

both voltmeters is ascertained by inserting equal known resistances in both branch circuits, when

$$v = v'$$

should be the result. Failing this, the balance is generally re-established by reversing the poles of the battery, the reason being that hydrogen electrodes are liable to accumulate metallic or other deposit upon their surfaces, which is effectually removed by oxygen.

When the instrument is to be worked between wide ranges of temperature, it is requisite that  $C$  should be variable, and nearly equal to  $X$ , and that  $\gamma$  should be very small compared with  $X$ .

By equating the values of the equations

$$X = \frac{v}{\gamma}(C + \gamma) - \gamma = r = \cdot 039369 \frac{v}{\gamma} + \cdot 00216407t - \cdot 24127,$$

$C$  and  $\gamma$  in the instruments constructed being equal to 17 and 2 units, we arrive at

$$r \text{ Cent.} = \left\{ (877 \cdot 975 \times \frac{v}{\gamma} + 101 \cdot 80877) \frac{1}{2} - 9 \cdot 0960553 \right\}^2 - 274,$$

from which a table has been prepared to be used with the pyrometer.

The precautions which have to be taken to insure reliable results in using the Differential Voltmeter are:—

1st. The dilute acid employed in both tubes should be of equal strength.

2nd. After disuse, the equality of the resistances of the voltmeters and connection should be verified by passing the current through them with equal resistances in each branch.

3rd. The battery power should be proportional to the resistances to be measured, whilst owing to the voltmeter exercising an opposing electro-motive force by polarisation, less than five Daniell's elements should not be employed.

4th. The india-rubber pads should be smeared from time to time with a waxy substance such as resin cerate.

With these precautions the measurements of the instrument have been compared with a very perfect Wheatstone bridge arrangement, and tables of results are given showing that it can be relied upon to within one-half per cent. of error of observation. Its principal advantages are stated to be: that the resistance is measured in work done, and does not therefore depend upon a momentary observation, that it is not influenced by motion on board ship or by magnetic disturbances, and that its construction is so simple that each part can be easily examined and verified.

It is regarded, however, only as a useful adjunct to the more important subject of thermometry, which forms the principal object of this paper.

#### THE GIGANTIC LAND TORTOISES OF THE MASCARENE AND GALAPAGOS ISLANDS\*

EVER since the foundation of Natural History Collections in Europe, naturalists had their curiosity excited by shells of Tortoises of enormous size that were brought home in vessels coming from India. From the accounts of travellers as well as from the great convexity of their shell, these tortoises were known to be terrestrial in their life, and totally distinct from the other giants of the Chelonian order, the marine Turtles. Various localities having been given as their habitat, such as the Cape of Good Hope, the Coast of Coromandel, Malacca, China, &c., the impression prevailed that they were found in many parts of India, and consequently nothing could have been more appropriate than the name given to them, *Testudo indica*.

It is not the object of the present article to treat in detail of the divergent views held subsequently by zoologists, some distinguishing several species from the difference of the form of the shell alone, others maintaining that there was one very variable species only which had been carried by ships from its native place into various parts of the globe where it became acclimatised, until

\* The substance of this article is contained in a paper read by the author before the Royal Society in June, 1874, which will appear in the forthcoming volume of the "Philosophical Transactions," and to which I must refer for the scientific portion and other details. Some facts which have come to my knowledge subsequently to the reading of this paper, are added.

Dr. Gray, the principal advocate of the latter opinion, himself was compelled to admit that there must be at least two kinds, one with a convex and the other with a flat skull. The scientific study of these tortoises may be said to have commenced with this distinction, but it commenced at a time when the work of disturbance and extermination by man had already reduced the amount of evidence so far as to well nigh bring the subject into the domain of palæontological research.

From the accounts of voyagers of the sixteenth and seventeenth centuries we learn that these tortoises were found at two most distant stations, one being the Galapagos group in the Pacific, the other comprising some of the islands of the Indian Ocean; Mauritius, Rodriguez, Aldabra, and probably Réunion. Widely different as these stations are in their physical characteristics, they had that in common, that they were, at the time of their discovery, uninhabited by man or even by any large terrestrial mammal. There is not the slightest trace of evidence that any of the intervening lands or islands have ever been inhabited by them.

At first the Tortoises were found in immense numbers and of extraordinary size. Leguat (1691) says that in Rodriguez "you see two or three thousand of them in a flock, so that you may go above a hundred paces on their backs;" and indeed, when we consider that these helpless creatures lived for ages in perfect security from all enemies, and that nature has endowed them with a most extraordinary degree of longevity, so that the individuals of many generations lived simultaneously in their island home, we can well account for the multitudes found by the first visitors to those islands. For a period of more than a century they proved to be a source of great benefit to the crews and passengers of ships, on account of their excellent and wholesome meat. In times when a voyage, now performed in a few weeks, took as many months, when every vessel, for defence's sake and from other causes, carried as many people as it was possible to pack into her, when provisions were rudely cured and but few in kind, these tortoises which could be captured in any number with the greatest ease in a few days, were of the greatest importance to the famished and scorbutic ship's company. The animals could be carried in the hold of the ship for many months without food, and were slaughtered as occasion required, each tortoise yielding from 80 to 300 pounds of fresh wholesome food; and we read that ships leaving the Mauritius or the Galapagos used to take upwards of 400 of these animals on board.

Although no account of the first discovery of the Galapagos Islands appears to have been published, so much is certain that it is due to the Spaniards, who applied the Spanish word for tortoise to this group of islands. It became the regular place of meeting and refitting to the buccaneers and whalers, who provisioned themselves chiefly with tortoises and turtles. But numerous and constant as these visits were, the reckless destruction of animal life was limited chiefly to the coast-belt, and numbers of the animals inhabiting the interior escaped; no regular or extensive settlement being attempted, the condition of the islands and of the animals inhabiting them remained in the main unaltered until the earlier portion of the present century. From the accounts of that period I select that given by Porter, a Captain in the United States Navy, as the one which contains by far the most interesting observations (Journal of a cruise made to the Pacific Ocean, New York, 1822, 8°). He found, in the year 1813, the tortoises in greater or less abundance in all the larger islands of the group which he visited, viz., Hood's, Narborough, James, Charles, and Porter's Islands. On Chatham Island he found only a few of their shells and bones, which appear to have been lying there for a long time, and possibly may have belonged to individuals transported from some other island. On Albe-

marle Island, the largest of the group, none were observed by him, evidently because he landed here only for a few hours on the south-western point. Abingdon, Binloe's, Downe's and Barrington Islands were not visited by him. He describes the steps of the tortoises as slow, regular, and heavy; they carry their body about a foot from the ground, frequently erecting their neck, which is from eighteen inches to two feet long, and very slender; also their head is comparatively small. In the daytime they appeared remarkably quick-sighted and timid, drawing their head into the shell on the slightest motion of any object; but they are said to be entirely destitute of hearing, as the loudest noise, even the firing of a gun, did not seem to alarm them in the slightest degree. At James Island Porter took on board as many as would weigh about fourteen tons, the individuals averaging about sixty pounds, that is, about 500 individuals; and he states that among the whole there were only three males which he distinguished by their great size and by the greater length of the tail. As the females were found in low sandy bottoms, and all, without exception, were full of eggs, he presumed that they came down from the mountains for the purpose of laying; the few males had been taken at a considerable distance from the shore, in the hilly interior of the island. The eggs are perfectly round, white, with a hard shell of a diameter of  $2\frac{1}{4}$  inches. He found the blood of the tortoises to possess constantly a temperature of  $62^{\circ}$ , whilst the general temperature of the air in the Galapagos varies from  $72^{\circ}$  to  $75^{\circ}$ .

Very significant are Porter's remarks as regards the differences of the tortoises from different islands. Those of Porter's Island he describes as being generally of an enormous size, one (not by any means the largest) measuring  $5\frac{1}{2}$  feet in length,  $4\frac{1}{4}$  feet in width, and 3 feet in depth. The form of the shell of the race inhabiting Charles's Island is elongate, turning up forward in the manner of a Spanish saddle, of a brown colour and of considerable thickness, whilst the tortoises of James Island are round, plump, black as ebony, and remarkably thin-shelled. The tortoises of Hood's Island, one of the smallest of the group, were small, and as regards form, similar to those from Charles's Island.

Twenty-two years had passed since Porter's Cruise, when Darwin visited the Galapagos Archipelago in the *Beagle*, in the year 1835. On his excursions in the interior he still met with large individuals, but a change by which the existence of these animals was much more threatened than by the visits of whalers, &c., had taken place. The Republic of Equador had taken possession of the Archipelago, and a colony of between two and three hundred people banished by the Government, had been established on Charles Island, who reduced the number of tortoises in this island so much that they were driven by necessity to send parties to other islands to catch tortoises and salt their meat. Also, pigs had multiplied and were roaming about in the woods in a feral state, no doubt destroying the offspring of those which hitherto had escaped.

After an interval of not quite eleven years H.M.S. *Herald* followed the *Beagle* on a voyage of discovery and survey. The naturalist of this expedition, which reached the Galapagos in the year 1846, found that the progress of civilisation had been great, or, in other words, that the displacement of the indigenous fauna by man and his companions had proceeded apace. On Charles Island the cattle had increased wonderfully, and were estimated at 2,000 head, beside wild pigs, goats, and dogs; the wild dogs keeping the goats and pigs very much down, whilst the tortoises had been exterminated between the visits of the *Herald* and *Beagle*. On the other hand, they were met with on Chatham Island, but the largest individual measured only two feet two inches in length.

Recent accounts of visits to the Galapagos do not give us the particulars of the present condition of the indi-

genous fauna, nor do they contain any information as regards the survivors of its Chelonians. The specimens which at rare intervals reach Europe *via* Panama, are young individuals not exceeding twenty inches in length or about twenty-five pounds in weight. The giants of their race appear to be extinct or nearly so, and it is scarcely to be expected that (except under most favourable conditions) any of the surviving comparatively young and small individuals of so slow-growing a form of animal life will be allowed, by an increasing lawless population, to live long enough to reach the dimensions of the individuals of former generations. Therefore, there is but little hope that valuable additions will be made to the scanty and incomplete material in our collections; and any information as regards the present occurrence of the several races in the various islands, is to be received with caution, as evidently the original distribution of the races has been much interfered with in the course of time by the carriage of tortoises from one island to the other.

The original condition and the fate of the tortoises of the Mascarene Islands were precisely the same as in the Galapagos. Their extreme abundance in the small island of Rodriguez\* has been referred to above. Down to 1740 they continued to be numerous in the Mauritius; for Grant ("Hist. Maurit.," p. 194) writes in that year—"We possess a great abundance of both land- and sea-turtles, which are not only a great resource for the supply of our ordinary wants, but serve to barter with the crews of ships who put in here for refreshment on their voyage to India." But they appear to have been much more scattered in the larger islands than in Rodriguez; and, according to Admiral Kempinfieldt, who visited the latter island in 1761, small vessels were constantly employed in transporting these animals by thousands to Mauritius for the service of the hospital. Soon, however, their number appears to have been rapidly diminished; and to the causes which worked their destruction in the Galapagos, here another was added, *viz.*, widely spreading conflagration, by which the rank vegetation of the plains was destroyed to make room for the plantations of the settler. They did not long survive the Dodo or Solitaire, and early in the present century the work of extermination was accomplished; there is at present not a single living example either in Rodriguez or Mauritius.

Our knowledge of the indigenous fauna of the Island of Réunion is still extremely meagre. If we can trust to tradition, a gigantic land-tortoise once inhabited this island; and if this be really the case, it must have become extinct long before the Mauritius and Rodriguez species, nor is there any evidence to show its affinity to one of the other races. The Seychelles do not appear to have been inhabited by these animals, certainly not within historical times, all the individuals found there having been imported from Aldabra and kept in a semi-domesticated condition.

The Island of Aldabra, the only spot in the Indian Ocean where this Chelonian type still lingers in a wild state in small and gradually diminishing numbers, lies in lat.  $9^{\circ} 25' S.$ , long.  $46^{\circ} 20' E.$  In reality it consists of three islands, separated from one another by a deep channel about half a mile wide. They are covered with verdure, low tangled bushes interspersed with patches of white sand; two of the islands are rather low, hummocky near the centre. The middle island is slightly the largest, extending six or eight miles in length and three or four miles in breadth; it is much higher than the others, and partly covered with very high trees that may be seen eight or nine leagues from the deck of a moderate-sized ship.

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(To be continued.)

\* Again amply testified by the rich collection of tortoise-bones made by Mr. Slater, one of the naturalists appointed by the Royal Society to accompany the Transit of Venus Expedition to Rodriguez.