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From Aristotle to *Wunderkammer*: The Development of Entomology and Insect Collections

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Though much of the emphasis in entomology today is based in economic and applied research in the study of insects, the field first concerned itself in antiquity with research in order to satisfy curiosity and better understand the world. In this work, collections and fieldwork were of paramount importance. The ancient world saw the beginnings of insect classification, as well as efforts in applied natural knowledge. Much of this knowledge was lost by the Medieval period, when entomology was studied in a limited capacity by a few members of the clergy. The early modern period brought the rise of insect collecting associated with status; encyclopedias were the main form of publication for entomological information. With the Victorian era came the professionalization of the biological sciences, including entomology and the delineation of the concept of evolution. Evolution would come to influence changes in classification in the twentieth century, which in turn were reflected in the changing role of museums in society. Though humans have been observing the insect world since the times of antiquity, entomology was limited in its scope and potential until the beginnings of taxonomic description and by developments made in this area of study in the sixteenth century and beyond. The classification systems designed to organize the world of insects, specimens of which work well as collectible items from the natural world, would come to influence the development of taxonomic systems for all of life and of the organization of the natural history museum as a place of public learning.¹

Much of the work on the history of entomology until now has concentrated on a single time period, putting it in the context only of the development of the biological sciences. Individual or small groups of systematists throughout the ages have been addressed in previous publications. Much of the work done by other historians has thus focused on niches of the larger picture of the development of entomology and of biology as a more general field. In this paper, the

¹ Herbert Osborn. *A Brief History of Entomology, Including Time of Demosthenes and Aristotle to Modern Times* (Columbus: Spahr and Glen, 1952), 17.

development of entomology is investigated as a specific branch of biology over a longer timeline than typically used. This has been done in an effort to show how changes over time affected both those working contemporaneously and those who came after. It will also show how the development of insect collections and displays shaped the development of the modern natural history museum, though the greater interest in museology has been on mammals and other 'big' creatures.

Entomology saw its start in antiquity with a utilitarian emphasis in understanding insects. There was not a true interest in the concept of 'insect' for its own sake until the time of the ancient Greeks.² Though Plato was the first to define terms related to the classification of insects, Aristotle was the first to attempt a systematization of insects. This classification scheme was based on anatomical differences and similarities between the insects he encountered. Aristotle's work was based on characteristics of insects, starting with the wings and mouthparts, and resulted in a rudimentary dichotomous key.³ With the rise of the Roman Empire came a decline in this interest. The focus of this early entomology was instead the study of pests and pollinators in the context of agricultural progress and other utilitarian purposes. In 77 A.D., however, Pliny published his encyclopedia, *Historia Naturalis*, the eleventh volume of which addresses insect life. Pliny's encyclopedia used a classification scheme very similar to that of Aristotle, though it is unlikely that Pliny knew of the earlier Greek philosopher, and influenced

² Günter Morge. "Entomology in the Western World in Antiquity and Medieval Times." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith (Palo Alto: Annual Reviews, Inc, 1973), 38.

³ Morge, "Entomology in the Western World", 40.

many works that came after it.⁴ For example, discussions of insects from *Historia Naturalis* were included in Conrad Gesner's *Historia Animalum*, published between 1551 and 1587.⁵

By the Medieval period, much of the knowledge of insects gathered in antiquity had been lost to Western Europe.⁶ In spite of this, some works on natural history created in this time contained information about insects. Most of these writings were limited in their scope to lists of names and sparse information on the insects named.⁷ Isidorus, Bishop of Sevilla, addressed insects in the twelfth book of *Origines sive Etymologiae*, in chapters entitled 'de vermibus' ('Vermin'⁸) and 'de minutis volatilibus' ('Tiny Flying Animals'⁹). Though they addressed only a very small number of insects, this work was the entirety of biological understanding of insects until the end of the period.¹⁰ This work represents a return to the investigation of insects purely for the sake of knowledge about the natural world, instead of for economic purposes. Though a number of books on natural history were printed in the eighth and ninth centuries, they were largely collections of the information of insects already available in other works¹¹; the reproduction of entomological material assisted with the continued existence of this knowledge.

Early modern Europeans revived the study of insects as a stand-alone field of interest, instead of focusing on the potential applied uses of entomological knowledge. People of diverse

⁴ Morge, "Entomology in the Western World", 49.

⁵ Harry B. Weiss. "Four Encyclopedic Entomologists of the Renaissance." *Journal of the New York Entomological Society* 35, no. 2 (1927): 196.

⁶ Morge, "Entomology in the Western World", 58.

⁷ Morge, "Entomology in the Western World", 63.

⁸ Stephen A. Barney, W. J. Lewis, and J. A. Beach. *The Etymologies of Isidore of Seville*. Cambridge, GB: Cambridge University Press (2006), 258.

⁹ Barney, Lewis, and Beach; *The Etymologies of Isidore of Seville*, 269.

¹⁰ Morge, "Entomology in the Western World", 59.

¹¹ Morge, "Entomology in the Western World", 63.

interests placed importance on the exotic locations where insect specimens were found.¹² This idea of exoticism and subjugating the natural world, even in far-away places, also manifested itself as an emphasis on natural singularities and the oddities of the natural world.¹³ These curiosities, including insects, were placed in collections of objects that were reserved for private viewing and demonstrated the collector's power and social status. Only the collector and a select few would be allowed to see the items the collection contained. Collections took much in the way of wealth to generate; specimens, free time, and available space were necessary for this hobby. Only the few could partake.¹⁴ In fifteenth century Italy, these collections included images of insects in a number of different art forms.¹⁵ In the next century, the rise in popularity of the *Wunderkammer*, or cabinet of curiosities, meant that collectors designed new organizational schemes, though these were largely unique to the collection.¹⁶ Insects worked well in cabinets of curiosity due to their small size and visual interest; they were largely preserved in boxes and followed the standard of spreading the wings of butterflies and moths. Unfortunately, there are no known collections from this period in natural history collecting that have survived.¹⁷ It is known, however, from inventory lists and images that biological specimens, including insects, commonly made up a significant portion of these menageries. Such collections were very costly to build up and maintain; only the wealthy could acquire and

¹² Janice Neri. *The Insect and the Image: Visualizing Nature in Early Modern Europe, 1500-1700* (Minneapolis: University of Minnesota Press, 2011), 3.

¹³ Deborah E. Harkness. *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2008), 53.

¹⁴ Harkness, *The Jewel House*, 22.

¹⁵ Neri, *The Insect and the Image*, xiii-xiv

¹⁶ Christine Davenne and Christine Fleurent. *Cabinets of Wonder*. New York: Harry N. Abrams, 2001.

¹⁷ Neri, *The Insect and the Image*, 76.

interact with specimens and the space needed to house them.¹⁸ The process of building a collection was largely a social endeavor; naturalists communicated among themselves in order to gather specimens from different places.¹⁹ Early modern collectors can be seen as amassing a kind of encyclopedia, consisting of large numbers of specimens, images, and objects.²⁰

During the early modern era, a number of actual encyclopedias were published. Among the most well known authors of an encyclopedia was Conrad Gesner, who published *Historia Animalum* between 1551 and 1587. The information Gesner included in this work was from other famous naturalists, such as Aristotle and Pliny, mixed with his own observations of the insects he collected. The volume of this work that addressed insects was published posthumously.²¹ As Gesner is known to have communicated with many other naturalists of his time and because this work was published in Latin²², *Historia Animalum* was likely not intended for the general population. The knowledge surrounding insects was related to continuing conversation on things such as morphological features and value, and collections of natural objects in special cabinets came to represent not only wealth but intellectual status as well.²³

Linked with the idea of intellectual status was the ability of others to replicate and verify or falsify evidence, which is necessary for a study to be truly scientific. It was found, in the case of naturalists, that an image was a better source of information about an organism than descriptive words or summaries. However, actual specimens were the best possible source from which to gain knowledge of an insect's morphological features. Items such as drawings and preserved specimens were considered immutable and the best way to keep information for future

¹⁸ Harkness, *The Jewel House*, 22.

¹⁹ Harkness, *The Jewel House*, 22.

²⁰ Neri, *The Insect and the Image*, 89.

²¹ Weiss. "Four Encyclopedic Entomologists of the Renaissance", 196.

²² Weiss. "Four Encyclopedic Entomologists of the Renaissance", 196.

²³ Harkness, *The Jewel House*, 31.

study by interested parties.²⁴ With the intention of verifying the reports of others, the Scottish physician and naturalist Thomas Moffett investigated the claim that only male wasps had stingers by observing the creatures first-hand. After killing an entire nest of wasps, Moffett looked at all of the wasps present and found that each had a stinger; the trait was not limited to male wasps.²⁵ Like many of the naturalists studying insects at this time, Moffett's observations of the insect world were published. Though it was published posthumously, "Insectorum sive Minimorum Animalium Theatrum...ad vivum expressis Iconibus super quingentis illustratum", which was published in English as "The Theater of Insect, or lesser living Creatures", was a natural history of the insects with contributions from the efforts of other men, including Gesner.²⁶

With the invention of the microscope in 1599 came fundamental changes in the way biology, including entomology, was approached.²⁷ Arguably the most famous of works assembled by early microscopists, Robert Hooke's *Micrographia* included numerous written observations and illustrations of insects as they appeared under the microscope. Hooke, in following with the contemporary trends of natural history illustrations and collections, concerned himself with the oddities of the natural world and focused his attentions on a single object for each of his illustrations.²⁸ Unfortunately, Hooke's specimens were easily broken and largely had

²⁴ Harkness, *The Jewel House*, 37.

²⁵ Harkness, *The Jewel House*, 38.

²⁶ Harry B. Weiss. "Thomas Moffett, Elizabethan Physician and Entomologist." *The Scientific Monthly* 24, no. 6 (1927): 563-564.

²⁷ Max Beier. "The Early Naturalists and Anatomists During the Renaissance and Seventeenth Century." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith (Palo Alto: Annual Reviews, Inc, 1973), 89.

²⁸ Janice Neri. "Between Observation and Image: Representations of Insects in Robert Hooke's 'Micrographia'" *Studies in the History of Art* 69 (2008): 90.

to be killed before their anatomies could be illustrated.²⁹ The killing of insect specimens, however, made them harder for Hooke to pose as he wished.³⁰ The images included in *Micrographia* worked as a way for Hooke to organize his thoughts and the things he saw under the scope for publication.³¹ In this way, Robert Hooke made the microscope a useful scientific tool for the gathering of data and observations about the natural world.³² In publishing his *Micrographia*, Hooke set himself up as a distant observer of nature, whose knowledge about the natural world was unbiased truth.³³ Hooke thus made himself appear to be an ideal member of the Royal Society, which placed high value on the opinion and observation of gentlemen-scholars.³⁴

Hooke was not the only person working in the field of entomology in the seventeenth century. Ulysses Aldrovandi, who was in contact with Gesner, was an entomologist, physician, and botanist working from Bologna. His work, “De Animalibus Insectis”, was published in 1638 and contained entries on insects that ranged in length from very short blurbs to incredibly long descriptions—up to seventeen pages. These articles contained a wide variety of information, including a range of name information, information from ancient naturalists, histories, and medicinal value, among other things.³⁵ Aldrovandi’s “De Animalibus Insectis” was an early piece of scientific literature addressing insects specifically, thus establishing entomology—

²⁹ Neri, “Between Observation and Image”, 92.

³⁰ Neri, “Between Observation and Image”, 90.

³¹ Neri, “Between Observation and Image”, 91.

³² Neri, “Between Observation and Image”, 102.

³³ Neri, “Between Observation and Image”, 83.

³⁴ Neri, “Between Observation and Image”, 85.

³⁵ Weiss, “Four Encyclopedic Entomologists”, 196-198.

especially insect systematics—as a specific field of study. This work even included an early dichotomous key for the identification of the upper levels of the classification hierarchy.³⁶

The organized field of insect systematics was not founded until the second half of the sixteenth century, as such things were not a focus of earlier scientific thinkers and collectors, and systems other than that of the ancients were few.^{37 38} Jan Swammerdam, a Dutch anatomist, was among those working on new systems of classification for the insects and classified the organisms based on the nature of their life cycle. Though the terms for forms of insect metamorphosis came after Swammerdam's time, his differentiation of insects as holometabolic, hemimetabolic, or ametabolic is still used in the modern classification of insects.³⁹ Elaborations made on this system consist of additional information on the morphological and biological characteristics of the insects studied, but remain based on Swammerdam's scheme based in metamorphosis.

The eighteenth and nineteenth centuries saw the continued rise of morphological focus in entomology. Among the authors publishing at this time was René Antoine Ferchault de Réaumur whose work, *Mémoires pour servir à l'histoire des insectes*, was based in the description of the anatomies of insects and their life histories for the sake of knowledge, not application.⁴⁰ Like many entomologists of the time, Réaumur saw the ideal for the study of natural history to be compiling all possible knowledge about the lives and “industries” of as

³⁶ Beier, “The Early Naturalists and Anatomists”, 85.

³⁷ John F. Clark. *Bugs and the Victorians*. (New Haven: Yale University Press, 2009), 3.

³⁸ Neri, *The Insect and the Image*, xxi.

³⁹ Beier, “The Early Naturalists and Anatomists”, 90.

⁴⁰ S. L. Tuxen. "Entomology Systematizes and Describes: 1700-1815." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith (Palo Alto: Annual Reviews, Inc, 1973), 98.

many insects as possible.⁴¹ Réaumur stated that “[a] class and a genus of animals of which the characters have been well fixed, are for us what general formulas are for geometers.”⁴² In doing so, he linked a biological to the study of mathematical concepts and solidified the study of insects as a legitimate scientific pursuit. In his study of systematics, Réaumur considered individual species to be representatives of a higher level of classification.⁴³ He even made note that the characteristics most obvious to the human eye are not necessarily the most important ones, stating that “[t]he signs which are most convenient to us to distinguish insects from one another, those which are most within our reach, and which rarely deceive us, sometimes can deceive us: they are not always taken from that which constitutes the essential character.”⁴⁴ In this way, a taxonomic system is not complete until the characteristics that constitute a unique insect species are known.

Others also focused on exacting observation and description of insect specimens. Those who worked with such organisms were concerned with the intense observation of minute details related to the anatomy of their study insects. The Swedish entomologist Charles De Geer worked on illustrations of anatomical structures in insects that had never been described before and made observations thereof. Pieter Lyonnet, a Dutch naturalist, also made exact illustrations and conducted anatomical investigations of insects, but he focused on all of the life stages of a single species.⁴⁵ Another influential entomologist of the time, Jules-César Savigny of France,

⁴¹ Tuxen, “Entomology Systematizes and Describes”, 98.

⁴² Mary P. Winsor. "The Development of Linnaean Insect Classification." *Taxon* 25, no. 1 (1976): 58.

⁴³ Winsor, “The Development of Linnaean Insect Classification”, 58.

⁴⁴ Winsor, “The Development of Linnaean Insect Classification”, 59.

⁴⁵ Tuxen, “Entomology Systematizes and Describes”, 99-103.

designed a way to describe and compare mouthparts based on their shape and insects' feeding habits based on serial morphologies that is still worked with today.^{46 47}

The world of collectors experienced a shift to organizing collections by the subject of study.⁴⁸ In many cases, these private collections of amateurs and naturalists were donated to or purchased by museums, such as the British Museum, in order to expand their collections and add type specimens to the museum holdings.⁴⁹ For example, the British Museum is thought to have purchased a collection of insects from Carolus Linnaeus himself.⁵⁰ Though collections were changing, systematization continued to be the most important work of entomologists and others in the eighteenth century.⁵¹

For much of the history of the study of insects, the organisms were named according to the whims of individual collectors and naturalists; there was no universal system for the naming of insects until the time of Linnaeus in the eighteenth century. With the introduction of Linnaeus' system of binomial nomenclature came descriptions of insects with systematized names of genus and species.⁵² Carolus Linnaeus focused on the wing and leg anatomies of terrestrial and aquatic insects. Because it was based on only a couple of characteristics, this system of classification was an artificial system. This resulted in the incorrect arrangement of a number of insect species. Unfortunately, this step was a necessary one. Linnaeus accomplished this with the original publication of his *Systema Naturae* in 1735.⁵³ The universal system of binomial

⁴⁶ Herbert H. Richards. "Anatomy and Morphology." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith (Palo Alto: Annual Reviews, Inc, 1973) 187.

⁴⁷ Tuxen, "Entomology Systematizes and Describes", 103.

⁴⁸ Davenne and Fleurent, *Cabinets of Wonder*.

⁴⁹ Osborn, *A Brief History*, 35.

⁵⁰ Osborn, *A Brief History*, 10.

⁵¹ Tuxen, "Entomology Systematizes and Describes", 105.

⁵² Osborn, *A Brief History*, 47.

⁵³ Tuxen, "Entomology Systematizes and Describes", 107-108.

nomenclature for the naming of insects and other living things was modeled on human census records, though this is not how nature works.⁵⁴ In addition to the naming of individual species, Linnaeus also worked with higher-level classification based on wing morphologies. By naming four groups—the Coleoptera, “Angioptera,” Hemiptera, and “Aptera”—instead of simply describing them, Linnaeus set the stage for the overall classification of insects in use today.⁵⁵ Linnaeus’ later versions of this classification system listed seven orders—Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera, and “Aptera.” Six of these seven orders are still used today in the systematics of insects. This system also included descriptions of the characteristics of each given order.⁵⁶

Johan Christian Fabricius of Denmark, another influential entomologist of the late 18th and early 19th centuries, differentiated between more insect groups and renamed those originally described by Linnaeus.⁵⁷ His *Philosophia Entomologica* was published in 1778. It was the first true textbook on entomology to be published, though university instruction in the field did not begin until the nineteenth century. In this work, Fabricius based his classification on the morphology of insect mouthparts. Though this expands on the artificial classification of Linnaeus by examining many characters, it is still not a natural system of classification as is thought of today.⁵⁸ Both Fabricius and Linnaeus followed the Aristotelian method of simplifying living things to a single character that is seen as sufficient to identify and describe. Fabricius suggested the existence of eight orders of insects based on the mouthparts, or

⁵⁴ Clark, *Bugs and the Victorians*, 45.

⁵⁵ Winsor, “The Development of Linnaean Insect Classification”, 62.

⁵⁶ Winsor, “The Development of Linnaean Insect Classification”, 63.

⁵⁷ Tuxen, “Entomology Systematizes and Describes”, 111.

⁵⁸ Tuxen, “Entomology Systematizes and Describes”, 109-110.

'Instrumenta cibaria'.⁵⁹ He did realize that his system of classification was an artificial system of classification, writing that in *Philosophia Entomologica* “we have chosen an artificial system of insects based solely on the mouthparts” and went so far as to differentiate between such artificial systems and proper natural classification systems.⁶⁰

Though these entomologists of earlier centuries interacted with each other's work, they were largely working and publishing as individuals. With the nineteenth century came the development of professional societies dedicated to the natural history of insects in Europe.⁶¹ The Société Entomologique de France was founded in 1832 and supported publications of papers written by entomologists. The Royal Entomological Society of London was started in 1833, along with multiple associated publications. Similar societies were also started in other countries. The journal *Entomologist* was published in London as well. In addition to professional society-supported journals, some publications were printed without the support of such a society. Some professional societies, such as the American Association of Economic Entomologists, and publications focused on how entomological knowledge could be applied to agricultural situations.⁶² Though the amateur naturalist conducted much of the work done in entomology, from collection to description, the professional societies gradually came to reject the idea of natural history and the label “naturalist”.⁶³

Along with the professionalization of entomology and foundation of entomological societies in the nineteenth century came the beginnings of university instruction on the subject of insects. It is assumed that professors of entomology would lecture on their fieldwork, though this may

⁵⁹ Clark, *Bugs and the Victorians*, 28.

⁶⁰ Tuxen, “Entomology Systematizes and Describes”, 98. (Trans.)

⁶¹ Tuxen, “Entomology Systematizes and Describes”, 95.

⁶² Osborn, *A Brief History*, 24-29.

⁶³ Clark, *Bugs and the Victorians*, 105.

have been little more than a hobby. Classes and lectures in entomology occurred on an irregular basis in a number of zoological and agricultural schools. Unfortunately, the teaching of the biological sciences, especially natural history, was seen by university authorities as firmly below the teaching of mathematics and classical literature in the hierarchy of the university setting.⁶⁴ The nineteenth century also saw the advent of early efforts toward specialization in specific groups of insects, such as the Lepidoptera, which includes butterflies and moths. As butterflies are lovely to look at in a preserved collection, many entomologists started with this group and gradually branched out to others. The first works in the vein of specialization were illustrations and art.⁶⁵

Though some specialized in specific groups, much of the work done in the nineteenth century was mostly focused on taxonomy in the large sense. This entomological work was pursued was in natural history in order to better understand the variety and number of creatures inherent to the natural world.⁶⁶ The development and systematization of entomology in this century was part of a larger trend toward the systematization of groups of living things found in nature.⁶⁷ The system of classification for insects that developed in the early nineteenth century emphasized the links between the insect, its mind, and its physiology. In this way, systematists worked for a more natural system of classification, which grew with the importance of the classification of insects.⁶⁸ One of the major developers of this system was the Frenchman P. A. Latrielle, who wrote that “[n]atural classes and genera are based not on only the mouth-parts, the wings or the antennae, but on careful observation of the entire structure, even of the smallest

⁶⁴ Osborn, *A Brief History*, 31-32.

⁶⁵ Osborn, *A Brief History*, 56.

⁶⁶ Clark, *Bugs and the Victorians*, 9.

⁶⁷ Clark, *Bugs and the Victorians*, 12.

⁶⁸ Clark, *Bugs and the Victorians*, 35.

differences.”⁶⁹ In Latrielle’s system, he became the first to limit the term “Insecta” to just hexapod arthropods. He also added more steps in the classification hierarchy between the order and the genus.⁷⁰ In spite of these developments, it was not possible to order the insects according to a universal, natural system until taxonomists had adopted the concept of evolution by natural selection.⁷¹ With the acceptance of evolution as contributing to the natural history and identity of an insect came the idea that the classification of these creatures ought to follow the evolution of species as one moves from the more general levels of the hierarchy to the more specific.⁷²

The development of the theory of evolution by natural selection in 1858 was influenced by the study of insects; both Charles Darwin and Alfred Russel Wallace took examples from world of insects to elucidate the mechanism of evolution.⁷³ Many of the invertebrate specimens that Darwin collected during his voyage on the *Beagle* were insects, and these specimens helped give Darwin a sense of and information about the ideas of sexual polymorphism, geographical distribution, and mimicry. From his insect collections, Darwin gained empirical evidence from insects that would assist him in the development of his theory of evolution, though an account only of his insect collecting was never published.⁷⁴ The rejection of evolution based on a belief in the immutability and permanence of species would hold back the study of biological systems;

⁶⁹ Carl H. Lindroth. "Systematics Specializes Between Fabricius and Darwin: 1800-1859." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith. (Palo Alto: Annual Reviews, Inc, 1973), 122. (Trans.)

⁷⁰ Lindroth, "Systematics Specializes", 122.

⁷¹ Lindroth, "Systematics Specializes", 123.

⁷² Osborn, *A Brief History*, 48.

⁷³ Herbert H. Ross. "Evolution and Phylogeny." In *History of Entomology*, edited by Ray F. Smith, Thomas E. Mittler, and Carroll N. Smith (Palo Alto: Annual Reviews, Inc, 1973) 172.

⁷⁴ Clark, *Bugs and the Victorians*, 108-110.

Darwin once commented that the “entomologists are enough to keep the subject back for half a century.”⁷⁵

One of the aspects of Darwin’s theory that is reflected strongly in insects is the concept of mimicry. Mimicry in insects is tied to both the development of new species and the geographic distribution of these species.⁷⁶ An example of mimicry in the insect world is the resemblance between species of butterflies belonging to the family Pieridae—consisting of the whites, yellows, and sulfurs—and butterflies of the genus *Heliconius*—the heliconian or longwing brush-footed butterflies—in tropical climates. Due to the actions of insectivores and the foul taste of some heliconids, certain colorations in tropical Pierids have evolved to resemble their distasteful neighbors. A brewer’s clerk with an interest in natural history, Henry Walter Bates, studied mimicry in tropical species of butterfly in the Amazon Valley, saying that “on these expanded membranes Nature writes, as on a tablet, the story of the modification of species, so truly do all changes in the organization register themselves thereon.”⁷⁷ By using butterfly species to establish his thoughts regarding mimicry in insect groups, Bates turned the group most sought after by insect collectors into a perfect example of mimicry and natural selection.⁷⁸ However, aspects of taxonomic research that were greatly affected by the theory of evolution did not apply to those who were more interested in simply collecting insect specimens and naming them.⁷⁹ Darwin’s theory was not widely influential amongst such entomologists. In spite of this,

⁷⁵ Clark, *Bugs and the Victorians*, 111.

⁷⁶ Clark, *Bugs and the Victorians*, 116.

⁷⁷ Clark, *Bugs and the Victorians*, 115-117.

⁷⁸ Clark, *Bugs and the Victorians*, 118.

⁷⁹ Clark, *Bugs and the Victorians*, 127-128.

insects were part of the redefining of biological research as a true scientific endeavor thanks to the agency of those who accepted Darwin's theory.⁸⁰

Until the 1870s, the sciences—including entomology—continued to be considered inferior to Classics in the hierarchy of formal education.⁸¹ Textbooks in what is now called biology, however, were being published well before this time. Among the most influential textbooks in the study of the biological world was the *Introduction to Entomology*, originally published in 1815 by William Kirby and William Spence. The work helped pave the way for entomology to move from the focus of the early nineteenth century—natural history—to a more serious and professional study of the biological world. The textbook contained not only information on the classifications of insects, but also their physiological traits.⁸² The shift from entomology as the realm of the amateur naturalist to the rigorous study of insects expected for a professional science left some in a grey area between the two forms of biological study. One entomologist who was stuck between amateur and professional was John Lubbock, who studied members of the Hymenoptera in England. For many, his publication of a popular science work on the behavior of ants, wasps, and bees was an example of experimental science that was not conducted in a way that agreed with the direction of professionalization the field was taking.⁸³ Lubbock was the first to track the individuals in a colony of social insects, however, and his artificial ant colonies work as an example of the transition from the semi-domesticated display to a true experimental set-up of domesticated study organisms.⁸⁴ On the subject of collections, Lubbock warned of complacency and underuse. Specimens had to be rigorously examined and

⁸⁰ Clark, *Bugs and the Victorians*, 130.

⁸¹ Clark, *Bugs and the Victorians*, 131.

⁸² Clark, *Bugs and the Victorians*, 15.

⁸³ Clark, *Bugs and the Victorians*, 86.

⁸⁴ Clark, *Bugs and the Victorians*, 93.

described in order to be of value to the collector; Lubbock warned that “collecting for the sake of collecting” would come to “narrow the mind” of the entomologist.⁸⁵ In this way, Lubbock symbolized the awkward middle-ground between professional and popular scientific study. He also demonstrated the ideal of a pure science, one not driven by economic gains. His dedication to the objectivity necessary for science shows the efforts that had and would be made by naturalists’ work toward the end of the nineteenth century.⁸⁶

From the late eighteenth century on, entomologists became more and more focused on the specifics of groups and locales within the study of insects. No longer was the focus on the overarching concept of the ‘insect’; instead, entomologists came to focus on specific orders and families. Many of the entomologists who specialized in the nineteenth century focused on the order Coleoptera, the beetles, possibly due to the relative ease with which these insects are preserved. One Frenchman, P. F. M. A. Dejean, focused on beetles after collecting insects of all kinds for a number of years. In *Spécies Général des Coléoptères*, Dejean worked to describe all of the beetles in his extensive collection, giving the name most commonly used to describe each insect instead of the first name given. He stated that he had “made it a rule to always preserve the name most generally used, and not the oldest one; because it seems to me that general usage should always be followed and that it is harmful to change what has already been established.”⁸⁷ In doing so, Dejean ignored the priority principle of biological taxonomy, which defines the name of a species as the one given first, not the most common.

Beetles were not the only specialized focus of nineteenth century entomologists. Some, such as J. W. Meigen of Germany, studied the Diptera, the flies. Meigen’s work in dipterology

⁸⁵ Clark, *Bugs and the Victorians*, 95.

⁸⁶ Clark, *Bugs and the Victorians*, 102.

⁸⁷ Lindroth, “Systematics Specializes”, 125-127.

is known for being a more natural system than many who came before him, as he based his classifications of flies on more than one group of characteristics.⁸⁸ Others expanded on the earlier specialization of lepidopterists in their study of butterflies and moths and specialized in increasingly specific groups within the lepidopterans. H. T. Strainton, an English entomologist, worked with the micro Lepidoptera. His work in classification was described as the gold standard to aim for; one man said of his work: “[h]e goes so far as to recommend that no species should be described upon less than twenty to thirty specimens,” which is quite the leap in the number of individuals used to describe a species.⁸⁹ Yet others went on and studied the Hymenoptera—which contains the ants, bees, wasps, and sawflies. This order is quite large and a challenge to define taxonomically.⁹⁰ As such, many entomologists who studied the Hymenoptera specialized further, choosing to focus on one of three suborders within the order. J. C. F. Klug, a director of the Berlin Museum, worked more broadly in the field of entomology but studied the hymenopterans most specifically. In his obituary, it was written that “Klug provides the best proof of the truth, only too little admitted by many contemporary scientists, that the activities within a *special* branch only then may be of real importance if supported by broad *general* knowledge.”⁹¹ As a museum director, Klug was in a position for which a broad knowledge of insects was most likely useful, regardless of what he chose to study in a more detailed manner. Another way entomologists specialized is in studying the insect life of a specific geographic region.⁹² In this way, entomology remained a sort of citizen science based in

⁸⁸ Lindroth, “Systematics Specializes”, 131.

⁸⁹ Lindroth, “Systematics Specializes”, 136.

⁹⁰ Lindroth, “Systematics Specializes”, 137.

⁹¹ Lindroth, “Systematics Specializes”, 137.

⁹² Lindroth, “Systematics Specializes”, 144.

local entomological study. The fundamentals of ecology and zoogeography could be found in the efforts of local groups of insect enthusiasts.

Classification of insect species and how a species was to be defined did not change drastically from the time of Latreille in the early nineteenth century until the rise of cladism in taxonomy during the late twentieth century. Relationships between species and the definition of species continued to be based around the most natural system of classification developed.⁹³ Institutions, such as professional museums, worked to accommodate the needs of an increasingly ‘professional’ population of scientists. The collections of natural history museums were designed to allow for relative ease of comparison of large numbers of insect specimens for the benefit of taxonomy.⁹⁴ These collections were, however, not up-to-date in their use of a system of classification; many were arranged according to the artificial Linnaean classification system through the late 1890s. Though this system worked well for naturalists, a focus on relatively few traits limited the accuracy possible for the arrangement of specimens.⁹⁵

With the beginning of the twentieth century came a more complete shift from the amateur naturalist to the professional entomologist. This shift is reflected most succinctly in the types of research undertaken by the two forms of entomologist: while naturalists focused on description and field work, professional scientists were expected more and more to engage in laboratory-based research.⁹⁶ In the mid-1900s came a movement for cladistics in taxonomic development. The German insect taxonomist Willi Hennig’s effort to rework the traditional taxonomy of

⁹³ Lindroth, “Systematics Specializes”, 148.

⁹⁴ Karen A. Rader, and Victoria E. M. Cain. *Life on Display: Revolutionizing U.S. Museums of Science and Natural History in the Twentieth Century*. (Chicago: University of Chicago Press, 2014), 14.

⁹⁵ Rader and Cain, *Life on Display*, 35.

⁹⁶ Clark, *Bugs and the Victorians*, 238.

previous centuries was based in common ancestry.⁹⁷ Both cladistics and the phylogenetic system developed in the twentieth century contributed to the growth in importance of evolutionary relationships in the determination of placement for insects in the taxonomic system.

Museums of the early twentieth century were institutions containing specimen collections that reflected their larger aims and a focus on making research possible for experts in various fields of biological study.⁹⁸ Natural history museums contained displays of the biological world consisting largely of preserved dead specimens, though some also dedicated space to living examples.⁹⁹ These institutions looked to present the most complete picture they could of biological diversity and systematics.¹⁰⁰ Many museums expanded their collections by purchasing from collectors and through the donation of collections generated by amateur entomologists; because of this, the work of the amateur naturalists remained relevant to the study of insect life. In addition, written works by those belonging to the ranks of the amateur remained extremely popular in the public sphere.¹⁰¹ Zoologist Thomas Montgomery once wrote that “[t]he specialist’s research is largely dependent, at least in America, upon the gifts of amateurs.”¹⁰² The challenge that faced scientific institutions was in their the need to have specific information—such as date and location where the specimen was caught—on-hand for each specimen in order for them to be scientifically relevant.¹⁰³ Much of the collections of these museums were divided into groups based on similarities in physical features and functions.¹⁰⁴ In

⁹⁷ C. Dupuis. "Willi Hennig's Impact on Taxonomic Thought." *Annual Review of Ecology and Systematics* 15 (1984): 3.

⁹⁸ Rader and Cain, *Life on Display*, 2.

⁹⁹ Rader and Cain, *Life on Display*, 4.

¹⁰⁰ Rader and Cain, *Life on Display*, 10.

¹⁰¹ Rader and Cain, *Life on Display*, 23.

¹⁰² Rader and Cain, *Life on Display*, 31.

¹⁰³ Rader and Cain, *Life on Display*, 33.

¹⁰⁴ Rader and Cain, *Life on Display*, 10.

addition, many museums were arranged as two separate collections—many of the best specimens a museum had in its ranks were kept in back collections for the use of professional taxonomists, while only certain specimens were available for the benefit of the general public.¹⁰⁵

The organization of these collections was conducted according to biological classification. However, this standard was mixed to varying degrees with categories that were more familiar to the average museum-goer, such as the status of being an industrial resource or relevance to contemporary news stories.¹⁰⁶ Some museums focused only on local species. An argument for the value of education of the public via natural history museum had existed since the late 19th century; in 1892, one man wrote that “[a museum] should be accessible to the student...In the display the fundamental idea should be the instruction and profit of the visitor.”

¹⁰⁷ The institutions themselves, however, did not necessarily share this sentiment. It was not until the 1910s that museums underwent a change in their main effort. Dr. Frederic A. Lucas, who worked for a wide variety of institutions, explained that “the exhibition of specimens, instead of being, so to speak, a side branch of museum work, has become one of the most important functions of a museum”.¹⁰⁸ Museums also worked to encourage amateur entomologists in their quest to collect insect specimens, in spite of the growing divide between the naturalists and the professional scientist. Many amateurs working in and for museums were treated as assistants and not encouraged in their studies; however, Montgomery wrote that

¹⁰⁵ Rader and Cain, *Life on Display*, 13.

¹⁰⁶ Rader and Cain, *Life on Display*, 36.

¹⁰⁷ Frederick Starr. “The Proper Work of a Great Museum: Of the American Museum of Natural History.” *Christian Union* 45, no.10 (1892): 499.

¹⁰⁸ Rader and Cain, *Life on Display*, 47.

“[y]oung naturalists starting out should be helped with fellowships and advice, mutually encouraged, not treated as preparators”.¹⁰⁹

With the further development of museums came a shift in focus from simple collections to providing ecological information about organisms in the form of dioramas.¹¹⁰ This was a more accurate portrayal of the natural world, as evidenced by entomologist William Morton Wheeler’s comment that “an organism cannot be isolated, even conceptually, from the peculiar environment to which it has become adapted during eons of geologic time, without a serious misunderstanding of its true nature.”¹¹¹ Interestingly enough, those involved in the development of museum dioramas were making use of the sorts of knowledge that had been the focus of amateur naturalists in the nineteenth century.¹¹² Instead of working for the creation of displays, curators of museums were focused on other functions of these institutions, such as the identification of pest species.¹¹³ In addition, curators found that issues relating to the maintenance of staff and continuation of funding would undermine their ability to focus on tasks related more to the identification, description, and classification of specimens within the museum.¹¹⁴

Taxonomic research conducted in museums in the 1930s is reflective of an overall shift toward ‘new systematics’ based on evolutionary histories and adaptation to changing environments in the study of biology.¹¹⁵ Dioramas and insect displays were becoming more and more focused on giving the public an opportunity to learn about an insect’s “environment, about

¹⁰⁹ Rader and Cain, *Life on Display*, 49.

¹¹⁰ Donna Haraway. "Teddy Bear Patriarchy: Taxidermy in the Garden of Eden, New York City, 1908-1936." *Social Text*, no. 11 (1984): 24.

¹¹¹ Rader and Cain, *Life on Display*, 55.

¹¹² Rader and Cain, *Life on Display*, 75.

¹¹³ Rader and Cain, *Life on Display*, 80.

¹¹⁴ Rader and Cain, *Life on Display*, 83.

¹¹⁵ Rader and Cain, *Life on Display*, 95.

the plants on which they feed, and about the animals that feed upon them,” as stated by entomologist Frank Lutz.¹¹⁶ In the realm of museum entomology, the American Museum of Natural History developed a Hall of Insect Life by the 1920s, which contained specimen cases and dioramas that were intended to show major concepts in the study of the biological world, such as biogeography and other aspects of the ecologies of insects.^{117 118} Herbert Schwartz, a colleague of Lutz, stated that museums were no longer “presenting a mere Noah’s Ark assemblage of species, two by two, male and female, such as had been the custom of the past”.¹¹⁹

By the arrival of the 1940s and 1950s, collections-based research was again at odds with other forms of biological study. Much of the work done in these institutions continued to be focused on systematics, though this work was coming to be seen as the realm of amateur naturalists and not professional biologists. In this vein, Albert Parr, a director of the American Museum, stated that museum researchers “must subordinate our search for more information about the variety of nature to the study of natural laws.”¹²⁰ This area of research was increasingly seen as more relevant to human life and a broader understanding of the natural world than systematics. However, not all agreed with the idea that systematics and taxonomical description were no longer worth the effort. Alan Waterman, director of the National Science Foundation, wrote in support of continuing efforts to classify the natural world by stating that such efforts “serve as the basis for the assessment of natural resources and hasten the introduction of new and economically important groups.”¹²¹

¹¹⁶ Rader and Cain, *Life on Display*, 103.

¹¹⁷ Frederic A Lucas. *General Guide to the Exhibition Halls of the American Museum of Natural History*. New York: American Museum of Natural History, 1920.

¹¹⁸ Rader and Cain, *Life on Display*, 104.

¹¹⁹ Rader and Cain, *Life on Display*, 104.

¹²⁰ Rader and Cain, *Life on Display*, 164.

¹²¹ Rader and Cain, *Life on Display*, 166.

In spite of a continuing trend in the field of biology—including the subtopic of entomological study—toward a system of taxonomy based on evolutionary relationships and molecular data, some professional biologists have continued to argue for the value of research based in the roots of the field. In 1998, Andrew Brower and Darlene Judd responded to an article in *Science* that suggested museum collections were no longer relevant to modern biological science; “[a]s insect-net-wielding curators of a natural history collection, we resent the implication that museum-based research is a dust-laden activity irrelevant to the study of evolution today.”¹²² Though the focus in entomology has shifted from the work of amateur naturalists to the endeavor of professional scientists, and from collections-based research to molecular data, entomology has contributed in a large way to the development of our understanding of the natural world and the relationships between the organisms that inhabit it.

¹²² Rader and Cain, *Life on Display*, 276.

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