

bute to the small spheres, so that all three spheres may touch one another. They touch when  $c = 1 + 2r$ ; whence we get

$$9r^4 + 24r^3 + 22r^2 - 24r - 15 = 0,$$

the solution of which is .85078.

Hence if the smaller spheres have their radii .85078 of the large one, they are all three in contact, and there is no pressure between the small ones, when they revolve with proper orbital angular velocity. Now the analogue of this solution in Roche's problem is very interesting. The problem is to find the relative sizes of planet and satellite, so that where the satellite is in limiting equilibrium the two bodies shall just touch. The solution will give a fair approximation to that hour-glass figure of equilibrium of rotating fluid, which I have treated otherwise in a paper in the Philosophical Transactions (vol. clxxviii. A., p. 379). The solution would be improved, although complicated, by allowing the larger body to be also deformed.

Unfortunately the solution requires the tabulation of several functions depending on elliptic integrals. Roche made, but did not publish, tables of certain integrals, which he used for obtaining his results. It appears that the problem to which I refer did not occur to him.

Some years ago I began the computations necessary for this solution, but as it appeared to be a much more laborious task than I had anticipated, I have put the work aside until I should find leisure to attack the problem again. G. H. DARWIN.

April 10.

### The Afterglows and Bishop's Ring.

I AGREE with your correspondents (pp. 101 and 127) that there has been a marked increase in the amount of dust in the upper regions of the atmosphere within the last few months, as evidenced by sky phenomena.

I did not notice the sunset of November 27, and it was not till the next morning I observed any increase in the dust phenomena here. About sunrise on the 28th "Bishop's Ring" was very conspicuous for the first time for a considerable period, as also were the whitish wisps in and near it, very similar to those forming such a noticeable feature of the Krakatão sunsets; but I have never again seen them so small and definite as when those sunsets first took place. The sunset of that day (November 28) was a magnificent and striking one, with a very deep pink glow. On the 30th there was a somewhat definite bright segment below the rosy glow, at first a dull buff, and then orange. This segment was a very striking feature of the earlier Krakatão sunsets, but I have rarely seen it since till that day. I noticed it again on December 4. The wisps continued to be very conspicuous up to December 13, after which date they gradually grew less so, and have now disappeared altogether.

After the middle of December I was travelling in Portugal, the Canaries, and Spain. The segment was invisible—or at any rate not a noticeable feature—after December 19 to January 30; but most of the time I was not favourably situated for seeing it on account of hills. From the last-mentioned date to February 11 (during which time I was in the neighbourhood of the Straits of Gibraltar) the sunsets—generally on a cloudless sky—were very striking, and almost nightly the orange segment was very bright and definite, though I think not quite so definite in outline as in the Krakatão sunsets, but it reminded me much of them. As I had not been in that locality before, I do not know whether such sunsets are common there, or whether the phenomena were due entirely to a general accession of dust.

Since returning to England on February 14, the segment has sometimes been visible, though much less striking than in Spain.

"Bishop's Ring" still continues very conspicuous about sunset. I have not seen it of late years when the sun has had any considerable altitude, except on the 18th ult., from 1.30 to 3.30 p.m.; I was then in Teesdale at from 1300 to 1700 feet above sea-level; it was quite plain when the sun was behind a cloud, and visible even with the sun free from clouds. It has never ceased to be visible at about sunrise and sunset since November, 1883, although at times very faint. Has it always occurred when the sun is near the horizon, and is it only because attention was called to it by its remarkable vividness at the time of the Krakatão sunsets that one has been able to see it ever since, though never before? Unlike Mr. S. E. Bishop I always see a certain amount of red in the outer margin; though in the late accession to its conspicuousness the red has been very

dull, rather to be called dull brown than red. This has also been the case at times before.

One other feature of the Krakatão sunsets has occasionally been visible of late in this country, namely, the second pink glow in the western sky. This was much more striking in Teneriffe, though still much fainter than in the Krakatão sunsets.

It would appear that if this dust is the same as that seen at Honolulu, it took six weeks to get from there to Dublin and Sunderland, while the Krakatão dust took two months in reaching the south of England from Honolulu.

Sunderland, April 10.

T. W. BACKHOUSE.

### Thunderstorms and Auroral Phenomena.

I AM residing in tropical Queensland, lat. 21° S., and consequently am not likely to see any auroral phenomena, particularly in the middle of our hot and rainy season; but last night between 8 and 9 p.m. there occurred the following remarkable appearances, which were seen by me and several others.

There was a sharp thunderstorm with incessant lightning visible on the southern horizon, occupying a width of 10° and an altitude of from 5° to 10° above the horizon, probably from 80 to 100 miles off.

But for the distant thunderclouds the sky was clear and star-light, with a few light cirrus clouds drifting before the north wind.

I was sitting on the lawn watching the distant flashes, when suddenly a patch or cloud of rosy light—5° to 6° in diameter—rose up from above the thunderstorm and mounted upwards, disappearing at an elevation of from 40°–45°. There were about twenty to twenty-five of these patches in the course of half an hour, sometimes three or four in quick succession; they took from one to two seconds to mount, and were not associated with any particular flash; the rosy colour contrasted strangely with the silvery light of Nubecula Major just above. There were also occasional streamers, sometimes bifurcated, of 2° in breadth, which shot up in the same way as the auroral streamers, which I have seen both in the arctic and antarctic zones.

Auroral phenomena are known to be electrical manifestations, but here were the same phenomena exhibited in connection with a thunderstorm in the tropics. Thinking this phase of electrical action worthy of note, I send you this account and enclose my card. J. EWEN DAVIDSON.

Branscombe, Mackay, Queensland,  
February 5th.

P.S.—The thunderstorm, patches of light, and streamers were distinctly *connected*; it was not a case of an ordinary aurora, with a thunderstorm interposed.

### Fossil Floras and Climate.

SIR WILLIAM DAWSON demonstrates that the plants of the cretaceous and tertiary series of Canada prove that the temperature of Greenland during the tertiary period was mild but not subtropical. That is sufficiently extraordinary, but geologists prefer, with strange inconsistency, the more astonishing contrast between Heer's arctic miocene palms and the glacial period. The fact is that these floras, comprising a few large-leaved evergreens and relatively tender ferns and conifers, are not normal in such high latitudes, but confined to localities which might have been stations on the north coast of a warm Atlantic Ocean. Therefore they perhaps require nothing more prodigious than the circulation of a gulf stream in an Atlantic isolated from the Arctic Ocean, a probable state of things at that time. At all events tertiary plants collected from near the Equator negative any generally enhanced temperature.

This applies solely to the tertiary period, when many actually living species of plants were in existence. As we recede in time species become more strange and extinct, and likely to mislead. No wise person would define, for instance, from surviving cycads the climatic conditions they may have endured when as common and widely diffused as blackberries are to-day. Even estimates based on such a group as *Gleichenia* may be quite inapplicable when they sustained the rôle now usurped by the bracken.

Sir William Dawson is aware that with even the best preserved fossil leaves, and with access to the most complete herbaria in the world, half-a-dozen different conclusions may be come to in

succession; while single and imperfect specimens are mere pitfalls. No imperfect or indistinct leaves, unless they possess exceptional characters, should be named, since however faithfully described or figured, they are simply confusing.

J. STARKIE GARDNER.

#### WILD SPAIN.<sup>1</sup>

THERE seems to be no limit in these days to the demand for books on popular natural history, especially when they combine a certain amount of science with a sporting element. The present volume, in which the authors endeavour to describe Spain from "a point of view hitherto almost unoccupied, that of the sportsman-naturalist," excellently illustrated as it is, will, no doubt, attract a host of readers, for it deserves to do so. One of the joint authors, Mr. Abel Chapman is already known to us as a writer on the bird-life of the Scotch Borders, and as an ornithologist who has laboured very successfully on the birds of Spain. His coadjutor, Mr. Walter Buck, who is resident at Jerez, has long devoted himself to the exploration of the lower valley of the Guadalquivir and the bordering Sierras—the most interesting districts of the whole peninsula.

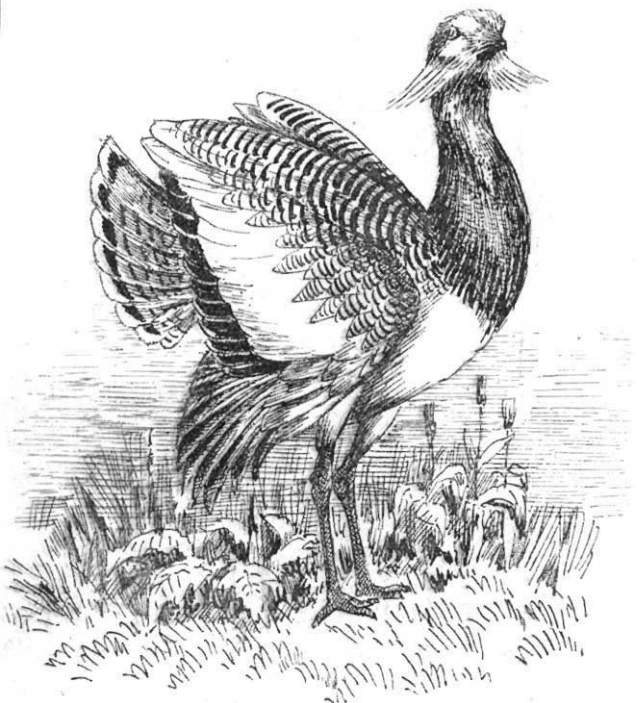
Although the larger mammals of Spain are by no means neglected, and even such extraneous subjects as corn, wine, oil, brigands and gypsies are cursorily treated of, "Wild Life in Spain" is emphatically a "bird-book." After their digressions on other points the authors return to their feathered favourites with a zest which shows that the study of the bird-life of the peninsula, combined no doubt with an ardent love of "la chasse," was the primary object of their wanderings.

In the fauna of Wild Spain the abundance of the larger birds of prey forms a very prominent feature, and several chapters are well devoted to this part of the subject. Almost all the finest and largest Raptors of the European ornis are to be met with in Spain. To the ornithologist, who in these latter days may search the greater part of "Wild Britain" without finding anything more exciting than a stray kestrel or a fugitive sparrowhawk, this superabundance of the larger Falconidæ must prove a great attraction. Eagle-shooting, which would be a fearful crime in England, is allowable, if not praiseworthy, in the Spanish peninsula, and even an occasional vulture may be killed without much harm being done. Moreover Spain is fortunate in possessing an eagle of its own, called by modern naturalists *Aquila adalberti*, which is in fact a local form of the Imperial eagle of South-eastern Europe. But the Adalbert's eagle is remarkable as showing several successive stages of plumage which do not appear to occur in its near ally. On these we have much information in the present volume from actual experience, which seems to prove that the Spanish Imperial eagle breeds indiscriminately in its youthful and adult liveries, birds in fully adult plumage having been found paired with others in the younger forms of dress. Besides eight or nine eagles two large vultures are abundant in the south of Spain, and the celebrated Lammergeier of the Alps known to the Andalucians by the appropriate name of "*Quebranta huesos*" or "bone-snatcher" is likewise still to be met with. How the eyries of this giant bird, situated in the mountains eastward of Jerez were visited and ransacked is told to us in two attractive chapters. As the breeding-season of the Lammergeier begins in January, when the Sierras are still under snow and the weather is inclined to be severe, such an expedition is by no means free from inconveniences.

Even in wild Spain, we regret to say, the Lammergeier

is yearly decreasing in numbers. "A decade ago they were fairly numerous in the vast area of rock-mountains which stretch between Granada and Jaen. To-day a week may be spent in that district without even so much as a distant view of this grand bird. The reason is unquestionably the use of poison, which is laid out broadcast by the goat-herds for the special benefit of wolves, but which is equally fatal to the Lammergeiers."

Another leading feature in the Spanish ornis is the Great Bustard, still abundant in Andalusia "on those vast stretches of silent corn-lands which form its home." "Big days with bustard," the various modes of its *chasse* and the principal features of its life are well described in "Wild Spain." It is curious that the authors do not seem to have been able to ascertain positively whether this bird is monogamous or polygamous. Even during the pairing season each band of bustards is composed of mixed sexes, the females preponderating, until the latter skulk off to perform the duties of incubation, and leave the males all together in separate packs. Bustard-shooting must indeed be glorious sport. Oh, that Salisbury



Male Great Bustard, showing off.

Plain could be restocked with this now nearly extinct (English) bird!

Next to the bustard the flamingo is perhaps one of the most attractive objects to the explorer of the wilds of Andalusia. In some seasons flamingoes visit the marismas in enormous flocks; in other years they are extremely scarce. In 1883 Mr. Chapman found them abundant in the month of April, and searched the country over a large area systematically, in the hope of finding their breeding-places. The exact fashion in which this bird sits upon its nest had long been a matter of controversy, and it was hoped that this interesting point might now be definitely settled. But in April all efforts were unsuccessful—it was evident the birds had not yet begun to breed—and a smart attack of ague was the only result of splashing about from day to day in the mud and water, with a fierce sun beating down upon the ornithologist's head. In May, however, during an

<sup>1</sup> "Wild Spain (España agreste), Records of Sport with Rifle, Rod, and Gun, Natural History and Exploration." By Abel Chapman, F.Z.S., and Walter J. Buck, C.M.Z.S., of Jerez. With 174 illustrations, mostly by the authors. (London: Gurney and Jackson, 1893.)