founded on insufficient or erroneous facts, some of which I shall endeavour to point out. The great aim of this chapter is to prove that the colours of animals are intimately associated with the colours of the objects they feed upon. Butterflies and moths being the most beautifully coloured of all insects and feeding on flowers, is held to be the first great fact in support of this view; and this is backed up by the remark that "the colours of caterpillars are mostly protective, being due to natural selection alone, while those of butterflies are mostly attractive, being largely due to sexual selection." To this we must altogether demur, as slurring over what is really a stupendous difficulty in the way of the theory. So far from the colours of caterpillars being "mostly protective" every entomologist knows that a large number of caterpillars in every part of the world are conspicuously coloured, and what is more to the point that their colours are as brilliant and varied as those of butterflies themselves, if we take into account the nature of their integument, the small amount of surface, and the uniform cylindrical form of their bodies. The caterpillar of *Papilio dissimilis*, for instance, on a bluish green ground has a series of broad irregular longitudinal bands of the richest orange yellow, and between these there are a number of round red spots; while those of many of the Euplæas are adorned with exquisite pink and yellow markings, and with a number of long fleshy processes of equally brilliant colours. Owing to caterpillars being so difficult to preserve, and being rarely collected and figured in their native countries, comparatively few of them are known, but it is certain that they often exhibit the most brilliant hues and the most exquisite patterns; and as they may be said to feed invariably on green leaves, while sexual selection cannot affect them, the natural inference is that the same general laws which produce colour in them are quite sufficient for the production of even more varied hues in the perfect insects, whose expanded wing surfaces, ever varying in size, form, and neuration, offer a field so much better fitted for its development.

In beetles the appearance of colour is also attempted to be correlated with their flower-haunting habits by means of equally doubtful facts. The magnificent Buprestidæ and Longicorns are, as far as my experience goes, almost wholly wood-feeders, frequenting the bark of dead trees, and very rarely found on flowers; the Cleridæ and Silphidæ feeding on dead animal matter, are often brilliantly coloured; and generally in beetles, the absence of colour may be traced to the need of concealment and protection, while whenever a special mode of protection exists, whether by nauseous secretions, hard integuments, rapid flight, or facilities for concealment, then colour appears in infinitely various phases; and this law generally prevails throughout the whole insect-world. In his argument in favour of bright hues being attractive to the opposite sexes of insects, Mr. Allen seems always to forget that it is the male that is attracted to the female, and not *vice versâ*; and when he says (p. 158) that he "cannot see why Mr. Wallace, who allows the attractive nature of colouring in flowers, should deny its attractive nature in the question of sex," I reply, that in flowers colour enables the insect to recognise the species, but no one has ever asserted that insects improve and alter the colour of flowers by their preference for certain varieties of colour irrespective of the honey or pollen produced; and in like manner I maintain that the colour of an insect is a guide to easy recognition by its mate, but that there is not one single particle of evidence to show that minute differences in the colour of the same species are observed by insects, still less that such differences are so important to them as to lead to the rejection of a healthy and well-organised mate; yet unless this is the case, the whole theory of sexual selection falls to the ground.

Again, the general connection between coloured flowers and coloured insects is by no means so general and constant as Mr. Allen supposes. Perhaps the richest displays of gay flowers in the world are to be found in temperate Australia, in South Africa, and in the South European Alps, yet in all these countries the butterflies are very inferior to those of tropical forests, where flowers are comparatively rare. In the forests of Para, for instance, gay flowers are very scarce, as noticed by Mr. Bates as well as by myself, yet the butterflies are endless in their variety of lovely hues. Of course there *are* bright flowers in the tropics, and as travellers notice these whenever they see them and also notice the handsome butterflies, it is easy to infer, as is here done, that the two invariably go together. We may also remark that the sexual allurement of a peculiar odour given out by special patches of scales on butterflies' wings has been discovered by Fritz Müller in the genera *Mechanitis*, *Dircenna*, and *Thecla*, all very brilliantly coloured groups, a clear indication that colour is not a sexual allurement, or we should find it most developed, not in conjunction with, but in the absence of, the attraction of odour.

We must now pass on to the vertebrates, and we here find very good evidence adduced of the existence of a colour-sense in fishes, reptiles, and birds, as we should expect from the known structure of their eyes; while in the case of mammals it is far less decisive. The attempt to associate the brilliant colours of these animals with their food and surroundings, acting through sexual selection, is, however, what we have now to consider; and though many alleged facts are adduced in support of it, several of them are as doubtful and inconclusive as in the case of insects. We shall confine our attention to the birds, which are the stronghold of the theory, and are so much more completely known than the less highly-organised fishes and reptiles. Mr. Allen claims the parrots as fruit-eaters, but they are really seed-eaters, their bills being specially formed to crack the shells and extract and grind up the kernels of nuts and other fruits. They do not therefore aid in the disposal of seeds, as they feed on brown nuts or unripe green fruits from which they extract the seeds, much more frequently than on coloured ripe fruits. The general green colour of parrots is undoubtedly protective, and this green colour is lost, and vivid tints appear just in proportion as, owing to various conditions, the need of concealment diminishes. This is especially the case in countries where mammals are few and a low type of organisation prevails, as in the Australian region, in Madagascar, and in South America; while in Africa and Asia, where a higher type of organisation prevails, the colours of parrots are more sober and protective. A little further on we find the Australian honey-suckers noted for their magnificent coloration; the fact being that they are decidedly a dull-coloured group, hardly superior to our thrushes, and not equal to our finches. Yet they are as universally flower-feeders as the humming-birds themselves; and the total absence of brilliant colour from these birds, which are *the* characteristic family of Australia, and have been developed in correlation with the brilliant Australian flora, absolutely negatives the idea of colour in birds being dependent on the amount of colour in the food and surroundings of certain groups. Again, the ground-feeding pheasant family are passed over as containing only one brilliant bird, the peacock, whereas it abounds in species of the most gorgeous colour. Such are the Impeyan pheasant of the Himalayas, whose metallic plumage is that of a gigantic sun-bird; the golden pheasant, the silver pheasant, and Reeves' pheasant of China, all unsurpassed for gay and conspicuous colouring; the glorious crimson and white-spotted tragopans, the elegant peacock-pheasants, and the intensely brilliant fire-backed pheasants of the Malay countries—together composing a group of birds whose colours are unsurpassed for beauty and splendour, and thus are directly opposed to the general gloom and absence of colour in their habitual surroundings.

In treating of mammals we find an equal want of discrimination in estimating comparative colour and conspicuousness. The tigers, the zebras, the beautifully marked antelopes, and the spotted deer and giraffes, which are really among the most brightly-coloured of all mammals, are passed over as less beautifully coloured than the squirrels and monkeys, in order to support the theory that arboreal mammals feeding on fruits should be (though unfortunately for the theory they are not) the most brightly coloured. Monkeys, as a rule, are very dingy brown or black, about one or two per cent. of the species having patches of bright colour on the bare skin of various parts of their bodies, while the nut-eating squirrels as a whole are certainly not superior to the grazing antelopes. In the summary of facts given at pages 184 and 185 there are many errors. *Scissirostrum Pagei* does not "belong to a family generally dull," while it is itself decidedly dull-coloured; the "pretty cigana" is a very plain coloured bird; Santarem, of which it is said "the pastures are destitute of flowers, and also of animal life, with the exception of a few small plain-coloured birds," is one of the richest localities for flowering shrubs in South America, and one of the few places where I remember the conspicuously coloured fruits on many of these shrubs, while the butterflies in the adjacent forests are gorgeous in the extreme; and lastly, the "gay-coloured squirrel," for which I myself am made responsible, is one of the dullest of the group, pretty indeed as are all squirrels, owing to its brown and yellowish ringed tail, but in no sense whatever "gay," while I certainly say not a word about its feeding on "bright-coloured fruits."

Such mistakes as these pervade this portion of the work, and are made the foundation for repeated argument and illustration; and they serve to show how impossible it is even for the most earnest and enthusiastic student to make a few months' labour suffice for a correct appreciation of the bearing of the overwhelming mass of facts presented by the countless species of the animal and vegetable world. I have marked a number of other passages to which I altogether demur, but many of them involve arguments which would extend far beyond the limits of an article. For the same reason I can only briefly refer to the concluding chapters on the "Colour Sense in Man," in which the theory of Mr. Gladstone and the German philologists is disproved in a manner which is absolutely conclusive.

In the summary and recapitulation we find all the facts and arguments we have referred to marshalled in an imposing array, and finally summed up in the following condensed formula:—

"Insects produce flowers. Flowers produce the colour-sense in insects. The colour-sense produces a taste for colour. The taste for colour produces butterflies and brilliant beetles. Birds and mammals produce fruits. Fruits produce a taste for colour in birds and mammals. The taste for colour produces the external hues of humming-birds, parrots, and monkeys. Man's frugivorous ancestry produces in him a similar taste; and that taste produces the final result of human chromatic arts."

Although I totally differ from Mr. Allen's conclusions as to the production of the varied colours of the animal world, I must express the extreme pleasure with which I have read his book, which I most cordially recommend to all who love colour, and can enjoy a thoroughly well-written volume on a most interesting but difficult subject.

ALFRED R. WALLACE

GEODESY

Die geodätischen Hauptpunkte und ihre Coordinaten. Von G. Zachariæ. (Berlin: Oppenheim, 1878.)

THE science of geodesy, though far from a popular one, exercises something like a fascination over its own devotees. It is not a standstill science; how to devise instruments—theodolites, altazimuths—which shall excel their predecessors; how to use these instruments so as to eliminate the sources of possible error they individually present; how, having got the observations, to eliminate in the use of them, their own errors as far as possible; and finally, how, after obtaining final results, to express the degree of reliance to be placed on them: these are all ever-fresh questions, capable, many of them, of engaging—as one may, for instance, see in the works of the late Prof. Hansen—considerable mathematical ability. The work before us is of Danish origin, and it is clear that the Danish meridian arc and the geodetic operations connected therewith have been executed in a thoroughly scientific manner. To those who are employed in geodetic operations, this treatise will be most welcome. In an introductory chapter we have the definitions of the mathematical surface of the earth, expressions for the radius of curvature and various lines connected with the spheroid, and remarks on the deviation of the actual surface from that of a true spheroid. The first section treats of the method of laying out a triangulation, of the measurement of angles, and of the measurement of base lines, together with the calculation of the probable errors of results. The second section deals with the calculation of triangles: after giving Legendre's theorem, the writer shows how spheroidal triangles may be computed as spherical, and gives the expressions for the differences between the angles of a spherical triangle and a spheroidal triangle having sides of the same length, with any position in azimuth. Then the method of calculating a triangulation by least squares is entered into. The third section deals with the subsequent expression of the results in the form of co-ordinates—of the method of calculating differences of latitude and longitude. Throughout the work, in all formulæ which are approximative, the nature or order of the terms omitted is expressed by a neat notation which is very useful. The fourth section is devoted to the measurement of heights, and levelling operations and calculations; the subject is gone into thoroughly, including the investigation of the coefficient of terrestrial refraction and the errors which may accumulate from various sources. The last part of the section is devoted to the consideration of the "Schlussfehler," or "error of close" in levelling. This error may arise from mountain attraction, or may exist even without it. We know that at the surface of the spheroidal earth the equipotential surfaces—take any two of them a few hundreds or thousands of feet apart—are not parallel, but the distance between them at any point is inversely proportional to gravity there. If P, Q be two points on the higher of two equipotential surfaces, p, q, their projections on the lower, then levelling from p to Q, if we in imagination take the path, $p P, P Q$, we have $p P$ as the height of Q above p; then continuing the levelling from Q by the path $Q q$, $q p$, to p, it is clear there will be an error in the close of the levelling of the amount $Q q - P p$. Practically, of course, this is very small. An error of close of levelling may occur in working over a mountain; the attraction of the mountain deflects the vertical, and too small a height is the result; of course if the hill is symmetrically shaped, the same amount of error is involved on both sides, and there would be no discrepancy in results obtained by levelling over and round or through the hill. But generally the error on the two sides is not the same. In the work before us the case is supposed of levelling being carried over a mountain-chain of uniform triangular section. In the triangular section $A B C$, C being the ridge and $A B$ the base, suppose levelling to be started from A the foot of one slope, along a level surface *through* the mountain, or, which is the same, along a level surface round it, to B, a point on the *same* level-surface as A; then up the slope from B to C, then down the other slope from C to the starting-point A. Then the error of close, or the "Schlussfehler," is a certain multiple of the integral of the difference between the horizontal component of the attraction of the hill at any point as P on the slope and the horizontal component of the attraction at p, which is the projection of P on the level surface $A B$, multiplied by the element of horizontal distance, and taken from A to B. So that if we do not misunderstand the writer, the numerical examples of "Schlussfehler," given at p. 290, are very much too large. In fact the before-mentioned multiple of the difference of potential at A and B, when added to the right-hand member of the equation (3) on the page referred to, very nearly cancels that term.

The fifth and last section of the work treats of the influence of small alterations of the spheroid of reference on the reduced triangulation, and of the determination of the elements of that particular spheroid which is most in accord with the results of the triangulation under consideration. The formulæ throughout the work are very neatly developed and the typography is admirable.

A. R. C.

OUR BOOK SHELF

A History of the Birds of Ceylon. By Capt. W. Vincent Legge, R.A. Part I. Imp. 4to. Pp. 1–345. (London: Published by the Author, 1878.)

THE many interesting papers on Ceylonese birds published during the last few years by Capt. Legge in the