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Contributions of deaf people to entomology: A hidden legacy

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Summary
Despite communication challenges, deaf and hard-of-hearing individuals made many new discoveries during the emergence of entomology as a scientific discipline. In the 18th century, Switzerland's naturalist Charles Bonnet, a preformationist, investigated parthenogenesis, a discovery that laid the groundwork for many scientists to examine conception, embryonic development, and the true, non-preformationist nature of heredity. In the 19th century, insect collectors, such as Arthur Doncaster and James Platt-Barrett in England, as well as Johann Jacob Bremi-Wolf in Switzerland, developed specialized knowledge in several insect orders, particularly the Lepidoptera. In contrast, the contributions to entomology of Fielding Bradford Meek and Leo Lesquereux in the United States stemmed from their paleontological studies, while the work of Simon S. Rathvon and Henry William Ravenel in economic entomology and botany, respectively, was derived from their strong interests in plants. These and other contributors found ways to overcome the isolation imposed upon them by deafness and, as a group, deaf and hard-of-hearing scientists established a legacy in entomology that has not been previously explored.

Keywords
Deaf, deafness, hard-of-hearing, deaf scientists, entomology, geology, horticulture, botany, paleobotany, naturalists, Aesop, Charles Bonnet, James Platt-Barrett, Frederick Bond, Johan Jacob Bremi-Wolf, Charles Butler, Syms Covington, Charles Darwin, Alfred T. Hollick, Joseph Dalton Hooker, Regina Olson Hughes, Thomas H. Huxley, Heinrich Ernst Karl Jordan, Leo Lesquereux, Henry Herbert Lyman, Michael Gerald McCarthy, Thomas Meehan, Fielding Bradford Meek, Louis Compton Miall, Charles R. Neillie, Marianne North, Simon S. Rathvon, Henry William Ravenel, Laura C. Redden, Edmund Ruffin, Károly Sajó, Herbert Huntington Smith, William Spence, Gertrud Theiler

Introduction

In 1910, George Veditz referred to deaf individuals as "people of the eye" in his Presidential address to the National Association of the Deaf (Veditz, 1912). In the field

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of Deaf Education, this expression is often associated with the use of sign language. In the history of science, however, regardless of whether deaf people communicated in sign language or not, their visual observations of the physical world led them to many great accomplishments (Lang, 1994; Lang and Meath-Lang, 1995). This is especially true during the 19th and early 20th centuries, which saw the emergence of entomology as a scientific discipline.

The legacy of deaf individuals in the history of entomology is a fascinating story of dedicated people who made significant contributions despite the barriers of communication and attitude they often experienced. Their deafness ranged from partial to profound, both unilateral (one ear) and bilateral (both ears), and occurred at different ages of onset. Some found a variety of strategies to communicate with their hearing associates, whereas others were more-or-less isolated. Many great scientists with interests in entomology also have ended their careers as they grew older due in part to the increased difficulty in communicating with colleagues. In this paper, we describe the contributions of a number of deaf and hard-of-hearing men and women in the early history of entomology, and highlight their roles as pioneers in this field.

The legacy begins

Aesop's fables

In discussing the role of deaf individuals in the early history of entomology we begin with the legend of Aesop (Fig. 1A). Believed to have been a deaf slave who lived in the sixth century BC on the Greek isle of Samos, Aesop was the first to introduce the fable as a form of teaching. He described many manners and characters of humans by using arthropods and other animals, as well as inanimate objects. Mentioned by Herodotus, Plato, and Aristotle, his entomological fables included such titles as "The Ant and the Chrysalis," "The Bee and the Spider," and "The Envious Glow-Worm." The popular tales believed to have been developed by Aesop were translated by later writers into many languages and the oral tales were carried on through time and attributed to him. The fables eventually spread throughout Europe; the first English version was printed in the 15th century (Merry, 2004).

In Aesop's fables, attributes such as patience or industriousness were often ascribed to arthropods. In his "Essay on Vain-Glory," Renaissance philosopher Francis Bacon mentions the attribute arrogance, "prettily devised of Aesop: The fly sat upon the axle-tree of the chariot-wheel, and said, "What a dust do I raise!" The stories also launched many allegories built on the ways of insects (Bacon, 1597, p. 133). "The Ants and the Grasshopper," for example, suggests a long-term reward for toiling. "The Bee and Jupiter" illustrates that the empowerment rendered by a sting can also be a liability (Capinera, 2004).

While the fables have entertainment value that has carried on through the ages, modern-day entomologists would be quick to find inaccuracies in the tales. Turpin (2000), for example, pointed out that in "The Ants and the Grasshopper" Aesop likely

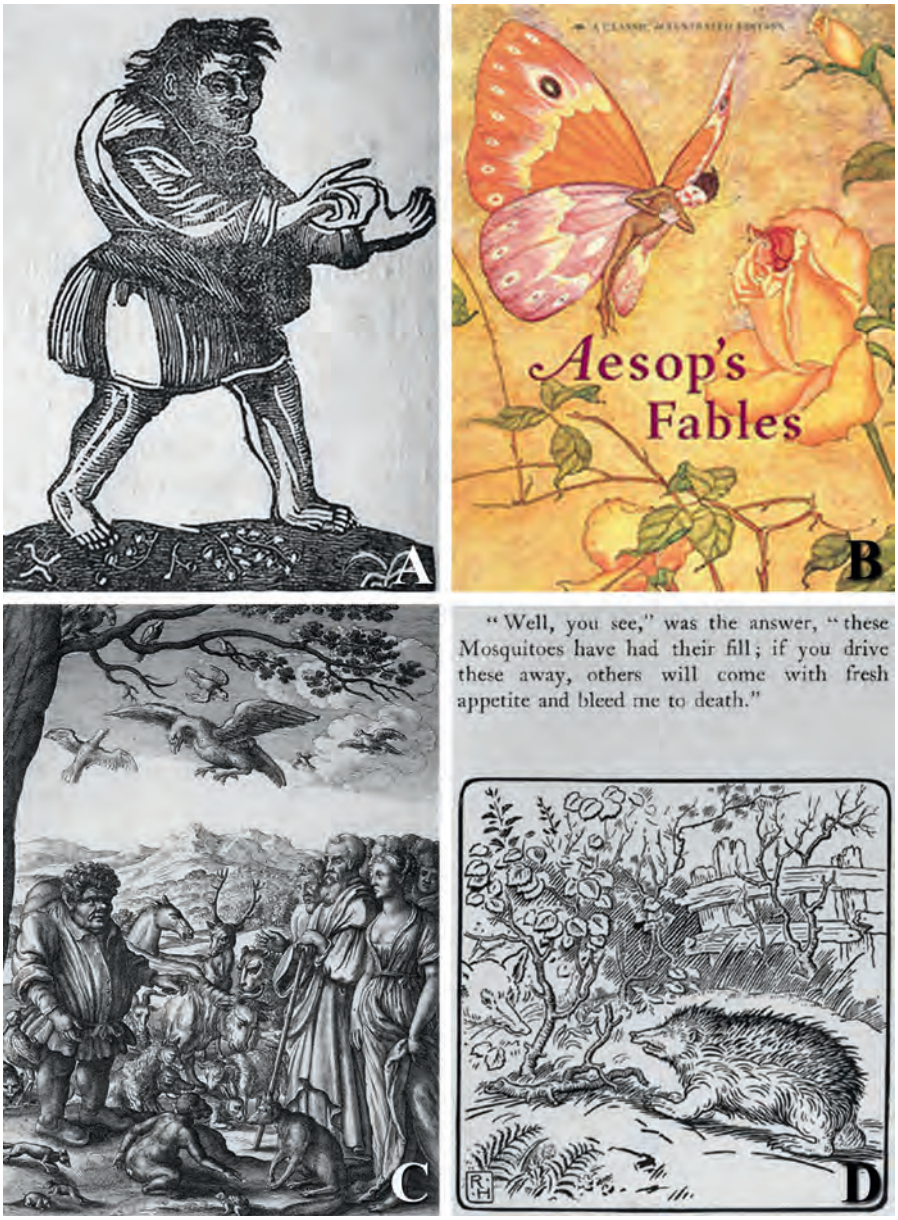

Figure 1. (A) Portrait of Aesop from the European Reading Room/Bulgarian Visual Resources. Image courtesy of Library of Congress. (B) As shown in this book cover, Aesop's fables often included many insects. The dialogue in the fable entitled "The butterfly and the rose", herein illustrated, reveals the interactions of these two organisms between themselves and others as a way to teach us about constancy, or lack of thereof, in humans. Image from the National Endowment of the Humanities. (C) Wenceslas Hollar's depiction of Aesop, University of Toronto Wenceslaus Hollar Digital Collection. Image from Wikipedia. (D) "The Fox and the Mosquitoes" is another example of Aesop's anthropomorphism, casting insects in human terms. Image from *The Fables of Aesop* by Joseph Jacobs with illustrations by Richard Heighway (1894).

was thinking of cicadas, better at making "music" than grasshoppers; and in "The Bee and Jupiter," he meant worker bees, since queen honey bees do not die when they sting.

In a sense, the deaf slave's stories about arthropods have provided literary roots to the field of "cultural entomology" later advocated by experts such as Hogue (1987). Parallel interests also can be found among anthropologists. The deaf anthropologist Ruth Benedict, for example, pointed out in her writings that an ant colony reduced to a few members would automatically reconstruct its whole system of patterned behavior with virtually no loss, whereas the human race, similarly reduced, would lose 99 percent of its culture. Ant behavior is instinctive, whereas human behavior is learned, she emphasized (Benedict, 1934).

Benedict was a remarkable woman. Because of her deafness, she struggled to focus on the traditional emphases in her fieldwork. She found it difficult to interview Native Americans, for example, and thus turned to more visual products of culture—pottery, dance, costumes, literature, poetry, architecture, and painting. In the process, she helped expand the field of anthropology (Lang and Meath-Lang, 1995).

Benedict was not alone as an accomplished individual who found personal deafness beneficial in the pursuit of science. There were many others. Thomas Alva Edison, for example, often appreciated his deafness as it afforded him opportunities to focus on his patents without auditory distractions. He occasionally used an ear trumpet, but never showed much interest in developing an electrical hearing aid. Edison would often become excited about any odd wonder, which led to occasional forays into entomology. On one of his daily walks around his laboratory grounds, he discovered an insect giving off an unusual odor. He was curious enough that he wrote to Charles Darwin about the "small green colored insects" giving off a strong naphthalene odor. He offered to send Darwin a specimen (Edison, 1877).

Similarly, Konstantin Tsiolkovsky, the Russian rocket pioneer, attributed his increased powers of concentration to his deafness. "[My deafness] estranged me from others and compelled me, out of boredom, to read, concentrate, and day dream…This caused me to withdraw deep within myself, to pursue great goals…" (Riabchikov, 1971, p. 92). On a humorous note, Tsiolkovsky, known as the "Father of Astronautics," likely was the first scientist to send insects into space. While he was a young boy, his mother had stimulated his interest in flight and space science with gifts of a kite and a colloidal balloon. On at least one occasion, Tsiolkovsky attached a bucket to his kite string to send insects upward as he dreamed of manned space flight.

Early research

In 1609, Charles Butler (1560-1647, Fig. 2A), one of the earliest naturalists, wrote *The Feminine Monarchie: Or a Treatise Concerning Bees and the due Ordering of Them*. Although probably experiencing only a very mild hearing loss, Butler was forced by his "dull hearing" to discontinue his special interests in the study of the sounds of bees. "[Only] I cannot altogether warrant the conclusion," he wrote in *The Feminine Monarchie* in discussing the songs of bees, "because in that confluted noise, which the buzzing Bees in the [busy] time of their departing [do] make, my dull hearing could

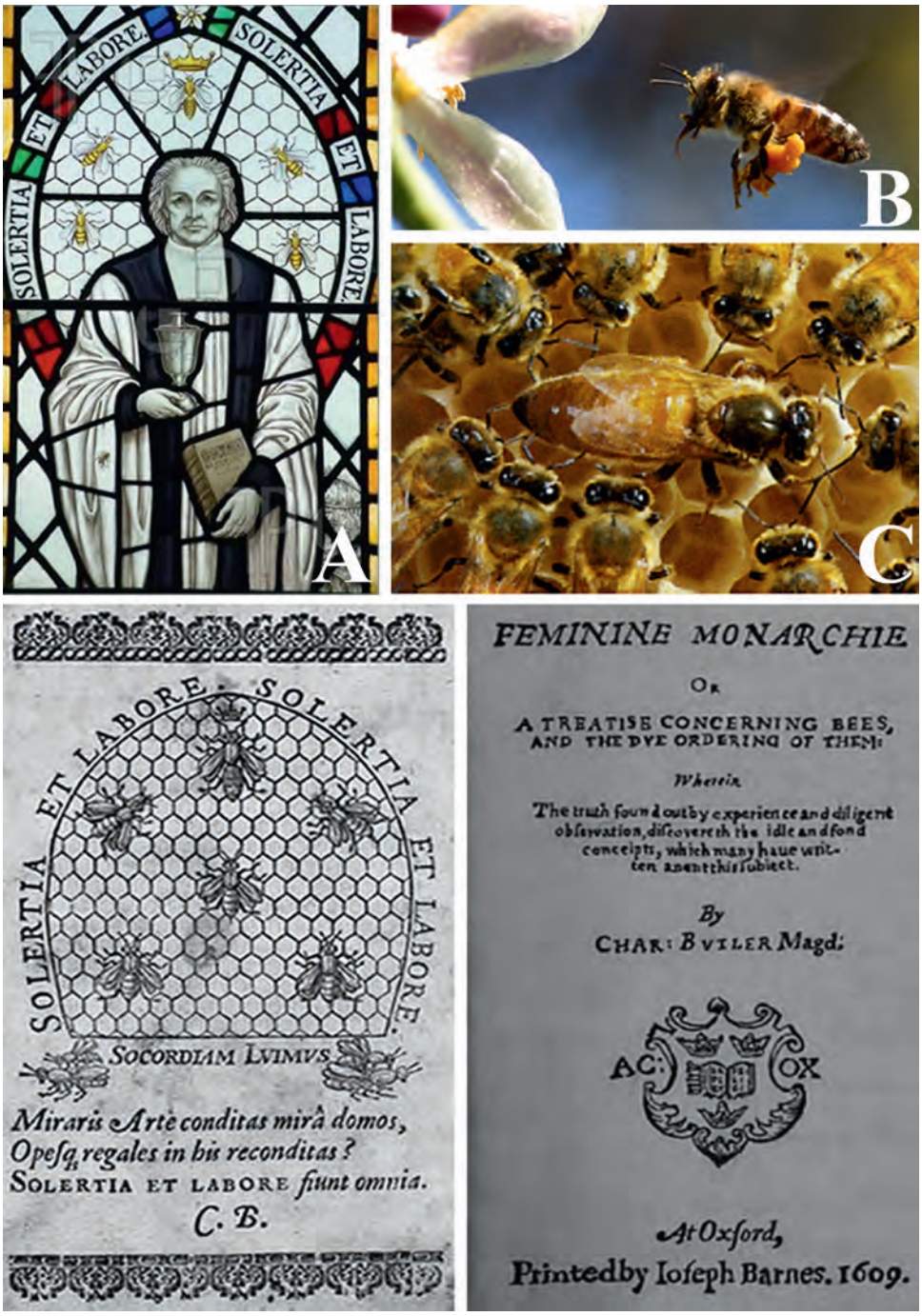

Figure 2 (A) Charles Butler, Vicar, beekeeper, and a student of honey bees, *Apis mellifera* L. (Hymenoptera: Apidae). Image reproduced from Bigstock, with permission. (B) Worker honey bee. (C) Queen bee surrounded by worker bees. Lower two panels: Two pages from the 1623 edition of his book, *The Feminine Monarchie: Or a Treatise Concerning Bees and the Due Ordering of Them*. Butler's general work on beekeeping contained amazing detail on all aspects of the subject of bees, including the use of the hive, the making of wax, mead, preserves and medicines using honey.

not perfectly apprehend it…" (Butler, 1609). To a man devoted to his investigations, even partial hearing loss may have been as disheartening as Beethoven's was in the field of music. Studying the sound of bees was only one aspect of his work, however. Butler went on to produce a classic apiculture text, which included the discovery that it is a queen and not a king that rules the hive, a topic that was debated until the mid-eighteenth century.

One might be inclined to dismiss late-onset hearing loss, whether mild as in Butler's case, or more severe, as having less impact on an individual's life and work. Yet, we will show that numerous distinguished entomologists or other scientists ended their careers as a result of communication difficulties.

In the 18th century, Charles Bonnet (1720-1793, Fig. 3A), born in Geneva, Switzerland, was seven years old when he lost his hearing, an experience which soon turned his interests to natural science. His parents were Pierre Bonnet, a member of the Geneva council, and Anne-Marie Lullin de Châteauvieux. "It was my deafness, which had already begun to manifest itself," Bonnet explained, "that frequently made me the object of scorn in the lessons and lectures and exposed me without stop to ridicule" (Bonnet and Savioz, 1948, p. 41). When his parents learned that he was being teased because of his hearing loss, they removed him from school and assigned him a private tutor, a Dr. Laget, who played a prominent role in inspiring Bonnet toward sciences. Bonnet was particularly fascinated by the account of the ant-lion (Neuroptera: Myrmeleontidae) in Noël-Antoine Pluche's *La Spectacle de la nature*, and by René-Antoine Ferchault de Réaumur's work *Mémoires pour servir à l'histoire des insects* (1738). It is not known whether Bonnet was aware that by the time Pluche had completed the last of his eight volumes of *La Spectable de la nature*, he had gone deaf himself. In 1740, Bonnet penned a paper summarizing a series of experiments establishing what is now termed parthenogenesis (reproduction without fertilization) in female aphids (Hemiptera: Aphidoidea, also known as tree-lice, greenfly, ant cow, etc.). This work in the embryology of insects made him, that year, the youngest corresponding member of the Académie des sciences in Paris (Anonymous, 2008).

Over the next few years Bonnet discovered that gas exchange in caterpillars and butterflies is performed through pores, called spiracula, and by 1743, his scientific studies had earned him membership in the Royal Society of London. Two years later, he published *Traité d'insectologie*, a pioneering work on the subject of parthenogenetic reproduction.

Bonnet's accomplishments went far beyond entomology and included studies of plant physiology, evolution, and artificial insemination of dogs. By the age of 25, his sight was nearly gone, making it difficult to use the microscope (Tuxen, 1973). This eventually forced him to concentrate more on philosophy and theoretical questions in biology. Although Bonnet was a committed preformationist (Brown, 1973), believing that female organisms contained within their germ cells a series of preformed individuals, he was, long before Darwin's time, one of the first biologists to use the term "evolution" in a biological context. He did accept the notion that individual species might have changed over the course of time as a result of environmental influences, but his

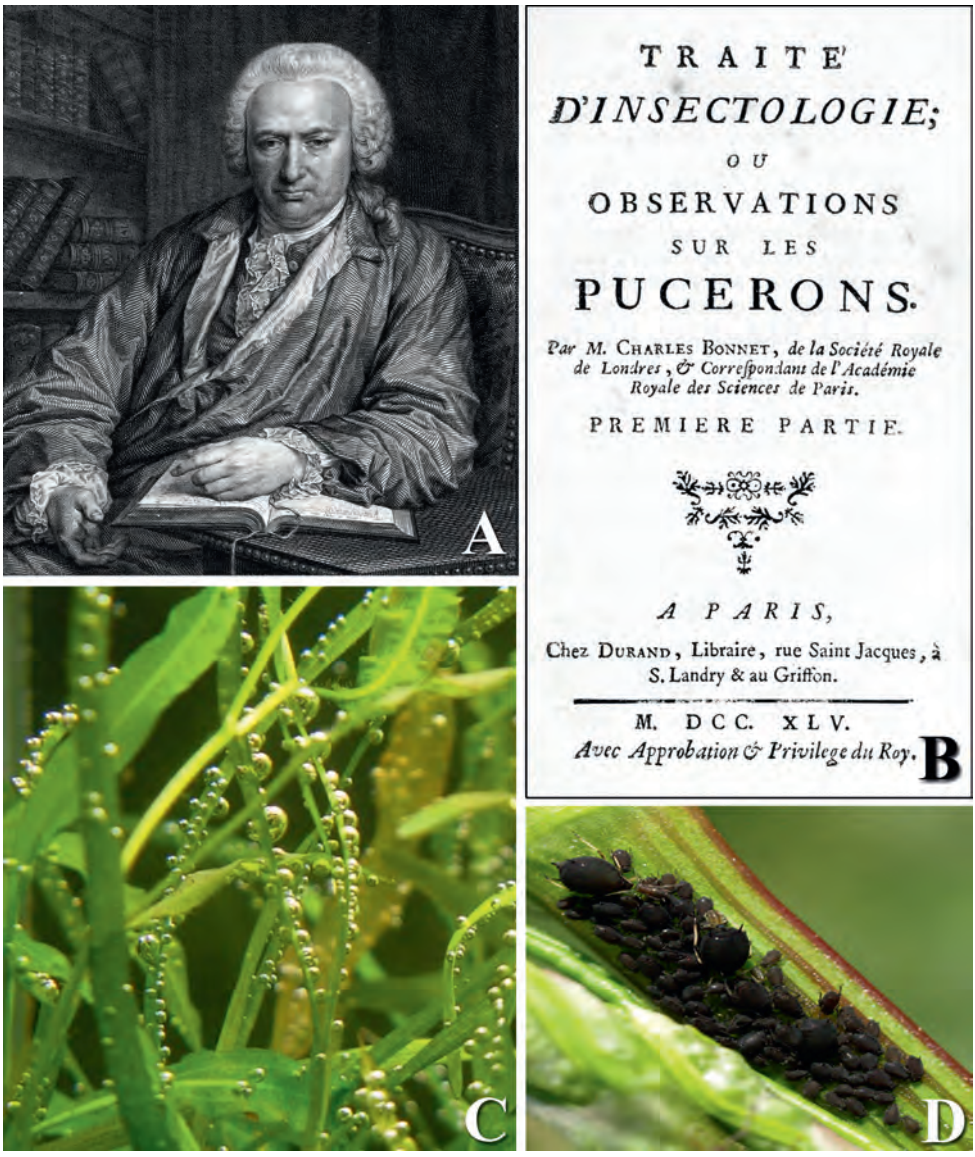

Figure 3. (A) Charles Bonnet, considered by many to be one of the founding fathers of modern biology. Image from Wikipedia. (B) Cover page for first part of Bonnet's *Traité d'Insectologie*, one of the earliest comprehensive books on entomology. Image courtesy of Biodiversity Heritage Library. (C) Bonnet turned to the study of plants when his loss of vision made it difficult to study small insects. His 18th century observation of gas bubbles on a submerged illuminated leaf was a contribution to the understanding of photosynthesis. Image courtesy of B. Olsen. (D) Bonnet's deafness as a young boy caused his parents to assign him a private tutor, which led to his interest in entomology, including the discovery of parthenogenesis, from a preformationist point of view. He is reported to have studied the *Euonymus* (Celastraceae) "tree lice" or "spindle tree aphid," *Aphis rumicis* Linnaeus (Hemiptera: Aphididae). Image from Biodiversidad Virtual, courtesy of Ferran Turmo Gort.

work did not have the genetic implications to contribute significantly to modern evolutionary theory (Reill and Wilson, 2004, p. 65).

Bonnet's success was remarkable considering his struggles with both deafness and failing eyesight, the latter making it also difficult to continue his voluminous correspondence. His deafness made him fearful of making mistakes that would embarrass him, and as a result, he frequently isolated himself. "At least," he wrote, "I have never lived in what one calls big society: My own tastes, my domestic circumstances, and especially my deafness contrasted too much with the life of society's people" (Lang and Meath-Lang, 1995, p. 43). To accommodate his disabilities, Bonnet employed assistants to conduct his investigations.

The 19th century: rise of entomological societies

Many entomological societies of today have their roots in 19th century local groups whose members lived within a short distance from each other and shared their collections or "cabinets" of specimens with one another. These local groups included a number of part-time and full-time collectors who were deaf pioneers very much in the mainstream of the emerging science. Some studied the anatomical structure and life-history of selected types of arthropods while others examined larger selections of insects and identified the specimens they collected.

The eminent and keen-eyed collector and evolutionary theorist, Charles Darwin, was certainly no stranger to deafness. He was himself tone deaf, unable to distinguish between musical notes. His personal assistant on the Surveying Ship H.M.S. *Beagle*, Syms Covington (c1813-1861, Fig. 4A) had been partially deaf from his youth, and Darwin befriended him, despite finding him an "odd sort of person" (Keynes, 2001, p. 179). Covington's deafness was likely increased by the repeated use of bird guns while collecting specimens. In 1843, Darwin sent Covington an ear trumpet and followed the steady increase in his friend's deafness over the years to follow (Ferguson, 1971). Darwin also had a relative who was deaf and he talked about this in correspondence with Covington.

On the *Beagle* (Fig. 4C, December 27, 1831 to October 2, 1836), Darwin's entomological interest was mainly focused on smaller, lesser known species of insects. There is evidence in Covington's journal and in the writings of other scientists that Darwin and Covington worked together at least nine months before formal arrangements were made with the captain of the *Beagle* (Keynes, 2001). Covington remained with Darwin throughout the voyage, assisting in collecting specimens (Fig. 4B), and they were virtually together at all times. They used nets to sweep terrestrial insects as well as aquatic species, and "fly-nippers" were used to collect larger terrestrial insects.

Born in Bedford, England c1813, Syms Covington first joined the *Beagle* as a "Boy 2nd Class" in 1831. He was 18 years old when he began to keep a journal. Darwin was only four years older. Covington's support of Darwin ranged from packing specimens on the *Beagle* and posting them home to England to assisting with collecting a wide range of insects and other zoological creatures and helping him take notes. After the

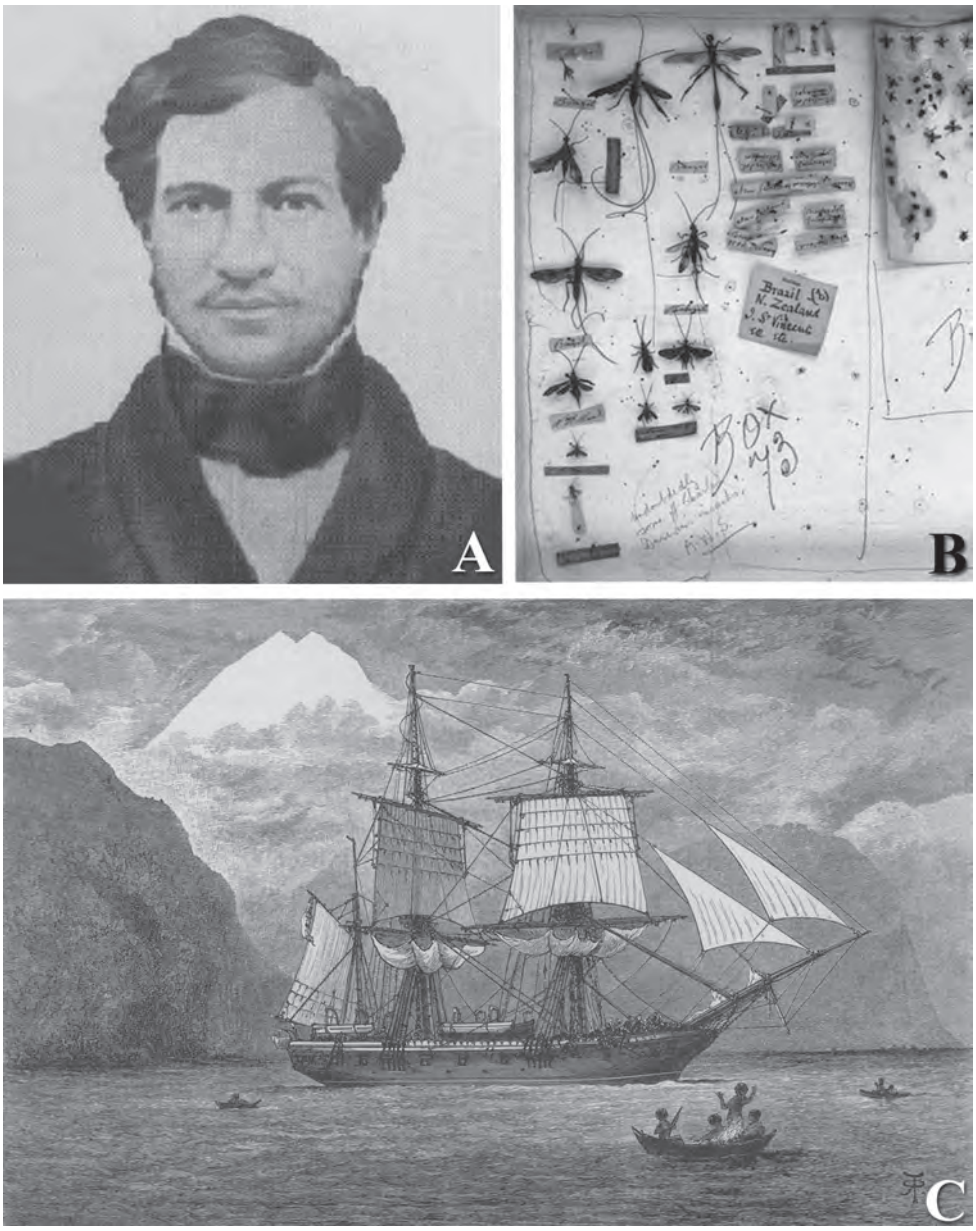

Figure 4. (A) Syms Covington, Charles Darwin's assistant during the voyage of the *Beagle*. Photograph courtesy of the Merimbula-Imlay Historical Society. (B) Some of the insects that Darwin and Covington collected in Brazil and in the Galápagos Islands. Image from Wikipedia. (C) The "H.M.S. Beagle in Straits of Magellan. Mt. Sarmiento in the Distance. Frontispiece." Image from the US National Library of Medicine.

voyage, Covington continued in Darwin's employ until 1839, when he emigrated to Australia (Ferguson, 1971). Even after this, where he married and had eight children, he continued to assist his friend. In 1856, Darwin thanked Covington for the "valuable Australian specimens" of barnacles for the book he had just completed, and he asked Covington if he had ever noticed any odd breeds of poultry, pigeons, or ducks, imported from China, India, or the Pacific Islands. "If so," Darwin wrote, "you could not make me a more valuable present than a skin of such." As late as 1858, three years before Covington died, Darwin wrote to him about how he was preparing to publish a work he had begun two decades earlier, "and for which I sometimes find extracts in your handwriting!" (Darwin, 1858). In 1859, referring to Covington's deafness, he told his friend that "it is a very great misfortune for you, but I fear you must look at it as incurable" (Darwin, 1859). He spoke of his own health, losing his son to scarlet fever, and the frail health of his daughter, and then followed with, "We all have our unhappiness, only some are worse than others. And you have a heavy one in your deafness." Darwin's *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life* was published only a few months after this letter was mailed to Australia. Covington died in 1861, at the age of forty-eight.

Two decades later, another deaf man, Arthur Doncaster (c1856-1931, Fig. 5A), a deaf business partner with William Watkins in London, became an expert on Lepidoptera. Watkins had established a butterfly farm on three-quarters of an acre for rearing Lepidoptera collected from all over the world. In 1880 Watkins left the business and Doncaster carried it on. Completely deaf, Doncaster conversed by using a slate hung around his neck. When customers asked for something in his shop, he wrote a reply on the slate and passed it to them to read and respond to him (Salmon *et al*. 2000).

Through his work, Doncaster became a world authority on tropical butterflies and worked in close conjunction with the British Museum (Natural History), providing considerable assistance to the curator of tropical butterflies. He and his staff were contacted regularly for advice by independent entomologists as well. "I captured at light in the High Woods near [Tunbridge Wells] on the 1st of July," wrote one collector in *The Entomologist's Record and Journal of Variation* in October, 1890 "a very fine specimen of *Plusia moneta*. I sent the specimen up to Mssrs. Watkins and Doncaster (as it was unknown to me), and they have identified it as that species" (Beeching, 1890, p. 185).

Doncaster was especially knowledgeable about the British moths and butterflies (Doncaster, 1887). The company purchased large collections as they became available, and over the years he donated nearly 27,000 specimens of butterflies and moths to the British Museum. He continued to run Watkins & Doncaster until the 1930s when he retired (Watkins and Doncaster, no date).

In Dübendorf, Switzerland, Johann Jacob Bremi-Wolf (1791-1857, Fig. 6A), the son of Johann Heinrich Bremi, a pastor, was profoundly deafened by typhus fever at the age of 11. His parents' dream of Jacob following in his father's footsteps was shattered and they encouraged him to pursue a trade as a turner. Working on a wood lathe, however, was not satisfying to the young man. He became fascinated with the world of insects, began collecting specimens around Dübendorf, and after he moved to Zürich he began categorizing them scientifically. Communicating primarily through writing

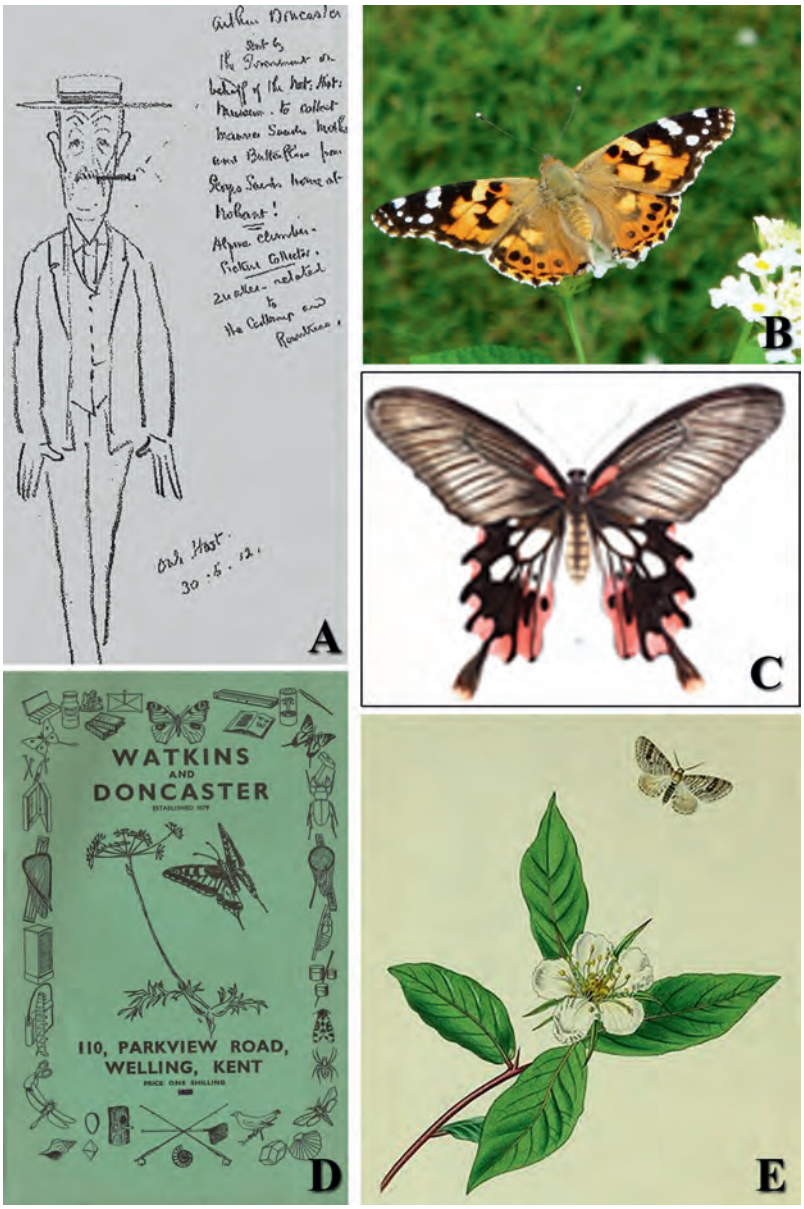

Figure 5 (A) Sketch of Arthur Doncaster, a deaf British naturalist who communicated with customers through a slate around his neck, and also corresponded with many naturalists. Drawn by John Hipkins on May 30, 1912, the caricature includes a caption referring to Doncaster collecting moths and butterflies. Image Courtesy of the National Library of Scotland. (B) Doncaster often collected his own specimens and reported on them. In 1877, he captured a hermaphrodite specimen of *V. Cambrica*, "a most singular-looking moth." This photograph of *Venusia cambrica* with a host plant is from Wikipedia. (C) In 1852, Philip Henry Gosse, F.R.S., requested specimens *Papilio mayo* Atkinson (Lepidoptera: Papilionidae) for his research "On the clasping-organs ancillary to generation in certain groups of the Lepidoptera". This photograph of a female *P. mayo* female comes from Wikipedia. (D) Watkins and Doncaster catalogue. Image courtesy of Watkins and Doncaster, the Naturalists. (E) In 1908, Doncaster studied the migration of *Pyrameis cardui*, finding all the specimens were much worn from their flight. This photograph of *Vanessa cardui* from Wikipedia.

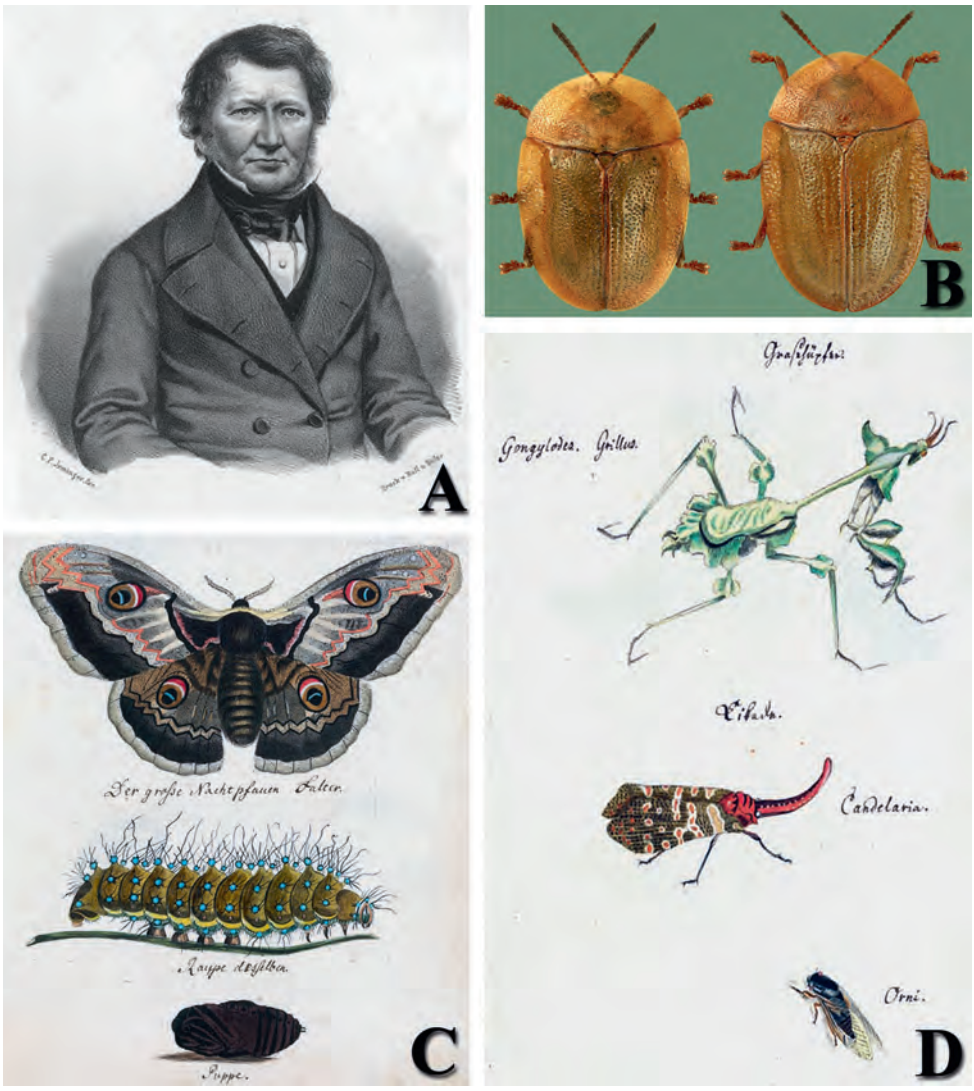

Figure 6. (A) Johann Jacob Bremi-Wolf, Swiss Entomologist. (B) *Cassida alpina* Bremi-Wolf. Image reproduced by permission of Milan Zubrik, NFC, Slovakia (zubrik@nlcsk.org). (C, D) Two pages from Bremi-Wolf' sketchbook. Images courtesy of Schwyzer (n.d.). The text on the lower left panel, all of which refer to *Saturnia pyri* (Denis and Schiffermüller) reads, as follows. On Top, "Der grosse Nachtpfauen Falter" or "The great night peacock moth." In the middle, "Raupe desselben" or "Caterpillar of the former." At the bottom, "pupa." The text on the lower right panel reads, as follows. On top, a praying mantis, which Bremi-Wolf called Grasshüpfer, or grasshopper, and gave the scientific name *Gryllus gongylodes* Linnaeus. In the middle, "Libada" that possibly should read "Zikada" or "Zicada" and named *Cicada candelaria* Linnaeus. At the bottom, "Orni", or *Cicada orni* Linnaeus. All images from Schwyzer (n.d.), see Figure References.

with others, he also became an avid reader, primarily science, history, and biographies, but also poetry and travel accounts. In May 1818 he married Magdalena Barbara Wolf and they raised two children (Schwyzer, no date).

Between 1835 and 1851, Bremi-Wolf corresponded with J. J. Siegfried, a professor of natural history in Zurich. The letters, and Bremi-Wolf's sketchbook, provide evidence of a dedicated entomologist. According to Schwyzer (no date), two biographies of Bremi-Wolf have been published. "Life of a Deaf Entomology Researcher," an obituary, was written by August Menzel, a friend and research colleague. Menzel published his summary of Bremi-Wolf's life and work in 1858, the year after the deaf scientist died. The second source was written by Bremi-Wolf's son, a 350-page book published in 1871. In addition, Jacob Bremi-Wolf's sketchbook included 54 sheets with great detail in the colored drawings of butterflies, beetles, caterpillars, and other insects, most with handwritten legend.

In his correspondence with Siegfried, Bremi-Wolf discussed a range of scientific interests, including plants, which he had dried, pressed, and carefully categorized systematically with Latin and German names. By 1835 he had identified more than 100 species of Swiss insects and began excursions with Siegfried. Their friendship grew and Bremi-Wolf honored Siegfried by naming for him a mosquito he had discovered. He also corresponded with such distinguished scientists as the Swiss geologist and paleobiologist, Oswald Heer, and the botanists, Johannes Jacob Hegetschweiler and Friedrich Schulthess. They exchanged many specimens among themselves. Bremi-Wolf published on insects found in both the country and the city. He helped to found the Entomological Society of Zurich and was a member of the Naturalist Society of Freiburg and the Zoological and Botanical Society of Vienna. His taxonomic work led to many publications, including summaries of his studies of Coleoptera and Diptera.

Like some other deafened individuals, Bremi-Wolf was conflicted throughout his life about whether his deafness was an advantage or disadvantage. At one point, he composed a poem about his deafness, which was found amongst his family papers after his death. A stanza from this longer poem illustrates how he valued the silence that enabled him to focus on his work without auditory distractions.

> I'm deaf!
> Yet, I will not grieve.
> I know from whence fate comes.
> God deemed it well to take from me this sense
> and knows what good will come from it.

Yet, in this same poem, he shows how at other times he fervently wished to hear again:

> There'll be a time
> when I shall surely hear!
> And then this present sorrow will be slain.
> My faith will be the guiding light,
> and at His throne I shall most gladly praise
> the fact that I am deaf!

Bremi-Wolf was a productive contributor to the taxonomic study of insects. He promoted novel ways to collect insects, including examination of forest soil and the excrement of toads. He discovered various species, including the tortoise beetle *Cassida alpina* Bremi-Wolf (Chrysomelidae). Many species of arthropods have been named in his honor, including the leaf-mining lepidopteran *Lithocolletis bremiella* Zeller (Gracillariidae). He also examined sponges, fungi (*Bremia*, the genus of downy mildew fungi, honors him), ferns, and aquatic plants, but his passion for studying insects was more intense. With his considerable knowledge of botany, he was able to contribute meaningfully to discussions of the intersections of these sciences, such as how some mites are injurious to economic plants.

In the United States, Simon Snyder Rathvon (1812-1891, Fig. 7A) of Lancaster, Pennsylvania was one of mid-19th century America's leading economic entomologists. Lancaster County's agricultural community benefited greatly from his knowledge of controlling destructive insects. He served as Professor of Entomology to the Pennsylvania State Horticultural Society, and wrote reports for the United States Department of Agriculture. Rathvon, who also edited the *Lancaster Farmer*, was a key member of the Lancaster Linnaean Society and the Philadelphia Horticultural Society. Although he had little formal education, he was awarded an honorary Ph.D. from Franklin and Marshall College (Lancaster, Pennsylvania) in 1878.

As a young boy, Rathvon worked whatever jobs he could find and in 1827 became an apprentice to John Bell, a Marietta, Pennsylvania tailor. For the next five years he borrowed and read books from private libraries. In September of 1832, he opened his own tailoring shop in Marietta, and maintained this business for more than 50 years. Rathvon was motivated by Professor Samuel S. Haldeman, a scientist of considerable standing, to pursue entomology. The creation of a Lyceum of Natural Science in Marietta in 1837 also led him to modest collecting. His deafness began in the 1840s, around his 30th birthday, most likely hereditary, since his sisters also suffered from deafness. He kept personal notes about his dreams, and wondered about their content, including the fact that he found himself struggling to communicate with his deafness in his dreams as well (Wheeler and Miller, 2006).

It was around this time that Rathvon began publishing advice to farmers and those who maintained orchards and vineyards, describing what they could do to contain the damage wrought by beetles and seven year locusts. For 25 years Rathvon served as Treasurer and a Curator of the Lancaster Linnaean Society. During 1862-1887, some 640 scientific papers were read before the society and preserved in its library (Winpenny, 1990). In this period, he helped to acquire more than 40,000 specimens and exhibit them in a modest museum run by the society. He also built a personal library that approached 1,000 volumes.

Rathvon's collection of 10,000 specimens of insects focused primarily on beetles (Coleoptera), especially the most speciose of them, the weevils (Curculionidae). He sent beetles to the foremost American coleopterologist of the 19th century, Joseph Lawrence LeConte (Essig, 1931). He was elected a Corresponding Member of the

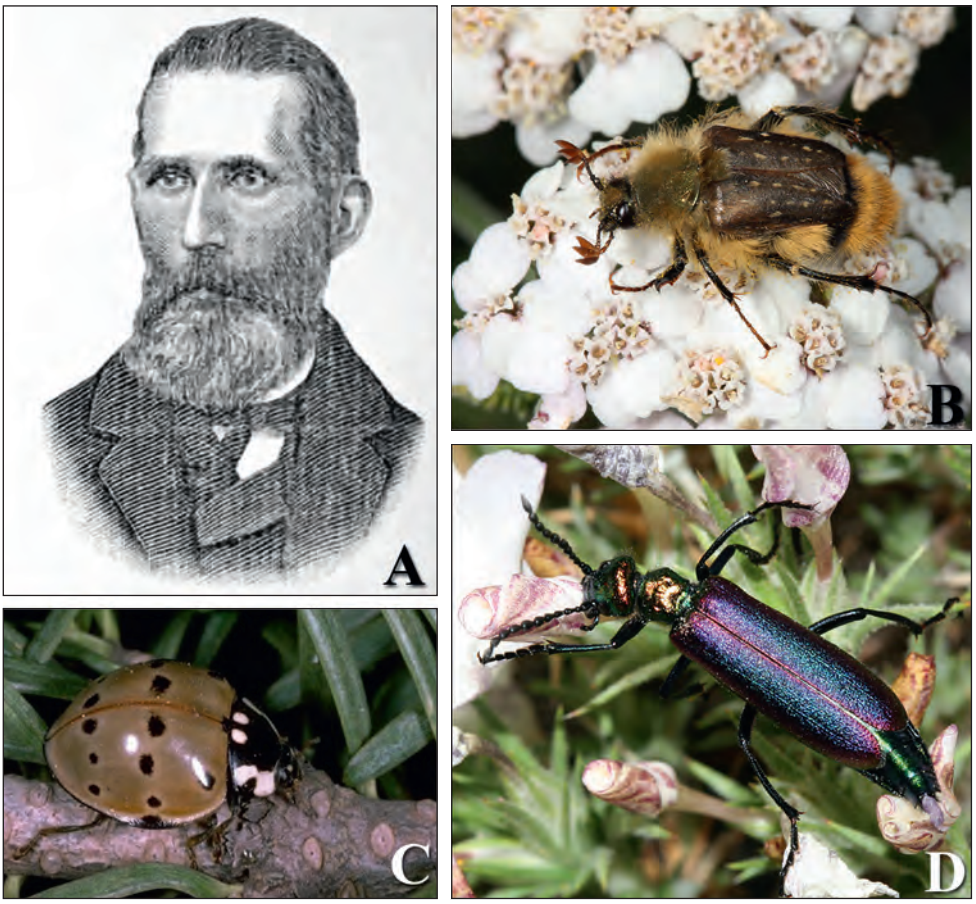

Figure 7. (A) Simon S. Rathvon, a noted American entomologist who popularized agricultural entomology. Image from from Sener, 1890. (B) *Lichnanthe rathvoni* (LeConte, 1863) (Coleoptera: Glaphyridae). Photograph courtesy of Joyce Gross. (C) *Anatis rathvoni* (LeConte, 1852) (Coleoptera: Coccinellidae). Photograph courtesy of T. W. Davies, California Academy of Sciences, San Francisco. (D) *Lytta rathvoni* LeConte, 1853 (Coleoptera: Meloidae). Photograph courtesy of Tom Murray.

Academy of Natural Sciences in Philadelphia (1854) and of the Entomological Society of Philadelphia (1862). Along with his numerous writings for the *Lancaster Farmer* and his readings of scholarly papers read before the Lancaster Linnaean Society or reports written for the State and the U.S. Department of Agriculture, he prepared a book-length manuscript treating *Injurious Insects of Pennsylvania*, a work that never was published and apparently has not survived.

In the 1880s, Rathvon's health steadily deteriorated and the partial deafness became total. He was described as having "vocal weakness" and "inarticulation" (Winpenny, 1990, p. 147). He died on March 19, 1891.

Interdisciplinary contributions

While specialists in entomology began to predominate at the beginning of the 19th century, cross-disciplinary contributions continued to enrich the emerging science. Among the deaf contributors from other disciplines were several botanists and horticulturists who helped to lay the foundation for understanding plants and their relationships to insects. Henry William Ravenel (1814-1887, Fig. 8A), born at the Woodville Plantation near Charleston, South Carolina, was primarily a botanist and agriculturalist, with a special interest in fungi. He began to lose his hearing early in life, which kept him from appearing much in public. Ravenel graduated from South Carolina College in 1832, and until 1853 he lived on his plantation in St. John's Parish, pursuing his botanical interests. After that, he moved to Aiken, South Carolina where he prepared a complete herbarium of both phenogamous (flowering) plants and cryptogamous (flowerless) plants, such as mosses, liverworts and hornworts, and well as pterydophytes (ferns and their allies), and other organisms formerly considered plants, such as algae and fungi. In 1849, he was elected Correspondent of the Academy of Natural Sciences of Philadelphia. For several years he edited, with excellence, the weekly *News and Courier* of the agricultural department. Because of his deafness, he felt unable to hold faculty appointments at universities. "Perhaps you are not aware that I suffer from partial deafness," he wrote in declining one faculty position, "—to such an extent, that I am in a measure cut off from ordinary social intercourse" (Haygood, 1987, pp. 129-130). He, nevertheless, was able to communicate one-on-one with others, although he struggled at times. When Catharine Beecher, of the well-known abolitionist family, came to his farm, he was unable to hear a word that she said (Haygood, 1987, p. 130).

Unlike Rathvon, Ravenel's botanical work was not focused on providing information directly beneficial to agriculture, although he recognized the kindred connections. His scientific interests also led naturally to entomological investigations. One example occurred in 1845 when members of the Black Oak Agricultural Society appointed him to a committee to study the problem of cotton rust, a destructive disease of then unknown cause. Many people had speculated about possible causes. The Black Oak planters looked to the soil, while Edmund Ruffin blamed "the depredations of myriads of very minute insects" (Ruffin, 1843, p. 79). After studying the problem, however, Ravenel was convinced that a fungus was responsible. Another study involved insects eating his fungi. He found through experimentation that a concoction of the roots and berries of pride-of-India, *Lagerstroemia speciosa* (L.) Pers. (Lythraceae), would discourage the insects. Similarly, while investigating the cause of a cattle disease in Texas, he helped established that the disease did not originate from the eating of a poisonous fungus, as some had assumed. Cattle fever later was discovered to be caused by a protozoan spread by ticks.

The best known of Ravenel's works is the *Fungi Caroliniani Exsiccati* (five volumes, 1853-1860), which attracted great attention in Europe and the United States. He discovered many new species of plants, and more than fifty now bear his name. His interest in fungi brought him into contact with leading European mycologists.

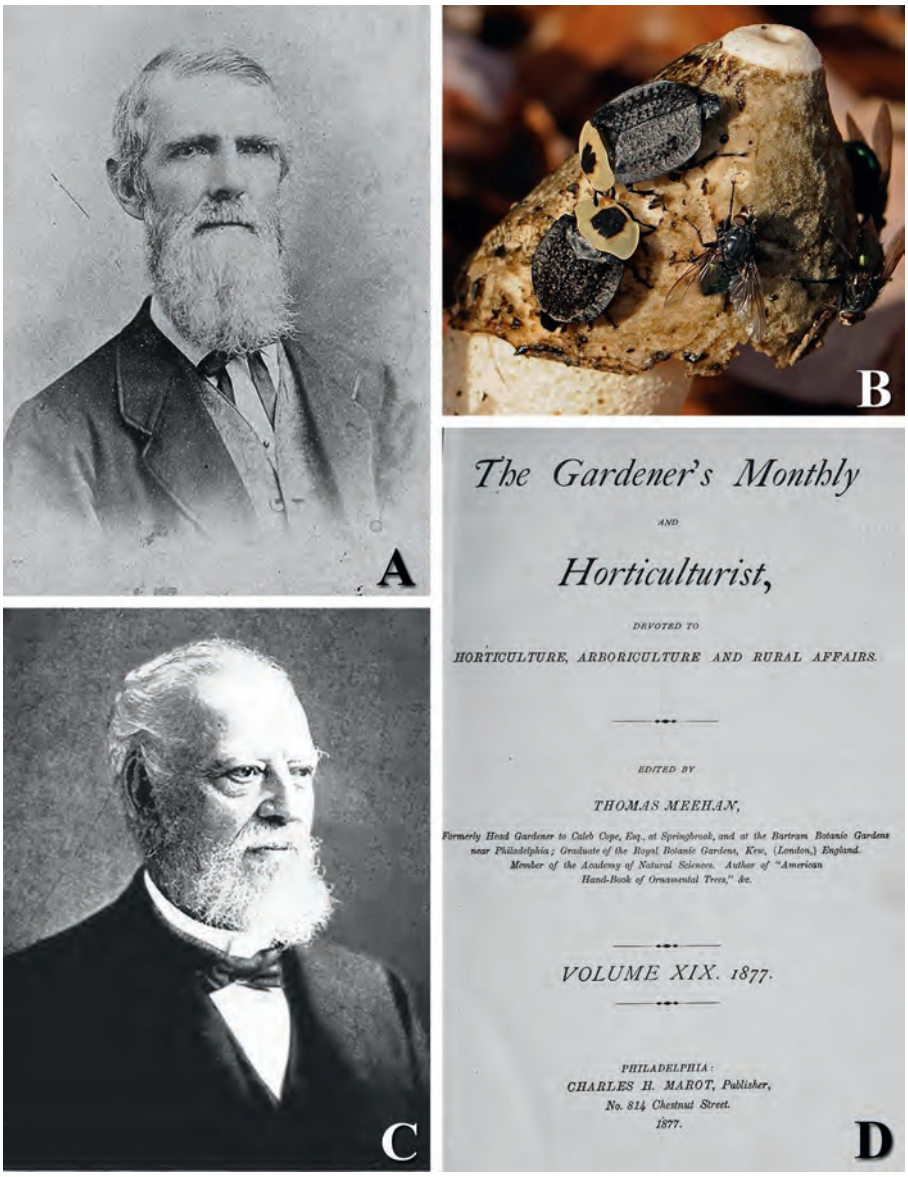

Figure 8. (A) William Henry Ravenel. Image from Wikipedia. (B) Agaricomycete phallus-like fungus, *Phallus ravenelii* Berk. and M. A.Curtis, with American carrion beetles *Necrophila americana* Linnaeus (Syrphidae) and calliphorid flies (Diptera: Calliphoridae). This species of fungus, also known as Ravenel's horn-like fungus, has a foul odor, which repels humans but attracts flies and other insects. Photograph courtesy of Richard Orr (Mid-Atlantic Invertebrate Field Studies, East Columbia, Maryland, USA). (C) Philadelphia horticulturalist Thomas Meehan also experienced deafness, although later in life and, as a result, turned down an opportunity to serve as President of the Academy of the Natural Sciences in Philadelphia. Image from Wikipedia. (D) A cover from one of the issues of Thomas Meehan's *The Gardener's Monthly and Horticulturalist*. Both Simon S. Rathvon and Henry William Ravenel published regularly in Meehan's monthly magazine on both botany and entomology topics for the benefit of farmers and horticulturalists. Image courtesy of Biodiversity Heritage Library.

Both Rathvon and Ravenel published entomological contributions in Thomas Meehan's *The Gardener's Monthly and Horticulturist*. Meehan (1826-1901, Fig. 8C-D), a renowned horticulturist who lived in Germantown, just north of Philadelphia, Pennsylvania, was born in England with partial deafness. His hearing loss was not as severe as that of Rathvon's and Ravenel's, and did not interfere much with his communication until his later years. The precocious young man, however, did not mingle with other boys in his youth. In *The Botanists of Philadelphia and Their Work*, Harshberger (1899) writes that Meehan spent his time in the fields as a naturalist and began publishing at the age of fourteen, which prompted membership to the Wernernian Society.

In 1848, Meehan emigrated to America, where he worked in Philadelphia for Robert Buist, Caleb Cope, and railroad entrepreneur Andrew M. Eastwick, then owner of Bartram's Garden. He established a nursery with William Saunders in Germantown, where he resided with his family for the remainder of his life. When the partnership with Saunders dissolved, he established Meehan's Nurseries, later Thomas Meehan & Sons. For seven decades, the nursery supplied plants to gardens, orchards, and estates from California to Europe.

Meehan's scholarly interest in botany resulted in his appointment as editor to *The Gardener's Monthly and Horticulturist* (1859-1888), which was continued in spirit as *Meehan's Monthly* (1891-1902). These were two of the largest horticultural magazines circulating at the time. Meehan also wrote agricultural columns for five other newspapers. He was elected to the American Association of Nurserymen, the Pennsylvania Horticultural Society, the American Pomological Society, the Academy of Natural Sciences (Philadelphia), the American Association for the Advancement of Science, and was an honorary member of the Royal Horticultural Society (London). He was a colleague and/or correspondent with leading botanists of the day, such as William Darlington, Josiah Hoopes, William Saunders, George Engelmann, John Torrey, Asa Gray, Mazwell T. Masters, Ferdinand von Mueller, George Nicholson, and Charles Darwin (Harshberger, 1899).

With an intense interest in plants, it is not surprising that Meehan developed a thorough knowledge of economic entomology, and his monthly magazines were replete with discussions of insects and their beneficial as well as harmful effects to plants. His first entomological publication, in 1860, focused on red spider mites on pear trees. After 1870 he published frequently on different insect pests in his monthly magazine. He lectured and published on topics such as the insectivorous sundew, *Drosera* (Droseraceae), the role of insect cross-fertilization in evolution and variation in plants, and, in 1870, he published "On Objections to Darwin's Theory of Fertilization Through Insect Agency" in the Proceedings of the American Association for the Advancement of Science. Indeed, many of Meehan's contributions provoked controversy as well as further research. Charles Darwin gave credit to Meehan's acute observations in many places in his works, and wrote to Meehan in 1874, encouraging him to continue his "interesting researches" on the colors of dioecious flowers, i.e., those which have male and female reproductive organs on separate plants. But, when

Meehan expressed his views denying the importance of fertilization of plants by insects, Darwin and others differed with him. Even when Meehan felt he had adequately changed his perspective, Darwin did not agree with him, and they had a more serious falling out. In 1883, Meehan presented a paper entitled "Variations in Nature: A Contribution to the Doctrine of Evolution, and the Theory of Natural Selection" at an AAAS meeting, in which he expressed strong support for Darwin's theory and emphasized that there was no conflict between the theory of natural selection and the doctrines of Christianity.

Meehan was the author of more than 600 publications including *The American Handbook of Ornamental Trees* (Philadelphia, 1853), *The Native Flowers and Ferns of the United States* (four volumes, 1878-1880), *Wayside Flowers* (1881), and *Contributions to the Life History of Plants* in 16 parts (*Proceedings of the Natural Academy of Sciences*, 1887-1902). He was one of the first to report of tree damage by the hornet *Vespa crabro* Linnaeus. He wrote of rapid changes in the history of species. He was dedicated to expanding the knowledge base in both horticulture and entomology. Upon the death of Joseph Leidy, Meehan was offered the presidency of the Academy of the Natural Sciences in Philadelphia, but because of his deafness he did not feel free to accept (Jellett, 1914).

Ravenel and Edmund Ruffin (1794 - 1865) passed on their observations of plants and insects to each other through correspondence. The 1848 *Report on the Geology of South Carolina* acknowledges the contributions of both men. Ruffin was a strange character indeed. His own deafness did not begin until shortly before the Civil War. While Ravenel was pro-slavery and owned slaves, most of his political writings were contained in his personal journal, and until the first shot against Fort Sumter was fired, he had hoped the war might be avoided and a peaceful coexistence be established between the North and the South.

The slave owner, Ruffin, on the other hand, was a "fire-eater," a name given to a pro-slavery extremist. He was the founder of the "League of United Southerners," which backed the concept of an independent southern nation. In fact, it was Ruffin who fired the first shot at the Battle of Fort Sumter, which marked the beginning of the American Civil War (1861-1865). It was during this battle when he rested his head against a Confederate mortar battery that fired a ten-inch round. The result was an immediate and serious increase in his deafness, which largely isolated him from others (Ruffin and Kirby, 2000, p. xii). For many years up until the Civil War Ruffin had published extensively on destructive insects, fertilizers, and other agricultural topics, at first in his *Farmers' Register*, a monthly publication devoted to the support of the interests of agriculture, and then in books and state agricultural reports. In 1861, he published *Agricultural, Geological and Descriptive Sketches of Lower North Carolina, and the Similar Adjacent Lands*, which was printed at the North Carolina Institution for the Deaf & Dumb & the Blind in Raleigh. As the war approached, Ruffin's agricultural and entomological interests were largely influenced by his desire to keep Southern planters satisfied with the quality of their soil, which hopefully would discourage slave owners from moving to western territories. Ravenel was much more focused on his scientific

pursuits during the Civil War. Ruffin, on the other hand, became so disillusioned with the Northern victory in 1865 that he wrote one last entry in his diary, picked up a gun, and killed himself (Matthew, 1988).

Paleontologists such as Fielding Bradford Meek (Fig. 9A) and Leo Lesquereux (Fig. 10A) contributed to the understanding of insect distribution patterns through their fossil discoveries (Figs 9B and 10B, respectively). Meek (1817-1876) was born in the city of Madison, Indiana. His hearing began to fail when he was a young man and progressed until he became entirely deaf. Meek's education was impeded by the delicate condition of his health. He first invested in a small mercantile business, which was a financial failure and later began to devote his time to natural history. During 1848-1849, he served as an assistant to D. D. Owen, working for the United States Geological Survey of Iowa, Wisconsin, and Minnesota. In 1852, he went to Albany, New York, as assistant to James Hall, in the paleontological work of that state. He also worked with the geological survey of Missouri and explored the Badlands of Nebraska with the noted geologist Ferdinand Vandeveer Hayden under a commission by Hall. In 1858, Meek left Albany and took up his residence in Washington, D.C., where he continued to work and live at the Smithsonian Institution until his death. Meek was entrusted with all the invertebrate paleontology. He was considered the best all-round stratigraphical paleontologist, responsible for institutionalizing paleontology in the Smithsonian and the Department of Interior. Meek, living in the Smithsonian Castle

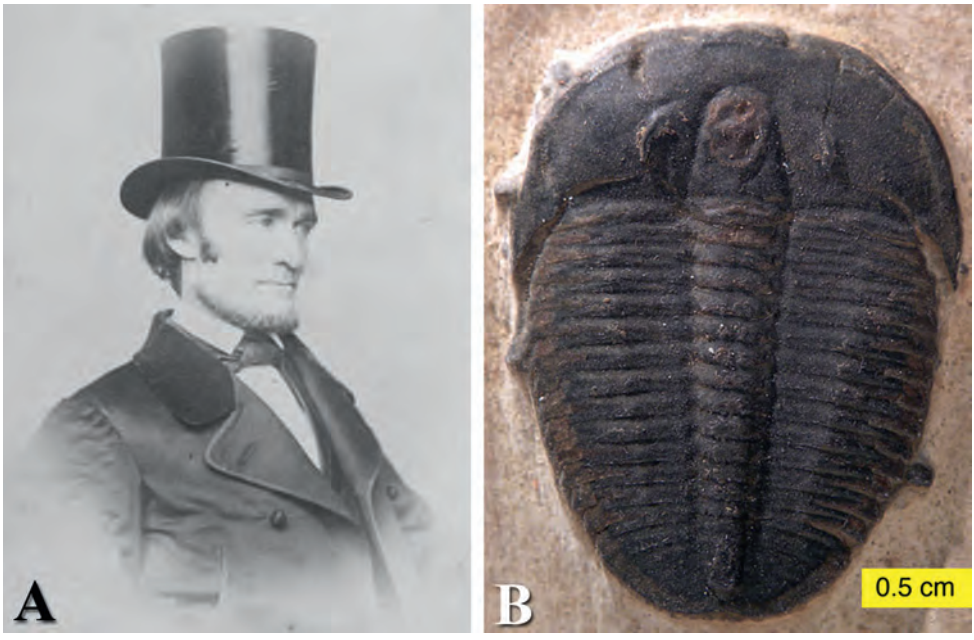

Figure 9. (A) Fielding Bradford Meek, circa 1868. (B) *Erathia kingii* (Meek), a hard-shelled ptychopariide trilobite with multiple body segments and jointed legs from the Paleozoic era that went extinct well before dinosaurs came into existence. Both images courtesy of Mark A. Wilson (Department of Geology, The College of Wooster, Wooster, Ohio, USA).

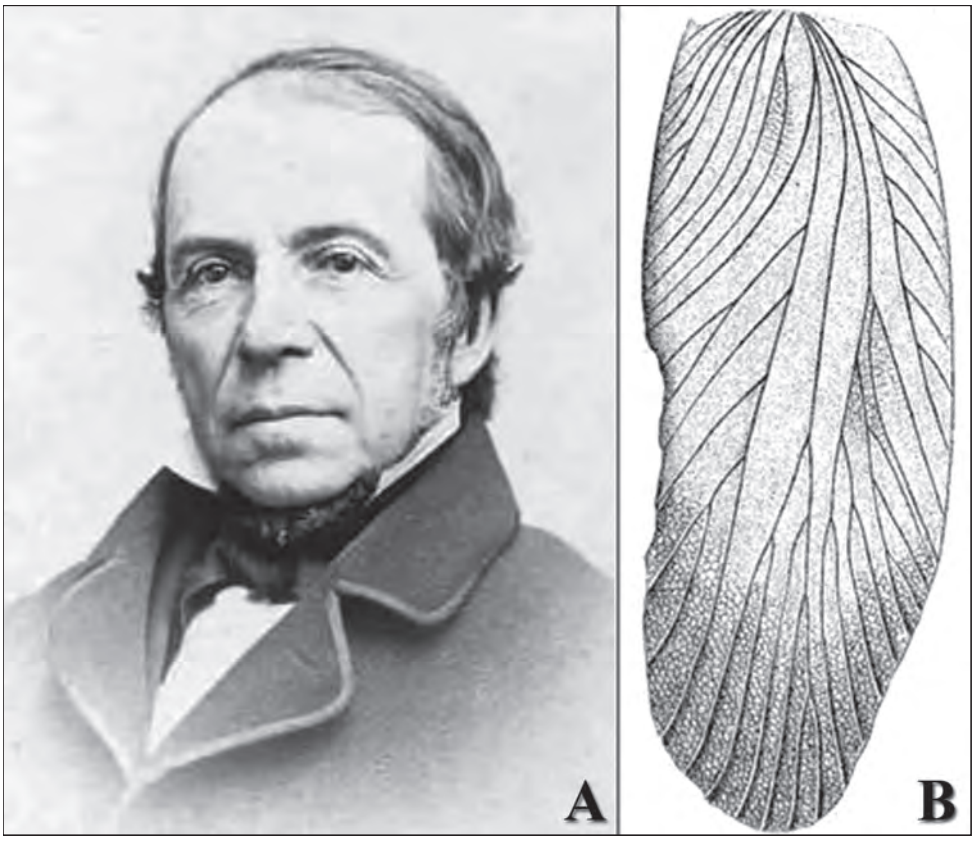

Figure 10. (A) Leo Lesquereux, the Father of American Paleobotany. Image from Wikipedia. (B) picture of the wing of *Etoblattina lesquereuxii* Scudder, a cockroach from the Carboniferous formation of Pittston, Pennsylvania, which was found in black carbonaceous shale in beds. Image from Scudder, 1879, see Figure References.

without a regular salary, supported himself with outside contracts, analyzing, describing, and illustrating invertebrate fossils from almost every phylum, all geological periods, and many localities (Nelson and Yochelson, 1980).

In a letter to John S. Newberry, Meek described his desire to isolate himself from the demands inherent in communicating with others: "I also prefer to spend my evenings with the books and specimens. I can hear and understand what they say, and they require neither small talk nor formalities" (Merrill, 1924, p. 839). Meek never developed skills in speech reading (lipreading). As Charles A. White (1896) explained, Meek "seemed averse to the use or recognition of any conventional signs. Still, he was always ready and eager to converse with his friends, and he always kept at hand a pad of paper and a pencil for their use." Like Lesquereux, though, he rarely attended social gatherings.

In addition to his deafness, Meek had pulmonary tuberculosis during much of his life. Even with these challenges, he published a larger quantity of descriptions of

invertebrate fossils than most others. Much of his work remains valid today. He discovered new genera and subgenera, species of Acephala (Cuvier's name for the bivalve mollusks) from Cretaceous formations, Gastropoda from the Tertiary, from the Jurassic and the Paleozoic. He studied species from nearly every known animal phylum, and coauthored many papers with Hayden. Meek's last publication alone, Volume IX of the United States Geological Survey of the Territories (1876), contained more than 600 pages and 45 illustrations. He was honored with membership in the National Academy of Sciences and, upon his death, his friend Joseph Henry, the first Secretary of the Smithsonian Institution, delivered the funeral oration in the Smithsonian Institution Hall (Lang, 1994).

With such a great volume of fossils to study, Meek published many reports on his geological survey work that included newly discovered myriapods (centipedes, millipedes, and other multilegged relatives) and other arthropods. His reports contained such titles as "Preliminary notice of a scorpion, a *Eurypterus*, and other fossils, from the coal-measures of Illinois" (Meek and Worthen, 1868). When trilobites first appeared in the fossil record they were already highly diverse and broadly distributed geographically. Their hardened exoskeleton facilitated fossilization. Thousands of species spanned the Paleozoic. The study of these fossils has facilitated important contributions to biostratigraphy, paleontology, evolutionary biology, and plate tectonics. Trilobites are often placed within the arthropods, subphylum Schizoramia within the superclass Arachnomorpha, although several alternative classifications exist (Gon, 2012). Meek was among the most notable trilobite suppliers.

Before the Pennsylvanian, about 320 million years ago, Arkansas (USA) was covered by seawater. The Ozark Mountains rose above the surrounding epicontinental sea during the Pennsylvanian, providing a hot, steamy habitat for insects. In 1859, Leo Lesquereux (1806-1889), the father of American bryology (the study of mosses, liverworts, and hornworts), working with the state geological survey, discovered a Pennsylvanian cockroach fossil near Frog Bayou in Crawford County.

The exact cause of Lesquereux's deafness is uncertain. It was likely a combination of a fall from a cliff (now known as "Lesquereux's Cliff") at the top of a mountain in Switzerland while he was a young boy, ulcers in the inner canals of the ears from a common cold (which also left his mother with deafness) and poor treatment from a doctor. He had consulted with the noted Parisian physician Jean-Marc Gaspard Itard. "The celebrated doctor," Lesquereux later explained, treated me shamefully. Demanding payment before making an examination of my case, fearing, he said, that I might leave Paris without paying his price, which was very high, he performed a first operation by liquid injections so strong as to produce an inflammation of the brain, and then refused to come to see me, saying that that was not his specialty, and that I must have another doctor" (Lesley, 1895, p. 198). The young deaf man was fortunate that Itard had not applied his other techniques. Itard was known at this time to have applied electric currents, pierce the eardrums of some of his students, and even fracture the skulls of some children with a hammer to drain "bad humors" to cure deafness.

After a period of recovery, Lesquereux was able to go on to study science. During the years that brought him into close friendship with the famed scientist Louis Agassiz,

he pioneered research and analysis regarding the origin and composition of peat. In 1847, he followed Agassiz in emigrating from Switzerland to America with his family. There, he participated in numerous scientific societies mostly through correspondence. Although he had learned to read lips in three languages, a remarkable feat, Lesquereux avoided meetings due to his deafness. He had learned English after becoming deaf and his pronunciation of the words was inaccurate. He was the first elected member of the National Academy of Sciences (Lesley, 1895).

Lesquereux's research with William Starling Sullivant in Columbus, Ohio culminated in two editions of the treatise *Musci Exsiccati Americani* (1856, 1865). His outstanding two-volume *Icones Muscorum* (1864) was a summary of mosses found in the eastern United States. Based on his past studies of European peat bogs, Lesquereux developed hypotheses concerning the origin of coal formations, and he corresponded with Darwin about these. His studies of Paleozoic floras resulted in his best work: *Description of the Coal Flora of the Carboniferous Formation in Pennsylvania and throughout the United States* (1879-84). This three-volume publication became the standard for the U.S. Carboniferous flora.

Lesquereux's 1859 discovery of the cockroach fossil occurred in Moscovian terrestrial shale. *Blattina venusta* was named by him in 1860 and this was renamed *Etoblattina venusta* (Lesquereux) by Scudder (1879). The deaf paleobotanist had earlier contributions to entomology, however. In 1855, for example, he published "Insectes de Mammooth-Cave dans l'Amerique du Nord," a summary of some of his findings in Kentucky. While studying fossil plants, he also was able to examine and publish on the burrows of insect larvae under the bark of certain plants.

During an interview in his later years, Lesquereux was asked if his long and intimate associations with great men such as Schimper, Brongniart, Marquis Gaston de Saporta, Schenk, Williamson, and Nathorst had not left him with many anecdotes and fond memories. Lesquereux remarked, "My associations have been almost entirely of a scientific nature. My deafness cut me off from everything that lay outside of science. I have lived with Nature, the rocks, the trees, the flowers. They know [me]. I know them. All outside are dead to me (McCabe, 1887, p. 839).

Not surprisingly, with the field of entomology being male dominated, like most scientific disciplines in the 19th century, women with disabilities faced a double challenge that made it difficult to contribute to scholarly endeavors. Entomology was no exception. Several deaf and hard-of-hearing women made contributions, albeit indirectly. In the USA, Laura Catherine Redden (1839-1923), who was profoundly deafened around the age of eleven, graduated from the Missouri School for the Deaf in Fulton. By the time she was nineteen years old, she had become an established writer and Civil War correspondent for the *Missouri Republican*. Her book of verse, *Idyls of battle and poems of the rebellion* (1864), had been read by Abraham Lincoln in the midst of the Civil War, and during the war she also published *Notable men in the House: A series of sketches of prominent men in the House of Representatives, Members of the Thirty-Seventh Congress* (1862), biographical sketches of members of the US Congress. The assertive young deaf woman was thus well respected. Many of her articles in periodicals were published under her pen name, "Howard Glyndon."

In February 1865, Redden sailed for Europe, where she remained nearly four years, mastering French, German, Italian and Spanish, and writing for the *New York Times*, *New York Sun*, and contributing to leading magazines.

Her reputation as a scholar and talented writer likely led the US Department of Agriculture to invite her to collect material and author papers, including one on the orange and citron culture. In 1865 the Department had reserved one of its greenhouses for tropical fruits. Correspondence was initiated to acquire as complete collection of fruits as possible to investigate their value for artificial culture. Two of the earliest articles on such fruits helped to emphasize the great possibilities the South offered for fruit and especially for citrus cultivation now that the Civil War had ended. The first of these articles, "Culture of the Orange and Citron," was written by Redden while in Sorrento, Italy, and "expressed the opinion that in view of the unopened and wide field for orange and citron growing in the United States, this industry if rightly pursued would make up for the injuries to the old southern industries and the time needed for their adjustment to new conditions" (Compton, 1921, p. 49). Importantly, Redden included her recommendation to the Agricultural Department that bees should always be kept where there are orange plantations. "If maintained on a large scale great profits may be obtained," she wrote, "as the very best honey is made from the flowers of the citron and the orange, which are the same in shape, size, color, and odor." Redden (1867, p. 154). Redden summarized the conditions needed for success in the industry, providing enough detail to enable any prospective grower to understand the requirements, and she provided useful hints about the soil density, manuring, weeding, and propagation by grafting. Compton (1921, p. 49) summarized the economic implications of Redden's discussion of bees, "Not only would the fruit be a source of profit to the planter, but in connection therewith there might be medical by-products, perfume, and honey production."

Unlike Redden whose interests were primary literary and whose work in science was of short duration, Marianne North (1830-1890, Fig. 11A) was a Victorian era British naturalist and botanical painter whose entire career was devoted to illustrating and studying plants, insects (Fig. 9B), and their habitats. As her deafness became increasingly worrisome and she was bothered by noises in her head (possibly tinnitus), she nevertheless continued to travel and paint specimens in their natural habitats (Sheffield, 2001).

Botanical illustration and entomology have had many interesting intersections through history. Arthropods engage in fascinatingly diverse biological relationships with plants. North traveled around the world, searching for rare plants and flowers. She had no formal artistic training and a rather unconventional technique, yet she documented her subjects in situ with detail and accuracy. More than eight hundred of her brightly colored paintings are exhibited in Kew's Marianne North Gallery.

Male scientists typically frowned upon the participation of women in scientific disciplines during this period of history, but, like Margarete Gatty and Eleanor Ormerod, North developed a fascination with botany and entomology that led her to pursue her passions and gain respect as a naturalist. North added descriptions of both plants and insects she encountered. "Mr. E. found me a Green Stick insect," she wrote in her

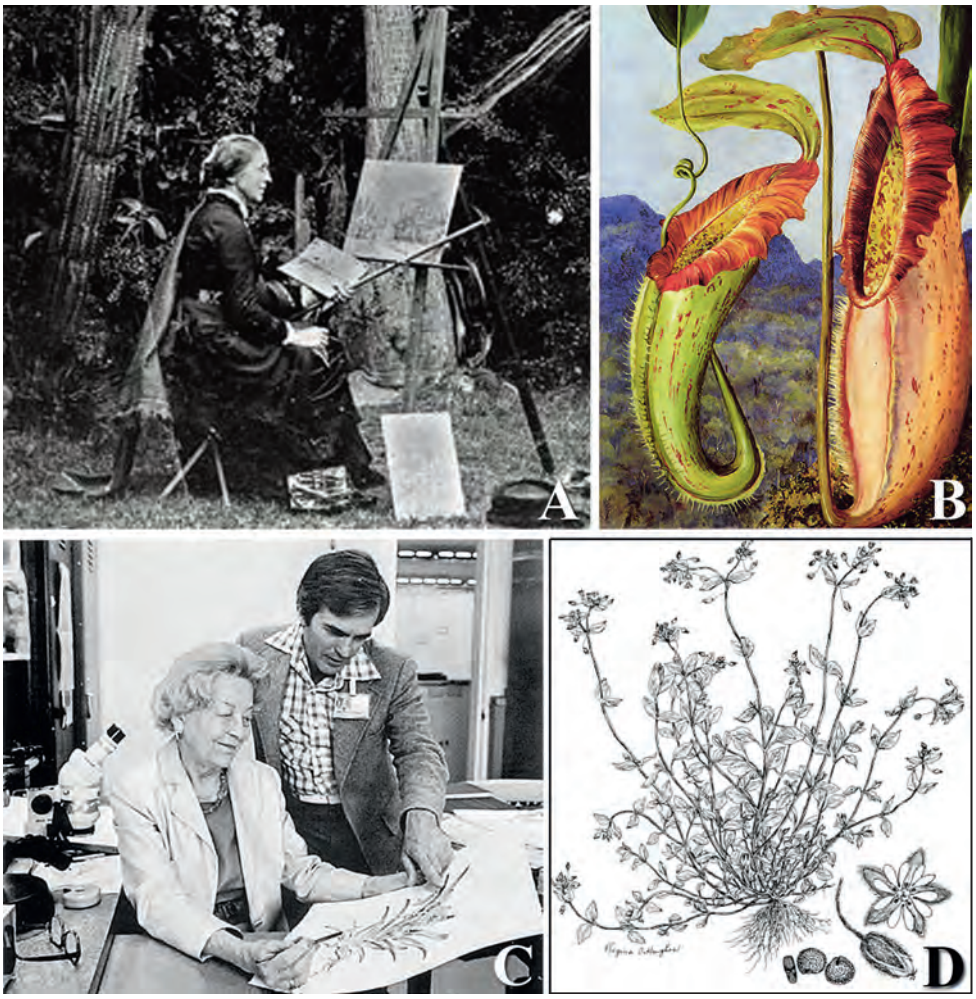

Figure 11. (A) The artist Marianne North painting a landscape. (B) Image of *Nephenthes northiana* Hook.f. (Nepenthaceae) painted by North. This and many other carnivorous plants include arthropods in their diet (Hamilton and Kourtev, 2011). Image from Wikipedia. (C) Regina Olson Hughes discussing a painting with Robert W. Read. Read, who served as Curator of palms in the Botany Department of the National Museum of Natural History and had side interests in orchids and bromeliads, frequently asked Hughes to illustrate his publications. Photo by Smithsonian Photographic Services. (D) Common chickweed, *Stellaria media* (L.) Vill. (Caryophyllaceae), known to be a reservoir for plant viruses and insect pests, including *Lygus* bugs (Heteroptera: Miridae) and thrips (Thysanoptera).

autobiographical notes, "which curled its long tail over its head like a scorpion and looked most vicious, but was perfectly harmless. It had gorgeous scarlet wings to fly with, but on the ground was invisible as a blade of grass" (North, 1894, p. 250). Her observations of arthropods included the economically important cochineal insect, *Dactylopius coccus* Costa (Hemiptera: Coccoidea), feeding on *Opuntia* cacti (Cactaceae) and the infestation of Brazilian vegetation by [garrapatas] or ticks (Arachnida: Acari).

She discussed the insect collection of George Henry Kendrick Thwaites with the English entomologist who was superintendent of the botanical gardens at Peradeniya, Ceylon.

North interacted with many great male naturalists. She called on Charles Darwin, who told her "I ought not to attempt any representation of the vegetation of the world until I had seen and painted the Australian. I determined to take it as a royal command." When she came back to Darwin with "vegetable sheep", *Raoulia eximia* Hook. f. (Asteraceae) and pictures of her journey, he wrote her that he could recall the scenes of countries he had visited but "my mind in this respect must be a mere barren waste compared with your mind" (Kastner, 1981). Sir Joseph Dalton Hooker named at least one species of carnivorous plant, *Nepenthes northiana* Hook.f. (Nepenthaceae, Fig. 11B) in her honor after one of her paintings in Borneo made Sir Harry Veitch realize it was a yet undescribed species and sent Charles Curtis to seek the seeds in order that the plants could be raised. *The Gallery of Marianne North's Paintings of Plants and Their Homes*, published by the Royal Gardens, Kew, contained numerous descriptions of insects along with the paintings. In the preface to this book, Hooker wrote that "Such scenes can never be renewed by nature, nor when once effaced can they be pictured to the mind's eye, except by means of such records as this Lady has presented to us, and to posterity, which will thus have even more reason than we have to be grateful for her fortitude…" (Hemsley, 1883, p. iv).

Following in North's footsteps was Regina Olson Hughes (1895-1993, Fig. 11C), who was born in Herman, Nebraska, USA. Hughes also distinguished herself as a botanical illustrator working in close collaboration with taxonomists and other scientists. She illustrated flowers, weeds (Fig. 11D), plants, and seeds that were collected and categorized from all over the world. Thousands of her scientific illustrations appear in textbooks and publications.

Progressively and profoundly deafened between the ages of ten and fourteen, she earned a bachelor's degree and master's degree before 1920. She is the only deaf artist to have had a solo exhibition at the National Museum of Natural History (NMNH) of the Smithsonian Institution (Rotunda Gallery). Hughes' experience included years of honored illustration work for the Agricultural Research Service and the U.S. Department of Agriculture. While an illustrator in the Department of Botany of the NMNH, her illustration of a bromeliad was on display in an exhibit of the research of Lyman B. Smith and Robert W. Read. She also holds the honor of having both a plant genus and species named for her —*Hughesia reginae* R. M. King and H. Rob. (Asteraceae). In *Selected Weeds of the United States (1970)* and *Common Weeds of the United States* (1971) she illustrated hundreds of species of the more prevalent weeds in croplands, grazing lands, non-croplands, and aquatic sites. Six thousand of her illustrations appeared in *Economically Important Foreign Weeds: Potential Problems in the United States*, a U.S. Department of Agriculture Handbook, published in 1927.

As with Marianne North, Hughes' drawings have been used by scientists interested in insect control. An example of this is shown in Fig. 11D, a drawing of the common chickweed, *Stellaria media* (L.) Vill. (Caryophyllaceae), in a discussion of plant viruses and insect pests (Anonymous, 2006). The Reed and Hughes (1970) volume has been

frequently cited by entomologists examining various insects in their investigations, such as Wurdack's (1980) treatment of the Melastomataceae for the Flora of Ecuador, and King and Robinson's (1987) study of the use of insects for controlling the spread of the yellow toadflax plant, *Linaria vulgaris* L. (Plantaginaceae).

Entomological interests in the deaf community

Most of the individuals mentioned so far, with the exception of Hughes and Redden, were not members of the Deaf community. As schools for deaf children were established in Europe and the United States, the education these children received allowed them to be better prepared for both trades and academic occupations. During the latter half of the 19th century, two young deaf men, Alfred T. Hollick and James Platt-Barrett, made their marks in entomology in distinctly different ways.

In 1872, Sir John Lubbock (later Lord Avebury) of the Royal Society, a close friend of Darwin, published a contribution to natural history in which he discussed animals that generally had been neglected. Lubbock employed the deaf microscopist and scientific illustrator, Alfred T. Hollick (1843-1910), to illustrate his scientific publications. The specimens were first grouped by Pierre André Latreille under the name Thysanura, commonly known as silverfish. Lubbock, however, believed there were two distinct orders and proposed a second classification, the Collembola. *The Monograph of the Collembola and Thysanura* (1873) contained seventy-eight plates, thirty-one of them in color, beautifully and painstakingly illustrated by Hollick. In Figs 12A-D, we present a selection of illustrations prepared by Hollick to represent his extraordinary work, including habitus drawings, detailed anatomical representations of a miniscule arthropod (Fig. 12E), and microscopic details that approach that of modern scanning electron micrographs (Fig. 12F).

In the preface to Lubbock's book it is explained that "the representations of the species, and the general execution of the plates, are the work of Mr. Hollick, a gentleman who is unfortunately deaf and dumb [sic], but in whom these terrible disadvantages have been overcome by natural genius." As Lubbock wrote, "I believe this is the first work which has ever been illustrated by a deaf and dumb [sic] artist. It will be seen that Mr. Hollick has spared himself no labour or pains. I feel much indebted to him for the conscientiousness with which he has reproduced the minute details of the originals, as well as for the beauty and accuracy of his work" (Lubbock, 1873, p. vii).

Hollick was born deaf and attended a school for deaf children in Brighton, England. He began his career working as a "microscope maker," probably under the supervision of a relative, the microscopist Joseph Beck. He then cultivated his artistic talents, which likely attracted the attention of many scientists working on entomological classification.

Hollick illustrated many plates for *Drawings Illustrative of Eozoon from the Carpenter Collection* (no date), *Original Drawings of Mites, Lice and Coccid Pests on Oranges* (1862), and 39 plates for the Arachnida-Araneidea volume of *Biologia Centrali-Americana*. He completed a collection of illustrations produced around 1870 that were intended for a Ray Society Monograph to supplement John Blackwall's

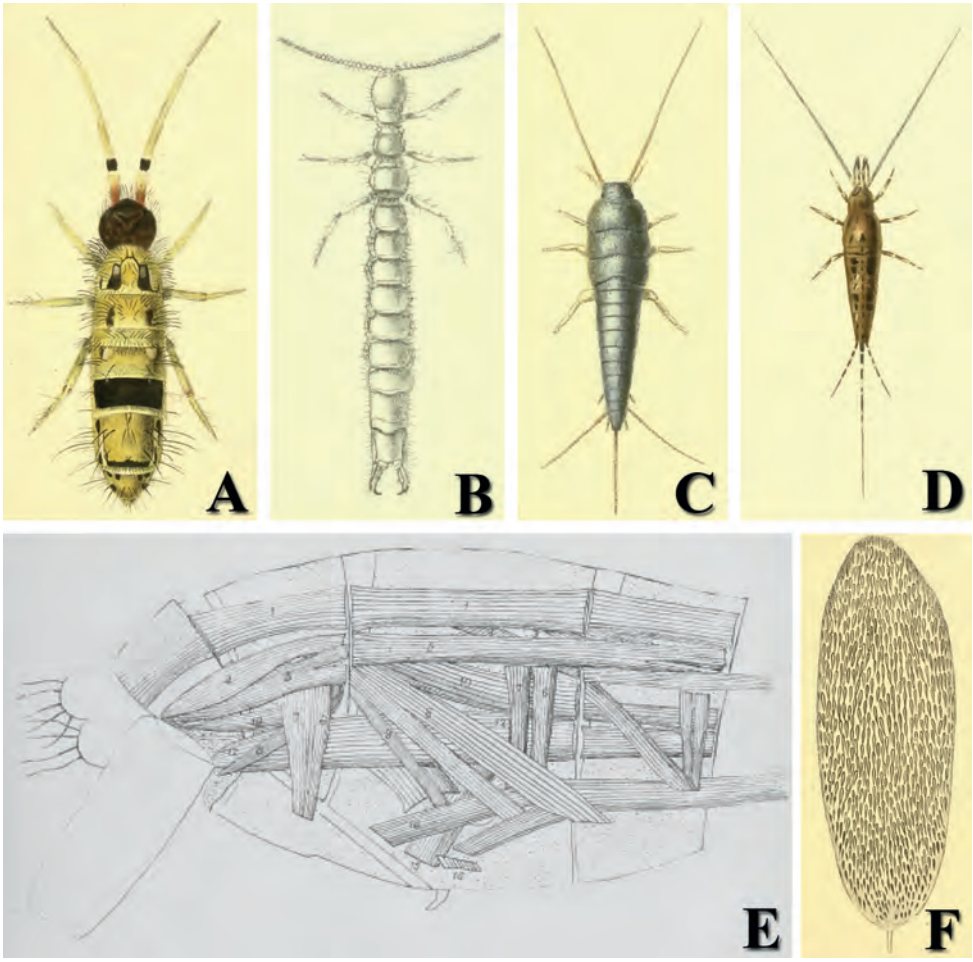

Figure 12. Alfred T. Hollick began his career as a microscope maker and prepared many illustrations – six shown above - for Lubbock's 1872 *Monograph of the Collembola and Thysanura*. These primarily soil-dwelling microscopic hexapods are currently considered members of several relatively ancestral orders of the Hexapoda. (A) *Orchesella cincta* (Linnaeus) (Collembola). (B) *Japyx solifugus* Haliday (Diplura). (C) The silverfish, *Lepisma saccharina* Linnaeus (Thysanura). (D) A species of "*Machilis*" (Archaeognatha). E. Lateral view of the posterior abdominal segments of the springtail (Collembola) *Pogonognathellus longicornis* (Muller), showing the position and attachments of the muscles. Lubbock had placed this species in the genus *Tomocerus*. F. Scale of *Seira domestica* (Nicolet) (Collembola). Note the exquisite details in this drawing, almost approaching what one sees with a modern scanning electron microscope. Images courtesy of Biodiversity Heritage Library.

Spiders of Great Britain and Ireland. Planned by Octavius Pickard-Cambridge, the monograph was never published (Smith, 1986). Hollick's illustrations appeared in many other publications including those of the physician, invertebrate zoologist, and physiologist William Benjamin Carpenter (author of *The Microscope and its Revelations*) and the vertebrate anatomist Richard Owen. Owen's *Report on the Foraminifera dredged by H.M.S. Challenger during the Years 1873-1876*, in particular, praised Hollick's

figures as among the most accurate that had ever appeared. Hollick also contributed many entomological illustrations for The Natural History Museum in London.

Through subsequent years, Hollick was employed by many other distinguished entomologists. In 1887, for example, George West Royston Pigott, a Fellow of the Cambridge Philosophical Society, wrote on "Butterfly Dust—Latticed and Beaded Ribs" in a column titled "Microscopical Advances" in *The English Mechanic and World of Science and Art*, crediting Hollick for a drawing of the long narrow scales of *Lycaena indica* Fabricius (Lepidoptera: Lycaenidae), "and I must say the lithograph is a most faithful copy of what we both most clearly discerned." (p. 379).

In 1888, the University of Aberdeen conferred the honorary degree of LL.D. upon Henry B. Brady for his services to natural science, especially his work with Foraminifera from the Voyage of the H.M.S. Challenger. "The illustrations of such a work are of vital importance," a progress report summarized in 1878, "and the author gave to this department the fastidious care of a skilled draughtsman and ensured equal accuracy in the work entrusted to the pencil of Mr. Hollick" (Anonymous, 1878, p. 534).

Hollick attended the Brighton Institution for the Instruction of the Deaf and Dumb, established by John Walker in 1841. The earliest records of other schools for deaf children in both Europe and the United States contain numerous references to teachers and students with entomological interests. In Birmingham, Great Britain, Charles Baker, who possessed normal hearing, first became interested in teaching deaf children in 1818. Over the next ten years he also became enamored of entomology, authoring in 1828 a small volume titled "British Butterflies," which included lithographic illustrations of each genus, comprising 33 species. These drawings were completed by his deaf pupils at the Edgbaston Institution (Anonymous, 1875). Baker went on to become headmaster at the school for the deaf at Doncaster in 1829. Twelve years later, a new pupil, James Platt-Barrett (1838-1916, Fig. 13A), arrived from Huddersfield.

It would not be surprising to learn that young Platt-Barrett was inspired by Baker to pursue a lifelong interest in butterflies. But entomology was not Platt-Barrett's primary profession. He was an instructor at the school for deaf children at Margate for nearly fifty years. It was at his house at Peckham, however, that as a young man Platt-Barrett helped to found the Entomological and Natural History Society. The accepted date of the founding of this group is 1872, but informal meetings were held in his house a year or two earlier. Platt-Barrett was elected president in 1877, but resigned membership just before he moved to Margate to teach.

A pleasant story is told of the early days of the Society. In 1872 a 21-year-old man wished to join, and when someone objected to such young men being members, Platt-Barrett said he would answer for him. That youth soon became one of the most popular writers on natural history subjects in the Society. His name was George Charles Champion and he had begun collecting butterflies and moths as a young boy in South London after being encouraged by his friend, Platt-Barrett. Within a few years Champion would travel to Guatemala for four years and return to England with 15,000 species of insects. He would become a Fellow of the Royal Entomological Society (Moore, 1917).

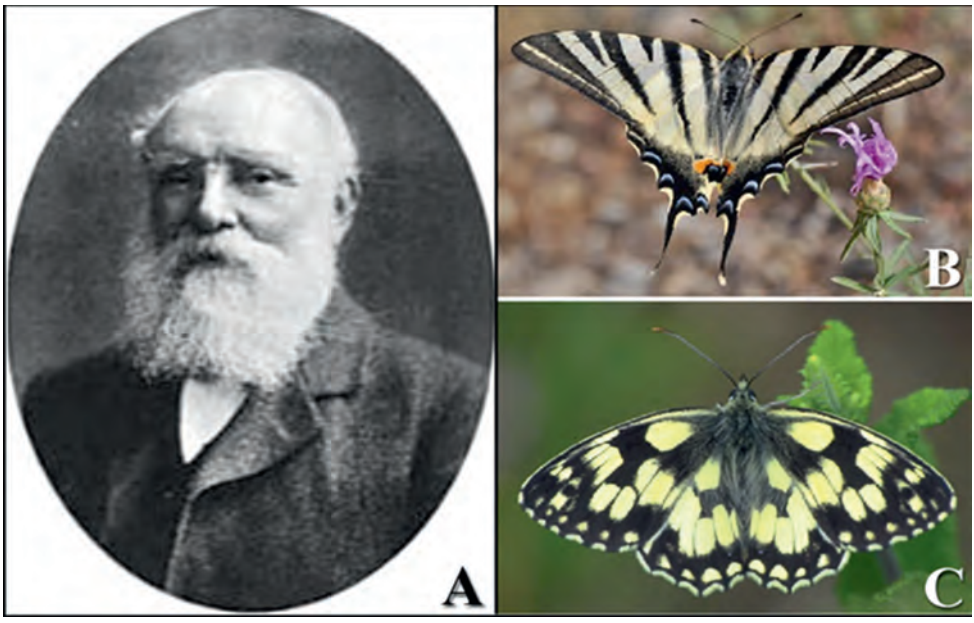

Figure 13. (A) James Platt-Barrett, an avid collector, shared his entomological knowledge through publications and presentations to both scientific societies and his deaf friends in the local community. Photograph courtesy of the British Entomological and Natural History Society. (B, C) Two of the many species of Lepidoptera studied by Platt-Barrett: (B) *Papilio podalirius* [this species is now known as *Iphiclides podalirius* (Linnaeus) (Papilionidae), and (C) *Melanargia galathea* (Linnaeus) (Nymphalidae) Photographs courtesy of Matt Rowlings, www.eurobutterflies.com.

Platt-Barrett did not rejoin the Entomological and Natural History Society until 1900. During the next seventeen years he was extremely productive. He was elected a Fellow of the Entomological Society in 1911. Despite his deafness, he seemed to find ways to communicate with his associates. For years he also provided evening science-related entertainment sessions to the Deaf community of South London. He frequently invited an entomology associate, who, not knowing sign language, felt himself to be the only "deaf" person in the meetings. Platt-Barrett would bring tales from his colleagues at the Entomological Society meetings and repeat them to his friends in signs, who laughed as heartily as the Fellows who heard them (Moore, 1917).

Platt-Barrett's entomological interests were mainly in the study of the larger moths and butterflies, traditionally known as macrolepidoptera, of Britain and Sicily. In various publications he described many species. From time to time he contributed notes to magazines. Essentially a field naturalist, he preferred his own observations to anything second-hand. He regularly sent field reports to *The Entomologist* during his excursions. His style was casual, but provided great detail in the descriptions of the specimens he collected. "Perhaps the most noteworthy Sicilian butterfly is *Papilio podalirius*," (Fig. 11B) he wrote in 1908, "which occurs from sea-level up to 4000 ft. I have not been higher. It is lovely on the wing, especially when floating on the breeze, three or

four together, a favourite spot being near a tree at the top of a low hill. I cannot yet resist taking a fresh specimen" (Platt-Barrett, 1910, p. 31). For a presentation on this topic, he used lantern slides, and was always generous in sharing the butterflies with his colleagues.

During this particular visit to Sicily, Platt-Barrett and his son were nearly killed during the terrible earthquake at Messina on December 28, 1908. His daughter-in-law and grandchild, who were sleeping in the adjacent room, were among the hundreds of thousands of victims. Platt-Barrett had spent months obtaining butterflies for his colleagues back home in England. The collection of several hundred specimens was destroyed in the disastrous earthquake, "together with all my belongings, notes included, only excepting my night attire. Everything else I had was burnt up" (Platt-Barrett, 1910, p. 30).

At scientific meetings he frequently exhibited his specimens. He was particularly interested in the butterfly genus, *Melanargia* (Lepidoptera: Nymphalidae, Fig. 13C), and one of his last essays was a paper read before the South London Society on the European species of the genus, with special reference to the Sicilian forms. His collection, which he bequeathed to the Horniman Museum, contains the much-figured form of *M. galathea* (Linnaeus), somewhat like *M. lachesis* (Hübner), which he obtained in North Kent in July, 1875. He was elected a Fellow of the Entomological Society in 1911.

Meanwhile, in the United States, nearly two dozen residential school programs had been established by 1860. The improved educational opportunities, especially after the Civil War, increased the numbers of deaf men and women who pursued scholarly areas, including science. The National Deaf-Mute College (now Gallaudet University) in Washington, DC graduated its first class in 1869. During the next decades at Gallaudet two faculty members held strong entomological and botanical interests: Charles R. Ely and John W. Chickering. Some of the deaf students at the college were inspired by them whereas others developed scientific interests independently. Some students, such as Cadwallader Lincoln Washburn (1866-1965) from Minneapolis, began with entomological interests, but found other fields in which to excel. Deaf from spinal meningitis at age five, he attended the Minnesota School for the Deaf in Faribault, graduating in 1884. As a student at Gallaudet College, he first pursued an interest in insects, writing essays with his own illustrations of spiders, bees, and caterpillars. In 1890, he was chosen valedictorian and presented his senior dissertation "The Working Mind of a Spider" in American Sign Language. In this paper, he described the faculties of spiders, in particular, the geometrical construction purposely designed to ensnare its victims, the ability to distinguish the vibrations produced by each thread of the web when touched, the spider's quick perceptions and movements, the ability to appreciate the advantages of the properties of its silken thread, and its judgment in observing the captured prey. Washburn's college essay was published the same year, providing detail to these and other observations, including how the spider's work has been beneficial to engineers in the design of suspension bridges and to astronomers in determining measuring lines and the distance of heavenly bodies. "When a spider accidentally comes in our way," he concluded, "before giving him a fatal blow, remember what

his ancestors accomplished, and then ask which would be most serviceable to science, our crushing him or our leaving him alone" (Washburn, 1890, p. 99).

Ironically, Washburn's uncle, Elihu B. Washburn from Illinois, then acting chairman of the House Committee on Appropriations for the U.S. Congress, bitterly opposed appropriations for the Columbia Institution (forerunner of Gallaudet College), arguing that higher education for deaf students was useless and of little value to them (Gallaudet, 1983). He lived to see his own nephew become widely recognized as the "Dean of American Etchers," excelling with his drypoint etchings, oil paintings, watercolors, and lithographs.

Charles R. Neillie (1870-1942) had first studied at the Western Pennsylvania School for the Deaf in Pittsburgh, where he learned through sign language. He then studied at Gallaudet College and became an entomologist, later receiving an honorary Master's for his accomplishments. He began working in Cleveland, Ohio as a horticulturist and then as the City Entomologist in the Forestry Division of the Department of Public Service. Tree blights are diseases characterized by rapid and complete chlorosis, loss of the green photosynthetic pigment, chlorophyll, browning, then death of plant tissues that can be caused by a variety of and pathogens, such as bacteria, fungi, other unicellular eukaryotes. As an expert on this subject, Neillie was one of the first to propose using airplanes as crop dusters.

The aerial application of a pesticide near Troy, Ohio on August 3, 1921 was well documented in the March 1922 issue of *National Geographic Magazine* (Neillie and Houser, 1922). A Curtiss JN-6 aircraft was used to apply lead arsenate (formulated as a dust) to a 6-acre stand of 4,815 *Catalpa* (Bignoniaceae) trees (probably the widely cultivated northern catalpa, *Catalpa speciosa* (Warder) Warder ex Engelm.) (Fig. 14). In a mere 54 seconds, the aerial team treated the entire stand with 175 pounds of pesticide formulation, which established a world's record for speed in applying insecticides to forested areas. Ever since, aircraft have played a role in the production of agricultural crops in the United States.

Previous efforts to control *Catalpa* sphinx caterpillars had failed. The experiment and subsequent publication brought the deaf Cleveland entomologist and his hearing colleague Houser into aviation history with the first use of aircraft for pest control in the United States.

Another deaf man whose scientific ambitions were closely followed by the American Deaf community was Michael Gerald McCarthy (1858-1915, Fig. 15), born in Ottawa, Illinois to parents who had emigrated from Ireland. He became totally deaf at the age of 15 as a result of an attack of cerebrospinal meningitis. He then entered the Illinois School for the Deaf in 1878 and graduated in 1880. While working in St. Louis as a laborer in Shaw's Botanical Garden, forerunner of the Missouri Botanical Garden, he developed an interest in botany as his life's work. At Gallaudet, he had an excellent mentor in John W. Chickering, who co-authored a paper with the young deaf man in the *Botanical Gazette* in 1886, one year before McCarthy graduated. When McCarthy received a B.S. degree a year later, he delivered in American Sign Language an oration entitled "The Forces of Vegetable Life." After graduation he worked for a time in the herbarium of the United States National Museum (National Museum of

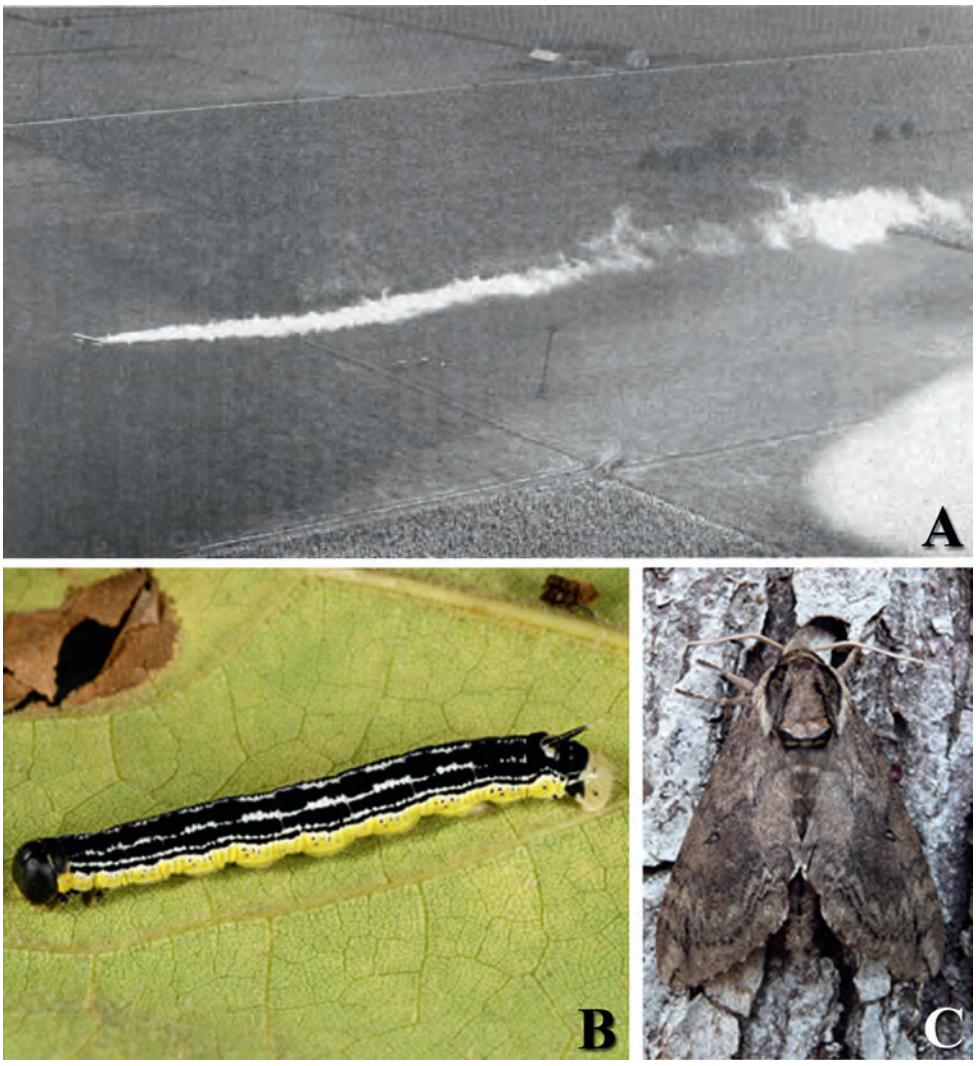

Figure 14. (A) Charles R. Neillie, a deaf entomologist, was the first to propose insect control through crop-dusting by airplane. The first airplane dusting took place in Troy, Ohio in 1921. The figure caption reads "The six acre catalpa grove, 4,815 trees, in the center of the picture was dusted with arsenate of lead in 54 seconds. A gentle wind was blowing in the direction indicated by the arrow. Note the dust passing through the grove in a dense white cloud." Photograph from Houser (1922), courtesy of the American Pomological Society. (B) The *Catalpa* sphinx caterpillar, *Ceratomia catalpa* (Boisduval) (Lepidoptera: Sphingidae), formerly known as *Sphinx catalpae*, which were devastating the *Catalpa* (Bignoniaceae) trees. Photograph courtesy of David Wagner (University of Connecticut, Storrs, CT, USA). (C) Adult *C. catalpa*. Photograph courtesy of Dave Moskowitz.

Natural History, Smithsonian Institution), later presenting to that organization more than 4,000 plant specimens he had collected (Troyer, 1999).

McCarthy gathered specimens in Texas in 1881 and 1882 and, while a student at Gallaudet, he made summer collecting trips to the Southeast, especially to North and

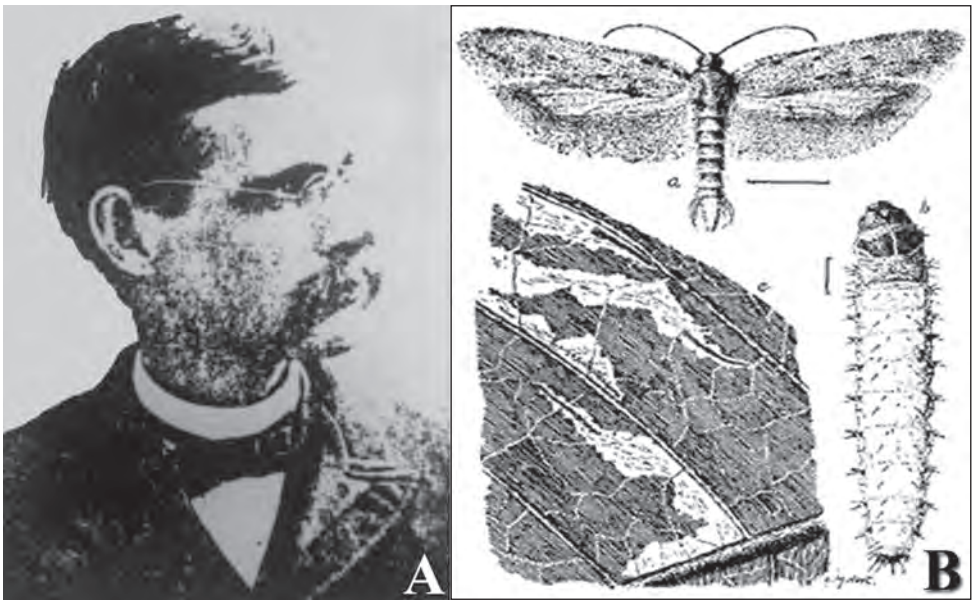

Figure 15. (A) Gerald McCarthy, North Carolina Entomologist. Image from Anonymous (1896). Courtesy of the Alabama Institute for Deaf and Blind. (B) Plate in McCarthy's 1897 article "A New Tobacco Pest" published by the North Carolina Agricultural Station. The figure includes an adult moth, *Gelechia piscipelis* Zell. (Gelechiidae) above; larva below at right; and a caterpillar-mined leaf below at left.

South Carolina. When the passage of the Hatch Act in 1887 provided additional resources for the state agricultural station, director H. B. Battle decided to add a botanist to his staff. In October 1888, McCarthy was named to the position of botanist at the state agricultural station in North Carolina, which essentially began a more scientific approach to controlling the many agricultural insect pests of that time (Wray, 1967). He established the first institutional herbaria in Raleigh (Ehrenfeld *et al*. 1998; Troyer, 1999). It was housed at the Agricultural Experiment Station and held examples of about 2,500 species.

By 1897, McCarthy was serving as both botanist and entomologist for the Experiment Station. In addition, he was secretary of the horticultural society, secretary in a Southern Pines research project, entomologist to the pest commission, and a member of the national committee on seed testing. According to Troyer (1999), disaster struck the hard-working deaf scientist when he was summarily dismissed from his position as a result of political events. A new governor and a majority of the legislature elected in 1896 led to new assignments, including those at the Experiment Station. He was given a mere one week to pack his belongings and leave.

After pursuing further studies in botany, entomology, and invertebrate zoology at Cornell University, McCarthy had learned that the political power in North Carolina had again changed hands, and he applied for his old job with the Station. In 1900, he instead was given a position with the state department of agriculture instead. McCarthy's

numerous publications included American Weeds (1892), Copper-Soda and Copper-Gypsum as Remedies for Grape Mildew (1890), Combating the Potato Blight (with J. H. Bunzli, 1890), Botany as a Disciplinary Study (1889) and *Wilmington Flora: A list of Plants Growing About Wilmington, N.C. with Date of Flowering, with a Map of New Hanover County* (1886, with Thomas F. Wood).

Among his many insect studies, McCarthy collected larvae of a leafminer of tobacco, *Gelechia piscipellis* Zeller, currently known as *Isophrictis similiella* Chambers (Lepidoptera: Gelechiidae), which enabled others to determine that its occurrence represented a change of habit, more or less accidental. His specimens of the hemipterous insect *Cyrtoneurus mutabilis*, probably *Cyrtomenus ciliatus* (Palisot de Beauvois) (Cydnidae) led to a better understanding of the damage produced in chufas (sedge), *Cyperus esculentus* L. (Cyperaceae), by puncturing the edible tubers. *The Fungous and Insect Enemies of Legumes* (with F. E. Emery, 1894), *Our Common Insects* (1894), and *A New Tobacco Pest* (1897) were a few of his many publications of value to economic entomology.

Late-onset deafness

In the absence of antibiotics and the prevalence of diseases in the 19th and early 20th centuries, as well as the common malady of presbycusis and other forms of old age deafness, it is not surprising that there were numerous entomologists who became deaf or hard of hearing in their later years. Many distinguished individuals could not find forms of support in this period of history to help them adjust to the isolating effects of the disability. These great men and women struggled to continue to participate in science and society when deafness deprived them of their ease of communication with which they had grown accustomed. We have organized them in chronological order by year of birth.

William Spence (1783-1859), born in Yorkshire, England and best known for his interests in insect behavior (Richard, 1973) and collaboration with William Kirby, the Father of Entomology in England (Essig, 1931) in the noteworthy four volumes of *Introduction to Entomology* (1815-1826), continued to attend meetings in old age. It is explained, however, that he "was, until deafness incapacitated him for public duties, President of the Entomological Society" (Annual Register, 1860, p. 490).

Similarly, Frederick Bond (1811-1899), born in Exmouth, England, had a great passion for collecting insects and amassed a great store of knowledge of the habits of various insects, especially Lepidoptera. He held ornithological interests as well. It is a common saying, wrote Dunning (1889, p. 155) in his tribute to Bond, that "a naturalist ought to have three lives: seventy years to collect, seventy to study his collection, and seventy to impart his knowledge to others." For the last dozen years of Bond's life, a time during which he experienced increasing deafness, he gave his services as assistant editor (for Lepidoptera) for *The Entomologist*, a British periodical. During his career, he had published on moths, butterflies, and other Lepidoptera as well as locusts (Orthoptera) and rare British insects. He was elected a member of the Entomological

Society in 1841 and regularly attended meetings until deafness rendered conversation difficult. His name is connected with the noctuid moth *Tapinostola bondi* Knaggs (Salmon *et al*. 2000).

Joseph Dalton Hooker (1817-1911, Fig. 16A) and Thomas Henry Huxley (1825-1895, Fig. 16B), allies of Darwin, as well as founders of the British journal *Nature*, were both challenged by deafness in their later years. "I am sorry to hear you are troubled by your ears," Huxley wrote to Hooker in October, 1888. "I am so deaf that I begin to fight shy of society. It irritates me not to hear; it irritates me still more to be spoken to as if I were deaf, and the absurdity of being irritated on the last ground irritates me still more" (Huxley 1903, p. 63). Four years later he wrote to Leslie Stephen, "But my deafness alone should bar me from decent society. I have not the moral courage to avoid making shots at what people say, so as not to bore them; and the results are sometimes disastrous" (Huxley, 1903, p. 234).

Louis Compton Miall (1842-1921, Fig. 16C), born in Bradford, England, the son of a Congregational minister, developed interest in natural history through his brother, a medical student. He published numerous works on the physiology and development of insects, including *The Structure and Life History of the Cockroach*, *Introduction to the Study of Insects* (with Alfred Denny, 1886), *The Natural History of Aquatic Insects* (1895), and *The Structure and Life History of the Holly-Fly* (with T. H. Taylor, 1907). By 1871 he was the Curator of the Museum of the Leeds Philosophical Society and, in 1892 he was elected a fellow of the Royal Society. His admiration of early works on insects led him to author *The Early Naturalists, their Lives and Work, 1530-1789* (1912). In the preface to this last he wrote, "The early naturalists have occupied so much of my leisure of late years that it becomes a pleasant task to write about them. My chief aim is to induce such readers as I may find to make themselves better acquainted with the founders of modern natural history. … Insects take up more than their due share of space, partly because they are really prominent in the works of early naturalists, partly because old books about insects give me more than common pleasure" (Miall, 1912, p. v). He had been experiencing deafness for some time, more than a decade before his death, and this prompted him to admit to being a poor listener "partly because I am deaf and partly because what other people say is generally wrong" (Baker and Bayliss, 1983, p. 102).

The career of the Hungarian entomologist Károly Sajó (1851-1939, Fig. 16D) was also ended by the onset of deafness. He had conducted research at the National *Phylloxera* Experimental Station and its successor institution, the Royal Hungarian State Entomological Station. In 1896, he was among the first in the world to publish a study, entitled *Living Barometers*, of how the weather affects living organisms. His *Sleep in Insects*, also published that year, described his discovery, from 1895 observations of the red turnip leaf beetle (Coleoptera: Chrysomelidae), *Entomoscelis adonidis* (Pallas), what is today termed "diapause," a period of suspended development in an insect. It was about this time that deafness resulting from scarlet fever led to his early retirement. Sajó spent the rest of his life conducting scientific research at his family estates, and, at great loss to entomology, curtailed his publishing about 25 years before his death. His unpublished notes, with his library and correspondence, were destroyed

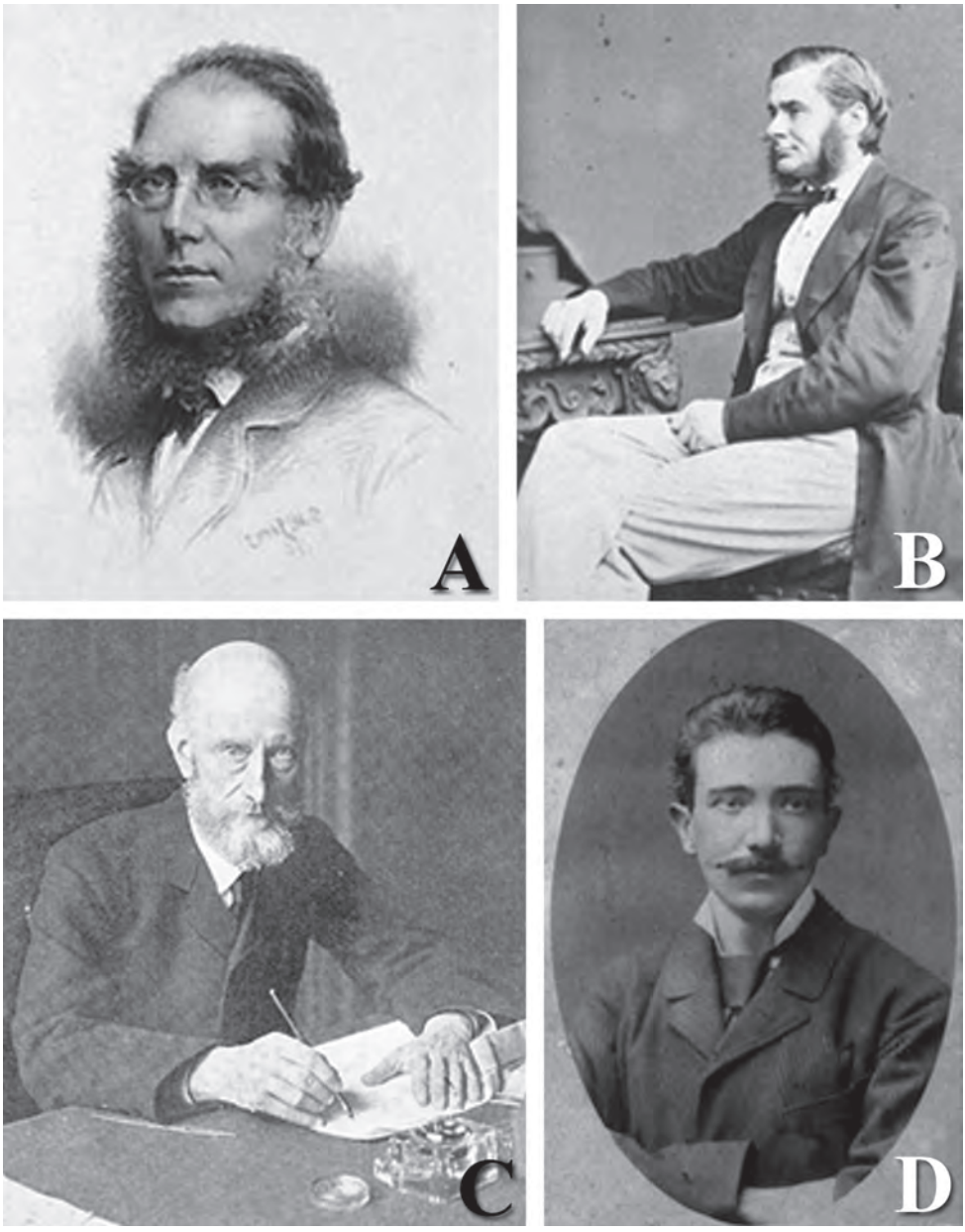

Figure 16. Some of the greatest naturalists with interests in entomology in the 19th and early 20th centuries were challenged with late-onset deafness, which made communication with others difficult and discouraged them from participating in scientific societies. (A) Joseph Dalton Hooker. (B) Thomas Henry Huxley. Images A and B from the National Institutes of Health. (C) Louis Compton Miall. Image from Wikipedia. (D) Károly Sajó. Image from Vig (2011), courtesy of *ZooKeys*.

in the World War II, and his surviving insect collection was donated to the Hungarian Natural History Museum in Budapest (Vig, 2011).

In the United States, the naturalist Herbert Huntington Smith (1851-1919, Fig. 17A) was undoubtedly one of the ablest entomological collectors during the last two decades of the nineteenth and the first decade of the twentieth Century. The Carnegie Museum of Pittsburgh, Pennsylvania has about 25,000 species of Brazilian Coleoptera assembled by him and many thousands of species of insects in other orders. He collected about 40,000 species of arthropods during the years of his journeys in Brazil up to May, 1886. Smith's death was tragic. On his walk to work at the Alabama Museum of Natural History in Tuscaloosa, the deaf naturalist was hit by a train (Holland, 1919).

In Canada, Henry Herbert Lyman (1854-1914, Fig. 17B), born in Montreal, began collecting and raising butterflies and moths before he was eight years old. He published his first paper at the age of 20 and became devoted to entomology. Lyman held one of the finest collections of Lepidoptera in Canada. He was a member of the Entomological Society of Ontario (serving as vice-president for several years), the Entomological Society of London, an honorary member of the New York Entomological Society and the Cambridge Entomological Club; and served as vice-president of the Natural History Society of Montreal.

During his later years, his colleagues had become distressed by his total deafness. Conversation with him was carried on with the aid of an ear-trumpet or through writing. He nevertheless continued to attend scientific meetings and other gatherings, although he could not hear a word of the papers and discussions.

Lyman and his wife, who had postponed their honeymoon, were among the passengers who lost their lives by the sinking of the ship "Empress of Ireland" in the St. Lawrence River in May, 1914. He bequeathed his collection of approximately 20,000 specimens to McGill University, which became the foundation of the university's Lyman Entomological Museum and Research Laboratory.

In his presidential address to the Entomological Society of Ontario, C. Gordon Hewitt said that Lyman "filled a unique place in our meetings, and in entomological meetings which he so zealously attended in other countries, and we shall miss his kindly presence and good-humoured impatience with those who, like myself, presented papers at the meetings without having prepared manuscript which his increasing deafness required as a substitute for the sound of the speaker's voice" (Hewitt, 1915, p. 28). At an earlier Jubilee meeting, members welcomed Lyman's charming wife with the hope that his constant attendance at their meetings would by her assistance be assured.

In Germany, Heinrich Ernst Karl Jordan (1861-1959, Fig. 17C) described 2,575 new species and wrote 460 scientific papers, as well as major monographs relating to world butterflies and hawk moths (Lepidoptera: Sphingidae). The onset of deafness accentuated the isolation he felt after the deaths of his wife and his good friend, Charles Rothschild, of flea (Siphonaptera) fame. Among Jordan's greatest achievements was helping to found the International Congress of Entomology, held in Brussels in

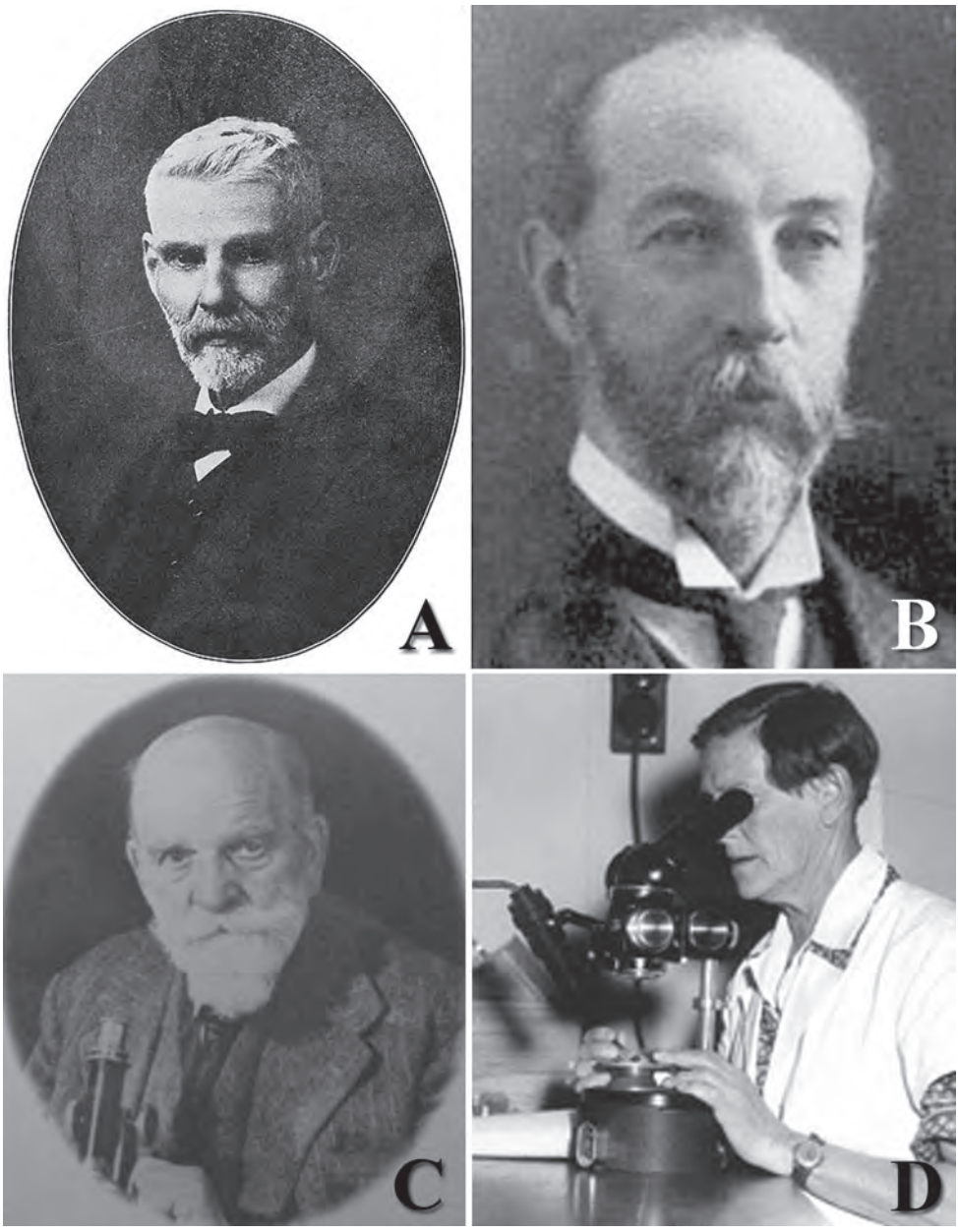

Figure 17. (A) Herbert Huntington Smith. Image from Wikipedia. (B) Henry Herbert Lyman. Image from http://www.empress2014.ca/seclangen/prttprsnlt.html, permission courtesy of A. Bourassa. (C) Heinrich Ernst Karl Jordan. Image from Wikipedia. (D) Gertrud Theiler distinguished herself as an acarologist with specialty in ticks (Acari: Ixodida) of vertebrates in Africa and as an equine nematologist. The South Africa National Tick Collection is named after her. Image from the Agricultural Research Council of South Africa, courtesy of A. Theron.

1910. He did not attend the congress solely because of his deafness. This gives us an idea of how much deafness influenced him.

Gertrud Theiler (1897-1986, Fig. 17D), a South African parasitologist, spent a number of years overseas doing postgraduate work in helminthology. She wrote highly regarded scientific papers relating to the nematode parasites of South African equines. On her return to South Africa in 1924 she obtained a lectureship at the Hugenot College, Wellington. In 1935 she was promoted to a professorship in Zoology and Physiology. During 1939 she lectured temporarily at Rhodes University College, but the following year accepted a research post in the entomology section at Onderstepoort. The resulting studies on ticks occupied her for more than two decades. Theiler's deafness and failing sight forced her to stop working.

Conclusion

This brief historical analysis traces the interactions of deaf and hard-of-hearing men and women with arthropods during the emergence of entomology as a scientific discipline. The hidden legacy of their contributed entomological knowledge is revealing, particularly in light of the many struggles they faced to communicate with others in the field. Some battled with personal frustrations, feelings of isolation, and conflicted emotions about living with a disability as they ventured very much on their own with their scientific endeavors. On one hand, deafness allowed for increased concentration and fewer distractions. On the other hand, living in silence may have brought about loneliness and challenges that called for increased fortitude.

Others lived in two worlds, one a scientific community of dedicated colleagues who sought to better understand the phylum Arthropoda; the other a community of Deaf people who use a visual sign language and share the "Deaf experience" as a cultural phenomenon. The onset of deafness later in life has left many great men and women living between those two worlds. In some cases, as we have shown, the discouragement led to career-ending decisions. Others persevered. In general, the passion for their work outweighed their personal challenges, perhaps best summarized in a letter Thomas Meehan wrote to George Engelmann in 1883, in which he said, "I begin to feel more strongly everyday that life is not worth living unless we can add some little to human knowledge with every day that goes over us." (Ginzberg Oberle, 1997, p. 1).

While deafness was a discouraging condition that led many men and women during these early years of the history of entomology to discontinue their research, in the modern era, new telecommunications technologies allow for greater participation in professional societies. Real-time captioning, professional note-taking, and, for those who know sign language, professional interpreting provide much greater access than scientists had experienced decades ago. Email, video telephony, and other forms of communication also allow for effective interactions between deaf and hearing

scientists. With such opportunities, the biological sciences, as well as other fields, stand to continue to benefit from the participation of a diverse pool of professionals.

Deafness is sometimes referred to as an "invisible" condition because overt manifestations of deafness are not always readily apparent. For this reason, as well as the lesser emphasis placed on phenomenological research, which is the basis of the present paper, deaf people have seemingly played a minor role in traditional historical narratives, including those in the development of entomology as a science. Yet, from the perspective of this historical analysis, the legacy of entomological knowledge developed on its own, and the issues of deafness became integral to the human experience that was part of the emergence of this science. These men and women knew that, their deafness aside, they were contributing meaningfully to the field. As one of James Platt-Barrett's colleagues summarized his deaf friend's work upon his death: He was "one of us." (Turner, 1917, p. 24).

This "hidden legacy" in entomology continues today through the work of contemporaries. Younger generations are now afforded increased opportunities for quality education to earn degrees and build careers. Hopefully, the next decades will see more women and minorities in entomology, including those with disabilities. The future of this science has much more achievement in store than the past has given.

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Figure 9
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