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Alfred Eaton: a Victorian naturalist at the ends of the world

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Abstract

Alfred Edwin Eaton (1844–1929) was amongst numerous Victorian naturalists whose exotic collections disseminated to the natural history museums of Britain laid the groundwork for our understanding of biodiversity. What sets him apart from his contemporaries was his first-hand knowledge of organisms at the polar extremes. This paper describes Eaton's contributions to polar biology, especially in the field of entomology, from two high-latitude expeditions: the 1873 Benjamin Leigh Smith Expedition to Svalbard in the European Arctic and the 1874 British Transit of Venus Expedition to Kerguelen Island in the southern Indian Ocean. His observations of flightless polar and subpolar insects, in particular, lent support to the work of *Challenger* naturalist Henry Moseley and botanist Joseph Hooker on species dispersal in the Southern Ocean and on adaptations that arise in response to the unique selection pressures in harsh, isolated conditions.

Keywords

Svalbard; Kerguelen Island; entomology; 1873 Benjamin Leigh Smith Expedition; 1874 Transit of Venus Expedition; aptery

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Abbreviation

RES: Royal Entomological Society of London

Introduction: the making of a naturalist

Though a relatively unknown naturalist compared to larger-than-life contemporaries like Darwin, Hooker and Huxley, Alfred Edwin Eaton (1844–1929; Fig. 1) contributed significantly to the biological discoveries of the day, particularly from two dangerous expeditions to the polar extremes. The origins of Eaton's scientific development as well as observations from a lifetime of work in the field can be found in his unpublished notebooks stored at the RES. These notebooks include meticulous lists and tables of floral and faunal data from the countryside of southern England, sketches of arthropods, diagrams for the collection and mounting of specimens and even recipes derived from plant and fungal species. They reveal a lifelong exhilaration with the natural world.

Most informative of the RES notebooks is *Notebook J 27 1859–1864* as it portrays Eaton's formative years, his precocious understanding of the local wildlife and a self-education derived from collecting forays throughout the countryside of his native Devon and further afield in southern England and conversations with locals and gamekeepers. For example, young Eaton gleaned from informants that woodcocks (*Scolopax* spp.) build their nests in dry places, but "as soon as the young are hatched they carry them to moist and muddy places to rear them. It is supposed that the Woodcock swims when migrating as one was seen swimming by a gentleman on the coast of Sussex" (Eaton 1859–1864). By age 18, Eaton understood the connection between form and function, as in this passage on the mechanisms of plant reproduction: "In anagallis arvensis (the blue-scarlet pimpernel) the dehiscence of the stamens is longitudinal, and where the flower closes the anthers are arranged round the stigma with their faces touching it and in this way the fertilization of the ovules is insured" (Eaton 1859–1864).

Another dominant theme of the RES notebooks was Eaton's lifetime commitment to the collection and preservation of specimens, particularly insects (Fig. 2). His growing interest in entomology is evident in the following passage, in which the teenaged Eaton paraphrased helpful instructions in *The insect-hunter's companion* (Greene 1863): "Look out for a large tree standing alone in a park or meadow. The trees best suited are poplars, willows, oaks, birches, beeches, ashes and hawthorns. A tree in a light soil with the surrounding soil worn away by the feet of cattle situated by the side of a dyke or the border of a field is in the most favourable situation…Take the sod in one hand and tap it gently with the trowel and pupa with no cocoon will drop out" (Eaton 1859–1864). Eaton's education continued at Cambridge University, where, like many others of his day, he pursued interests in theology and natural history. At the university, Eaton's reputation as an entomologist spread with his frequent contributions to entomological journals and membership in the Entomological Society London. By age 25, Eaton had already published significantly on the taxonomy of

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Fig. 1 Portrait of Alfred Eaton. (Reproduced with permission of the Royal Entomological Society, UK.)

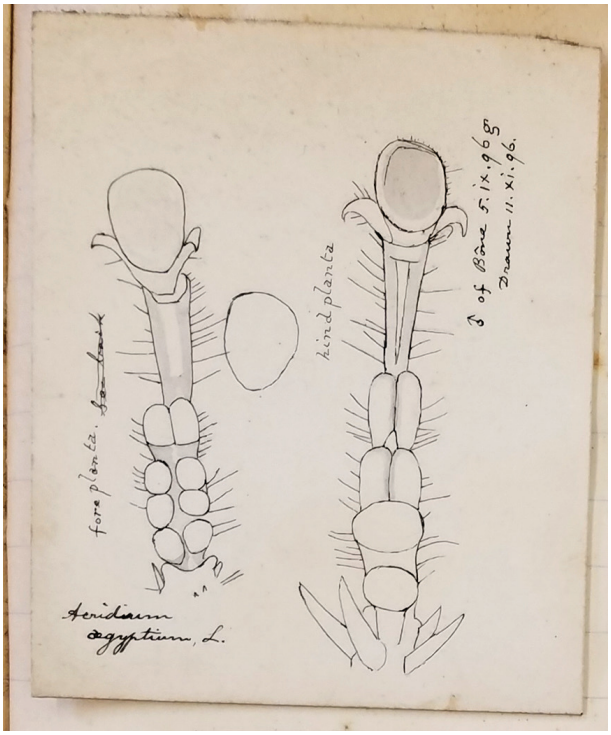

Fig. 2 Sketch of the Egyptian grasshopper (*Anacridium aegyptium*) by a young Alfred Eaton in one of his notebooks at the RES. (Photograph by author.)

the Ephemeroptera (mayflies) and had described several new species that are still valid today.

Northbound to Svalbard

By the summer of 1873, Eaton had completed B. A. (1868) and M. A. (1871) degrees at Cambridge and served as a vicar in Ashbourne, Derbyshire. How polar explorer Benjamin Leigh Smith (1828–1913) selected Eaton for his third expedition is unknown; it is possible that their paths crossed by way of a common circle of Cambridge scholars. What is clear is that in spring 1873, Eaton had compiled, at the request of Leigh Smith's half-sister, the artist and feminist Barbara Bodichon (1827–1891), a list of the animal and botanical species of Svalbard (Capelotti 2013). Eaton was preparing himself for adventures farther afield for he had landed the position as "Ship's Surgeon and General Practitioner" aboard Leigh Smith's chartered, steam-powered schooner *Diana* (Fig. 3).

On 10 May 1873, *Diana* left the docks of Dundee for a summer of exploration in Svalbard, where her mission was two-fold: to carry relief supplies to a Swedish expedition stranded in Mosselbukta, northernmost Svalbard, and to complete a geographical and scientific survey of the remote northern edges of the archipelago. Its ship appropriately named in honour of the Roman goddess of wild animals, and the hunt, the Leigh Smith expedition was, like most of its day, underwritten by a large-scale hunt. Leigh Smith and his companions "zealously devoted themselves to the *cultus* of our mythological patroness, and left to my care the miscellany of Natural History" (Eaton 1873: 3762).

The endeavours of *Diana*'s crew have been described in three journals written by the expedition chronicler Lieutenant Herbert Chermside (1850–1929) and which currently reside at the Scott Polar Research Institute Cambridge. From the edited edition of the Chermside journals (Capelotti 2021), along with rare photographs of the 1873 Svalbard expedition that have recently come to light, a vivid picture of Eaton's activities, eccentricities and energy emerges (Devlin 2021):

> Eaton, equipped with an Alpens Pack, a straw knapsack like a carpenters tool bag, numerous vials, corks, instruments &c, an *enormous* pair of boots, a glass bottle with a hole in the bottom of it to carry his shot and a rusty single barrel, and followed by a little "Jack," who

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Fig. 3 Steam-powered schooner *Diana* in Svalbard in the summer of 1873. (Photograph used with permission of the Grenna Museum, Sweden.)

> is apparently an aspiring entomologist, takes the hillside and gets to work as usual, like a sandpiper turning up every likely looking stone for worms and insects, and I expect like them congratulating himself in tones as expressive, ere he consigns each treasure trove to a fitting receptacle. (Chermside, in Capelotti 2021: 109)

Entomological research

Eaton's entomological work was viewed by Chermside and *Diana*'s crew with a mix of fascination and trepidation. "Eaton (was) very busy poisoning flies and other insects. We all are all very glad of this, as … we are a little nervous about their being in the cabin" (Chermside, in Capelotti 2021: 76). A month later, Chermside's concerns of a shipboard infestation persisted: "Eaton was much elated at having during his researches discovered a larva or parasite from some animal: forbid such in the cabin" (Chermside, in Capelotti 2021: 85). Eaton's search for insects continued along Svalbard's rough coastline, where he seemed undaunted by the threat of polar bears (*Ursus maritimus*).

> My best opportunities for collecting on shore occurred when the others were away deer-stalking. On these occasions I usually went unarmed, preferring the chance of being able to drive off with stones any bear that might attempt to make a friendly advance upon me… Sometimes, however, in very bearish localities, one of the hands would be sent with a rifle to guard me; and dull work it must have been to him to be kept loitering about while such numbers of stones were being turned over, for not a bear was forthcoming. (Eaton 1873: 3762)

He later remarked that "The captain had insisted upon my being attended like a convict by a man with a loaded rifle…" (Eaton 1874: 3805).

Chermside often joined Eaton's collecting ventures and so documented the naturalist's findings: "I have not touched on entomology, knowing nix on the subject. Moths have however been captured, both the small kind, known to inhabit Spitzbergen, and a larger, I believe, entirely new sort" (Chermside, in Capelotti 2021: 168). The "new sort—" two male moths discovered by Eaton in Wijdefjorden—first found their way to the German entomologist Phillip Christoph Zeller (1808–1883), who analysed them in 1874, and then to Britain's Henry Tibbats Stainton (1822–1892), who wrote that Eaton's two specimens "must certainly be a good new species, for which I should propose the name of *Plutella polaris*" (Stainton 1880: 109). *Plutella polaris* would not be seen again for another 140 years, when Norwegian scientists rediscovered it in Wijdefjorden in the summer of 2015 (Nordahl 2017; Søli et al. 2018).

Eaton had equal success with the discovery of new Hymenoptera, all parasitic wasps, at Wijdefjorden, Lomfjord and Heclahamna. The species he collected there were later examined by the entomologist Reverend Thomas A. Marshall (1827–1903), who concluded that "four are new" (Marshall 1877: 241). One of these, the wasp *Orthocentrus*, was brachypterous and incapable of flight, a common adaptation of high-latitude insects.

Botanical research

Eaton's second area of expertise was plants, and his "botanising" excursions appeared throughout Chermside's journals: "Eaton has been travelling daily, right up to the glacier feet and, on the whole, has done excessively well in the way of plants in this bay" (Chermside, in Capelotti 2021: 168). His ever-present alpenstock proved "a most serviceable implement to an arctic or alpine collector; for, in addition to its utility in cliff-climbing and on snow slopes, its spike is an excellent substitute for a trowel for rooting up plants" (Eaton 1873: 3762). The "indefatigable" Eaton wrote their scientific names "with all care and precision, on the lids of the nice little wooden coffins prepared for any rarity vain enough to bloom, and pining for sepulchre in a museum" (Chermside, in Capelotti 2021: 130).

Eaton's botanical investigations continued under the microscope with his observations of the algae and unicellular phytoplankton responsible for red and brown snow. "I procured some pieces of decayed ice discoloured by diatoms: these plants grew on the surface of the ice-crystals in the interstices of the honeycombed part, and there formed a coloured layer between the newer snow and the hard ice from four inches to two feet in depth" (Eaton 1873: 3763). Red colouration in snow is due to the photoprotective carotenoid pigment astaxanthin found in

various green algae, whereas snow of a light brownish colour comes from the diatom photopigment fucoxanthin. The Svalbard diatoms were later studied in Dublin by the minister–naturalist Eugene O'Meara (1815–1880), who wrote that of the 181 species previously known to the Arctic, Eaton had single-handedly collected "no less than 92" (O'Meara 1874: 254). In honour of the expedition's naturalist and leader, two new species would be named *Amphora eatonia* and *A. leighsmithiana*.

Upon *Diana*'s return to home waters, Eaton's botanical collection was dispersed to experts across the British Isles. The phanerogams and higher cryptogams were sent south to Spencer Le Marchant Moore (1850–1931) at the Royal Botanic Gardens Kew, whilst the algal samples were sent north to George Dickie (1812–1882) at Aberdeen University. Eaton's botanical work from the Svalbard expedition culminated in his own publication, *A list of plants collected in Spitzbergen in the summer of 1873, with their locations* (Eaton 1876a).

Biota from the deep

By the summer of 1873, when Eaton was untangling invertebrates and seaweeds from nets on *Diana*'s deck, dredging was a labourious yet proven means to obtain marine specimens. The 1830s and '40s dredging operations in the Aegean by Edward Forbes (1815–1854) had led to his publications on deep-water molluscs, echinoderms and cnidarians. Forbes's Azoic Hypothesis, stating that the ocean was devoid of life below 300 fathoms, or ca. 550 m (Forbes 1844), had been debated by the scientific community and then disproved by the Norwegian fisheries superintendent Georg Ossian Sars (1837–1927) and his zoologist father Michael Sars (1805–1869; Rozwadowski 2005). Eaton's understanding that life inhabited all oceanic zones prompted his recording of the fathoms in which the marine specimens were collected. Additionally, he had been advised and supplied with equipment by the famed malacologist J. Gwyn Jeffreys (1809–1885), who had collected deep-sea specimens throughout the Shetlands and Hebrides (Anonymous 1885). Chermside described the challenges of obtaining live, intact specimens: by the time, a marine organism was "with infinite difficulty hauled to the surface, he resembles a bag of ballast, and the aforesaid rarity's most intimate friends would have the greatest difficulty in recognising him. In other words, the bag gets full of stones, and all the animals are pounded to fragments or reduced to become amateur jellyfish" (Chermside, in Capelotti 2021: 172). Still, from their back-breaking efforts came hard-won successes. The mollusc collection (pteropods, gastropods, conchifera and brachiopods) was sent back to Jeffreys, who found that two gastropods, an *Eolis* from Fairhaven and a *Natica* from Lomfjord, had ambiguous species designations, as indicated by his question marks and, therefore, may have been new species (Jeffreys 1876).

Eaton's search for marine specimens continued into the gastrointestinal tracts of marine mammals. Edward Miers (1851–1930), the curator of the crustacean collection at the Natural History Museum London who examined Eaton's crustaceans, remarked that: "Some of the specimens in the collection were found in a Saddleback's (harp seal [*Pagophilus groenlandicus*]) stomach killed off the Western Ice in green water" and the "species are most of them well-known Arctic forms; but the specimens generally are of a large size and in an excellent state of preservation" (Miers 1877: 131).

Auxiliary duty as 'sawbones'

In addition to being the expedition naturalist, Eaton served as "Ship's Surgeon" and ad hoc medical officer for *Diana*'s crew. His collecting trips were occasionally interrupted to attend to an injury, as when "Eaton who as amateur sawbones … was soon however brought up, and the boats rowed off" to attend to a shooting onboard *Diana*, but luckily it was "nothing serious, the third mate had pointed a rifle at the dog, and accidently shot the steward through the arm and the dog through the jaw" (Chermside, in Capelotti 2021: 110). Eaton's medical assistance extended to the international community of whalers and sealers hunting in the waters of Svalbard: "The captain of one of the (Norwegian) smacks comes on board for a sawbones, one of his men having shot himself in the arm, and Eaton goes off to look after him" (Chermside, in Capelotti 2021: 145).

A successful return

Diana returned to the shores of Dundee on 27 September 1873, where Eaton's extensive collection of Arctic specimens was offloaded. "Rev. A. E. Eaton presented a collection of Crustaceans, Annelids, Echinoderms, Tunicates, Coelenterates, and Sponges, which he made during a visit to Spitsbergen", reported Albert Günther, the Keeper of Zoology at the Natural History Museum to the Board of Trustees (Günther 1912: 29). The specimens were disseminated to Britain's naturalists for examination. Of the resulting publications, Eaton would pen three on his own: one on the botany (Eaton 1876) and two on the zoology (Eaton 1873, 1874). His first zoological publication focused on Arctic mammalogy: the pinnipeds, cetaceans, reindeer, foxes and polar bears (Eaton 1873), whilst the second covered ornithology and ichthyology (Eaton 1874). He wryly commented that "Before we sailed from England I was asked at Cambridge to leave the mineralogy of the

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mainland of Spitsbergen alone, and to devote my time to plants and animals" (Eaton 1874: 3822), perhaps to leave some work for the geologists. Svalbard proved to be Eaton's testing ground; thereafter, his reputation as an unflappable and competent collector was cemented. Invitations to expeditions farther afield were fast in coming.

Southbound to Kerguelen's Land

Though the Kerguelen archipelago, in the southern Indian Ocean, remained amongst the "least explored and most inaccessible oceanic islands in the southern hemisphere" (Stokes & Huxley 1879: v), Britain's Royal astronomers considered its location strategic to observe the 1874 Transit of Venus. Naturalists Joseph Hooker, Thomas Huxley and Philip Sclater spotted an opportunity. In a petition to Her Majesty's Treasury, they wrote that

> This large island was last visited in 1840 by the Antarctic Expedition under Sir James Ross, in mid-winter only, when it was found to contain a scanty Flora of flowering plants, some of which belong to entirely new types, and an extraordinary profusion of marine animals and plants of the greatest interest, many of them being representatives of North-temperate and Arctic forms of life … the rare opportunity of sending a collector to Kerguelen's Land should not be lost. (Stokes & Huxley 1879: v–vi)

It would be summer in the Southern Hemisphere, which would provide optimal conditions for collecting botanical specimens, they reasoned; plus, they knew the perfect man for the job, a field-tested naturalist "who was well-qualified to bring to bear his experience of the Arctic fauna and flora upon those existing in the southern hemisphere under parallel physical conditions" (Stokes & Huxley 1879: vi).

On 20 June 1874, Eaton departed from his ministerial post at London Paddington and lugged his equipment aboard the steamship *Windsor Castle*, on route to Kerguelen Island via the Cape of Good Hope. *Windsor Castle* arrived in Cape Town one month later, only to have the voyage to Kerguelen delayed because of "accidents to their own and other ships, which rendered necessary a change of vessels," wrote Father Stephen Perry (1833–1889), the leader of the Transit of Venus Expedition (Perry 1881: 405). Ever the opportunist, Eaton headed into the hills surrounding Cape Town to collect botanical specimens. The result was the discovery of possibly 34 new lichen and six fungi, two which were named *Daedalea eatonii* and *Galera eatonii* in honour of their discoverer (Anonymous 2020). The astronomers kept equally busy, using the layover to hone their photography skills and prepare the telescopes and chronometers for the forthcoming Transit of Venus on 9 December (Godley 1970; Hudon 2004).

On 18 September 1874, Eaton and the Royal astronomers set off from Simon's Bay on HMS *Volage* and its supply ship, aptly named HMS *Supply*, for the second leg of their journey to the Kerguelen archipelago. After a "stormy passage" that separated the two ships, they rendezvoused in Royal Sound on the south-eastern coast of Kerguelen Island on 11 October 1874 (Eaton 1879a: 7). The Brits were not alone in Royal Bay, the crew discovered. American astronomers had already built their observation station at Molloy Point on its northern shore, and whaler huts, casks of blubber and stone graves of sealers were evident along the shoreline (Corbet 1875: 53). Guided by sealers with a knowledge of the kelp-dense waters and an eagerness to work for grog, *Volage* and *Supply* steamed westward into Morbihan Bay, eventually finding a protected anchorage in Observatory Bay (Fig. 4). "Constant snow-storms and rains interrupted the work of the landing and erecting huts and instruments," yet by 26

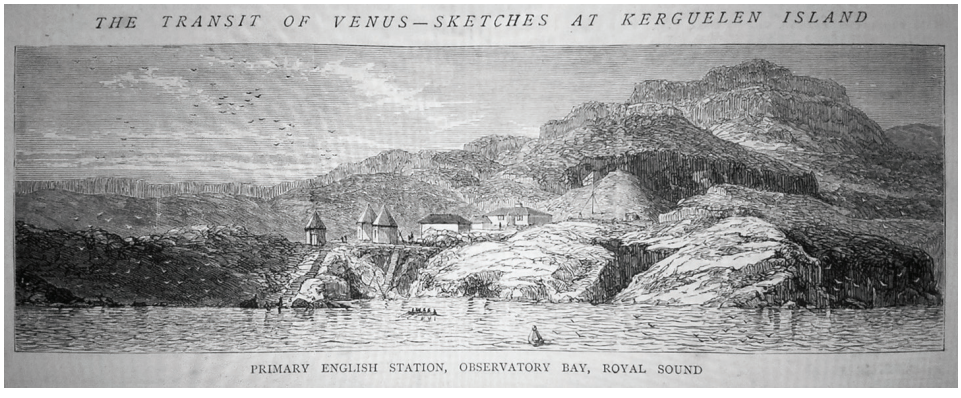

Fig. 4 The Observatory Bay base camp occupied by royal astronomers observing the 1874 Transit of Venus on Kerguelen Island. (Illustration from *The Graphic*, 27 March 1875, used with permission of the British Library.)

October, a base camp comprised of wooden observatories and dwelling houses was completed 50 feet above the rocky shoreline (Perry 1881: 406).

The sub-Antarctic weather proved treacherous for Eaton's collecting of biological specimens. "Sudden squalls" off the mountainous coasts made boat operations extremely hazardous (Eaton 1879a: 4). The terrain was riddled with "dangerously deep" mud-holes with a "consistency of liquid mortar"; on some parts of the island, they had an "average depth … up to a man's waist" (Eaton 1879a: 3). Fjords, lakes, bogs and terraced hills rendered some parts of Kerguelen "absolutely inaccessible," whereas other areas could "be reached only by following the devious windings of a complicated maze" (Eaton 1879a: 3). Despite these challenges, Eaton obtained specimens "from altitudes of 500 or 600 feet [ca. 152–182 m] above the sea to the depth of about 10 fathoms [ca. 18 m] along the coast" (Eaton 1879a: 7).

Eaton attributed his success to "the liberality and kindness" of the *Volage*'s Captain Fairfax, who conveyed Eaton "in his gig to almost every part of the bay that was accessible by boat in Kerguelen Land weather, and surrendered his cabins without reservations to the reception of buckets and specimens of all descriptions, excluding only seals and cetaceans, accommodated elsewhere" (Dickie 1879: 54). Mirroring Chermside's role as expedition narrator, a 24-year-old naval officer Lieutenant Cyril Corbet (1850–1876) chronicled the day-to-day events, fortunes and misfortunes of the "Venus crew" including those of Eaton. Corbet had a different interpretation of Eaton's shipboard activities: Eaton "seems to have been a regular nuisance on board the ship, with his bird and sea-leopard skinning and stuffing: the officers say they were actually stunk out of the ward room and Captain's cabin; they made him bury his skins on shore at last, to keep them till he sails for home" (Corbet 1875: 68). The collections spilled over into Eaton's living quarters at Observatory Bay: "I never saw anything like Eaton's room (on shore)—so full of all sorts of birds, skins, insects, seaweeds, etc. etc., with just two boards left spare, and a blanket, for his bed" (Corbet 1875: 117). Like Chermside, a summer before, Corbet was intrigued by the odd naturalist: Eaton "had been going about in nothing but a pair of drawers and a water-proof, barefooted, and no hat—he had lost it" (Corbet 1875: 105). Corbet found himself joining Eaton's collecting treks and specimen dissections, albeit reluctantly. "Capt. Fairfax and Mr. Eaton, the naturalist, would like very much to have his skull (from an elephant seal [*Mirounga leonine*] killed by Corbet), I could not muster up sufficient courage to take his head off, he looked so nasty", wrote Corbet (1875: 68).

From October 1874 to February 1875, Eaton collected and/or observed 170 animal species and 277 types of plants, largely from the vicinities of the three astronomical stations at Observatory Bay, Supply Bay and Thumb Peak (Eaton 1875a, 1879a; Godley 1970). "I looked over Eaton the naturalist's room, and was much struck with the extensiveness of his collections; his work for the Royal Society will be a great success, anyhow," concluded Corbet (1875: 95–96).

Auxiliary duty as astronomer

To replicate the data collection during the Transit of Venus event, Father Perry ordered three observation stations to be built, and Eaton was recruited to assist. The first observatory was constructed at Observatory Bay, and, under the command of Corbet and Lieutenant Elmsley Coke, a second station was constructed at Swain's Haulover and

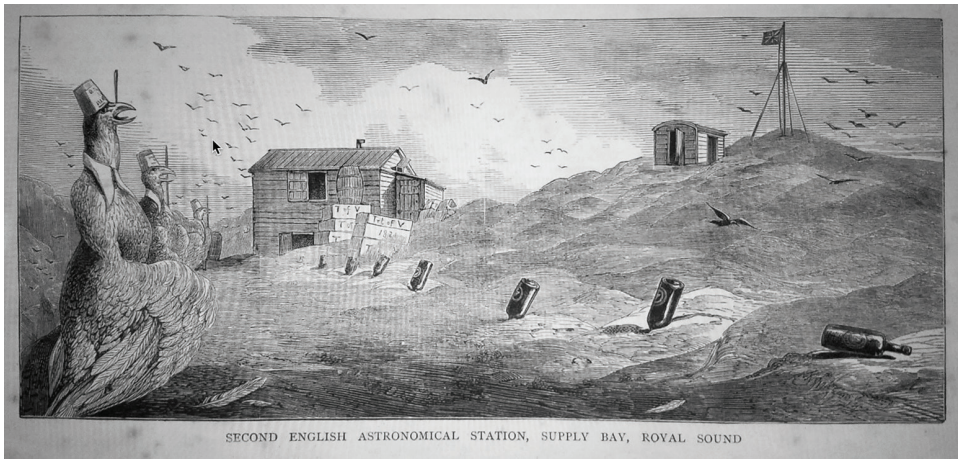

Fig. 5 Humorous depiction of the royal astronomers as seabirds at the Supply Bay astronomical observation station, perhaps after celebratory libations upon recording the 1874 Transit of Venus. (Illustration from *The Graphic*, 27 March 1875, used with permission of the British Library.)

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named Supply Bay. Eaton was assigned to aid Lieutenant Somerville Goodridge with building and operating the third one, at Thumb Peak. Despite relentless storms that ripped the roofs off the observatories, the astronomers doggedly rehearsed for the transit on 9 December (Fig. 5). "We got a few observations in the evening," recalled an anxious Corbet, "but it was terrible work in the high winds—lamps flickering and blowing out, couldn't hear the ticks of the clocks or anything" (Hudon 2004: 17). When 9 December was finally upon them, high on Thumb Peak Goodridge and Eaton were ready. As Venus slowly crossed the Sun's disk, "time was taken from the solar chronometer Fletcher 950, of which the dial was limited to 12 hours. The observations were recorded, from Lieut. Goodridge's words, by Mr. Eaton" (Goodridge 1881: 476). The weary astronomers then celebrated with Oxford sausages and champagne (Corbet 1875: 89). The recording techniques used by the Royal astronomers during the 1874 Transit of Venus have been described by Corbet (1875), Corbet & Coke (1881), Hudon (2004) and Frost (2005). *Volage* and *Supply* departed Kerguelen Island on 27 February 1875. "We watched the dreary desolate island for ever so long… with light hearts and full of happiness at getting away from Kerguelen at last after five months of it, which seems an age, and at other times nothing but a mad whirling gap in one's existence", wrote Corbet (1875: 121) of their departure.

Contribution to the discussion of flightless insects

Upon Eaton's return to England in 1875, the Kerguelen specimens were "entrusted to competent persons for examination and descriptions" (Stokes & Huxley 1879: vi), as had occurred two summers prior with the Svalbard biota. The resulting publications were compiled in a volume of the *Philosophical Transactions of the Royal Society* (1879) dedicated to the 1874 British Transit of Venus Expedition. Whilst preparing his manuscripts for this volume, Eaton was meeting with the famed botanist Joseph Hooker (1817–1911; Eaton 1876b). The two naturalists would have had a lot to discuss as Hooker had extensive knowledge of the Kerguelen flora from his journeys to Antarctic and Subantarctic islands when on the Ross Expedition (1839–1843); moreover, he was tasked with analysing Eaton's plant specimens from the Transit of Venus Expedition. Meanwhile, Eaton was working on his own manuscript on the botany of Svalbard (Eaton 1876a) as well as on entomological papers for the Royal Society. "Dr. Hooker's manuscript journal, which is full of very interesting and valuable matter, has been kindly placed at my disposal," wrote Eaton (1879a: 5) of his collaboration with Hooker. For the dedicated volume of *Philosophical Transactions*, Eaton wrote the introduction, which included physical features of Kerguelen Island and the history of visits by naturalists, and contributed sections on the Neuroptera (net-winged insects) and Lepidoptera (butterflies and moths). Of the Neuroptera, he quipped that they were "as plentiful as the snakes of Iceland" (Eaton 1879c: 248).

Whilst collecting insects on Kerguelen, Eaton had been quick to notice that a common feature of the Lepidoptera (Eaton 1879b), Coleoptera (analysis by Charles Waterhouse 1879) and Diptera (analysis by George Verrall 1879) was their aptery or brachyptery; for on 31 December 1874, he had penned a preliminary report to the Royal Society, stating that "The entomology of the island is very interesting. Most of the larger insects seem incapable of flight" (Eaton 1875a: 354). In over a page of the report, he described the variations in wing design, from "abbreviated wings" to wings that were "extremely minute" or "linear and very narrow," and some insects that were "completely destitute of even the vestiges of wings." He also remarked on the behavioural adaptations of the Kerguelen insects to flightlessness: the tineid moth "if alarmed, jumps to a distance of two or three inches at a time. During its passage through the air the wings are vibrated" (Eaton 1875a: 354–355). A detailed taxonomic analysis of these insects was conducted by Eaton (1875b) shortly thereafter, whilst he served as a vicar in Croydon.

Flightless insects also interested the naturalist Henry Moseley (1844–1891) on the research vessel *Challenger*, which passed through the Kerguelen archipelago in January 1875, contemporaneous with the Transit of Venus Expedition farther south in Observatory Bay. When writing his report on the Challenger Expedition (1872–1876), Moseley often referenced Eaton's flightless insects: "Crawling about the heart of the cabbages, and sheltering there, are to be found swarms of the curious wingless fly, likewise peculiar to Kerguelen's Island, and islands where cabbage is found. The fly (*Calycopterix moseleyi*, Eaton) is simply a long-legged brown fly, with very minute rudimentary wings" (Moseley 1892: 166–167).

The prevalence of flightless insects inhabiting harsh environments had been documented by naturalists and explorers long before Eaton and Moseley. In 1855, whilst speculating on the selection pressures resulting in flightless beetles in the Madeira Islands, Charles Darwin (1809–1882) wrote to Hooker about the "very curious point in the astounding proportions of Coleoptera that are apterous; & I think I have grasped the reason, viz that powers of flight (would) be injurious to insects inhabiting a confined locality & expose them to be blown to the sea" (Darwin 1855). Darwin was on the right track. Selection

pressures that influence flightlessness in insects—high latitudes and/or attitudes, a stable, isolated environment, extremes of cold and/or wind—have been summarized by Roff (1990). Of these criteria that Kerguelen Island fulfils, commentators on the Transit of Venus Expedition have emphasized the island's punishing winds: "Wind selects for flightlessness through an energy trade-off between flight and reproduction" (Leihy & Chown 2020). In this way, wingless females can divert more energy to egg-laying than to wing and flight muscle development and maintenance. In some flies from Eaton's Kerguelen collection, the females had reduced wings compared to males of the same species, and in some cases, the females were flightless, whereas their male counterparts were capable of flight (Verrall 1879). It turns out that 47% of indigenous insects in the southern oceanic islands are flightless, compared to 8% on Arctic islands and 5% globally (Leihy & Chown (2020).

Moseley (1892: 168) noted that the trait of flightlessness provided an "interesting link between the forms of life inhabiting these widely separated islands" of Kerguelen, Crozets, Falklands and other high-latitude southern islands. Hooker had observed a similar geographical distribution of plants during his travels to Antarctic and Subantarctic islands when on the Ross Expedition. Eaton's Kerguelen cryptogams and phanerogams strengthened Hooker's conviction that Kerguelen plants had dispersed from a South American origin rather than the more proximate Africa. Darwin summarized this in *On the origin of species*:

> it is an almost universal rule that the endemic productions of islands are related to those of the nearest continent, or of the nearest large island. The exceptions are few, and most of them can be explained. Thus, although Kerguelen Land stands nearer to Africa than to America, the plants are related and that very closely, as we know from Dr. Hooker's account, to those of America. (Darwin 1859: 420)

In his paper in the *Philosophical Transactions* volume dedicated to the Transit of Venus Expedition, Hooker put forth a number of mechanisms for plant radiation across the southern oceans, such as prevailing winds, ocean currents and birds, yet he reemphasized seed dispersal by "stepping stones" of islands and "intermediate tracts of land that have now disappeared", and he noted that the islands' "present vegetation consists of the waifs and strays of a mainly Fuegian flora" (Hooker 1879: 14). In contrast, Darwin proposed a mechanism of seed dispersal in the southern oceans via icebergs. In the end, Moseley agreed with Hooker:

> Mr. Darwin suggests that Kerguelen's Land has mainly been stocked by seeds brought with ice and stones on icebergs. The occurrence of *Pringlea* (Kerguelen cabbage) on Marion Island, as on the Crozets and Kerguelen's Land, probably points, however, to an ancient land connection between these islands, which the antiquity and extent of denudation of the lavas would seem to bear out. (Moseley 1892: 146)

Moseley was privy to geological and oceanographic evidence that the earlier naturalists were not. "This view is directly confirmed by the discovery by the 'Challenger's' soundings of the Kerguelen Plateau, which 'rises in many parts to within 1,500 fathoms of the sea surface, and forms the foundation of all islands situated in this part of the world'" (Moseley 1892: 147, quoting Wild 1877: 19). These 'stepping stones of islands' in the Southern Ocean that provided a mechanism for plant dispersal could by extension be applied to the dispersal of flightless insects as well as other organisms.

Conclusion: Eaton's legacy

Expedition narrators Herbert Chermside and Cyril Corbet described Eaton's keen knowledge of the natural world, eccentricities, humour and charisma, which drew others to join him in his collecting adventures. Eaton's willingness to work in extreme environments proved critical in supplying raw data—rare, high-latitude biota—to specialists in Britain like Hooker and Moseley, for example, as they proposed mechanisms of species dispersal. The biological reports resulting from the 1873 expedition of Benjamin Leigh Smith and the 1874 expedition to study the Transit of Venus make evident that Darwinian themes loomed heavily in the collective psyche of the science community late into the 1800s as scientists analysed specimens from remote parts of the globe. Synergies between naturalists and early oceanographers led to a growing understanding of biodiversity, the connectedness of the world's ecosystems and adaptations that arise in response to unique selection pressures.

Svalbard and Kerguelen would be the first and last of Eaton's far-reaching expeditions, respectively, though a chronological list of his travels in an RES notebook, penned in now fading ink, revealed that his wanderlust was far from over. An insatiable curiosity for the natural world prompted nearly annual departures from his duties of the Church until his health diminished in old age. From these collecting adventures across Europe, northern Africa and the Canary Islands, he emerged an expert on the orders Ephemeroptera (mayflies) and Psychodidae

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(moth flies). His monograph on the Ephemeroptera is considered "the standard for all later mayfly systematics" (Peters et al. 1980: 535). For six decades, Eaton remained a prolific contributor to entomological journals and a member of the Entomological Society. Upon his death in 1929, his wife donated to the British Museum a collection of over 1800 pinned specimens, mostly moth flies, and 200 microscopic slides, at the time considered the "largest and most important (collection) in existence" (Anonymous 1930: 63; Peters et al. 1980: 535).

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