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Kay Etheridge
Gettysburg College

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Abstract

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Book Summary: This volume offers fresh perspectives on key elements of science in societies throughout Spanish America, Europe, West Africa, India, and Asia as they overlapped increasingly during the Age of Revolutions—an era of rapidly expanding scientific investigation—as well as the role of scientific change and development in tightening global and imperial connections.

Keywords

Maria Sibylla Merian, illustration

Disciplines

Biology | Illustration

Chapter 3

The History and Influence of Maria Sibylla Merian's Bird-Eating Tarantula

Circulating Images and the Production of Natural Knowledge

Kay Etheridge

A 2009 exhibition at the Fitzwilliam Museum on the confluence of science and the visual arts included a plate from a nineteenth-century encyclopedia owned by Charles Darwin showing a tarantula poised over a dead bird (figure 3.1).[1] The genesis of this startling scene was a work by Maria Sibylla Merian (German, 1647–1717), and the history of this image says much about how knowledge of the New World was obtained, and how it was transmitted to the studies and private libraries of Europe, and from there into popular works like Darwin's encyclopedia. It is unlikely that Merian ever imagined the future longevity and influence of her images and text, but her visual records, like those of other naturalist/artists, were employed by Buffon, Linnaeus, and others in their efforts to understand and order plants and animals from around the world. Classification was greatly aided by images created by naturalists in the field, particularly when specimens were not available. But while such illustrations helped scholars to visualize and organize natural systems, images such as those by Merian and other artist/naturalists also were copied and reused in the numerous publications that blossomed in the nineteenth century designed to catalog

Figure 3.1. A bird-eating spider pictured in an encyclopedia owned by Charles Darwin. The image is from Brehm, *Illustrirtes Thierleben*, vol. 6.

and popularize nature. The knowledge incorporated in the works by Europeans exploring the New World was not always obtained by direct observation, however, and the role of slaves and indigenous people as sources begs further examination.

The flow of information from the New World to Europe can be examined through the example of Merian's work. The study covers also the ways in which indigenous knowledge was shaped by mediators such as Merian and others and how local sources were perceived by traveling naturalists and their European audience. Finally, the ways that information from new worlds of nature were disseminated to Europeans of varying socioeconomic groups will be considered.

The Consummate Naturalist/Artist

From the Renaissance onward, information regarding the natural world was promulgated in ever-increasing volume by Europeans traveling the globe in various capacities. Maria Sibylla Merian provides a rather distinctive case; she is generally omitted from the pantheon of great naturalist/artists even though she produced images of nature that were considered by contemporaries to be the finest examples of natural history art to date, particularly those in her *magnum opus*, *Metamorphosis insectorum Surinamensium* (see for example figure 3.2).[2] Her background and training in a household of artists, engravers, and publishers uniquely prepared her to create her own books on European flowers and insects—and ultimately *Metamorphosis*, which depicted New World organisms in a way never before seen.[3] But the beauty of Merian's depictions of plants and animals and the accuracy with which she painted them were not her major contributions to the flow of information from tropical jungle to European consumers of natural histories. Her work added an essential new dimension to our comprehension of nature by considering the relationships and interactions of organisms for the first time.

Merian's informal education would have been enhanced by the many natural history books published by her family's firm, such as John Johnston's *Historia animalium*, an early zoological encyclopedia containing plates engraved by her half brothers.[4] Johnston's volume on insects, typical for the time, featured the adult moths and butterflies in rows with the larval life stages (caterpillars) on separate plates, and sometime in separate volumes. Perhaps influenced by Johnston or other books in her childhood home, Merian became fascinated by moths and butterflies at an early age. By the age of thirteen she was raising moths and butterflies through metamorphosis, and by age thirty-six she had published two volumes with fifty plates and text entries each on European moths and butterflies.[5] In these "*Raupen* [caterpillar] books," she broke with the long-standing tradition of isolating organisms from their environs and pictured caterpillars on their host plants along with the metamorphic stages of the insects, a compositional format that she continued to employ to great effect in *Metamorphosis*. Merian's accompanying text described aspects of the insects' ecology and behavior, which was revolutionary for the time. Merian herself referred to her depiction of the insects' life cycles along with the plants upon which the caterpillars fed as her "novel invention." Indeed it was novel, as she was the first to combine organisms of different taxa together on a page, and to do so in a way that reflected their ecological relationships.[6]

Figure 3.2. Banana (*Musa x paradisiaca*) with moth and larva of the bullseye moth (*Automeris liberia*). **Merian, *Metamorphosis*, plate 12. Image courtesy of Artis Library, University of Amsterdam.**

Although Merian usually worked alone or in later years with her daughters,[7] she was an active participant in the network of European collectors and scholars interested in insects. Once her reputation was established she frequently was given specimens.[8] However, Merian was not interested in

collection for its own sake or in classification, which she left to others.[9] She was not unique in studying metamorphosis; Johannes Goedaert (Dutch, 1617–1668) studied insect life cycles before her.[10] But Merian appears to have been alone in her detailed observations of organismal interactions. Her way of going about her work also was unusual for the time and sometimes puzzling to her contemporaries.[11] Upon receiving specimens from one collector, she thanked him and returned the specimens, writing that she did not need more preserved animals but wanted to understand "the formation, propagation, and metamorphosis of creatures, how one emerges from the other, the nature of their diet."[12] However, Merian's access to the scholarly network in Amsterdam had an important consequence; the tropical insects she viewed at the homes of important collectors were the impetus behind her remarkable studies in Dutch Surinam.[13]

After decades of experience capturing, raising, and painting insects and plants from German and Dutch fields and gardens, Merian traveled to Dutch Surinam and attempted to replicate her methods in an exploration of the marvelous tropical specimens she had seen. Her own words from the preface to *Metamorphosis* indicate that her travels were motivated by curiosity, and she sought to satiate her desire to understand and document these exotic insects at great personal expense and risk:[14]

> In Holland I marveled to see what beautiful creatures were brought in from the East and West Indies . . . in which collections I found these and countless other insects, but without their origins and generation; that is, how they change from caterpillars to pupae and so forth. This prompted me to undertake a long and expensive journey and to travel to Surinam in America . . . to continue my observations there; thus I traveled there in June of 1699 so as to carry out more precise investigations and remained until June of 1701. . . . In Surinam I painted these sixty views, precisely from life on vellum, with their descriptions. . . .
>
> After I had returned to Holland, and my paintings had been seen by several interested persons, they strongly encouraged me to have them published, judging them to be the first and most remarkable work ever painted in America. . . . The work consists of sixty copperplate engravings on which are displayed some ninety studies of caterpillars, worms, and maggots; how they change in color and form when molting, and finally change into butterflies, moths, beetles, bees, and flies. All these creatures are shown on the same plants, flowers, and fruits they ate for their nourishment. Here are also included life stages of West-Indian spiders, ants, snakes, rare toads and frogs,

Figure 3.3. Spiders and ants (circa 1704). **Watercolor model for plate 18 in Merian, *Metamorphosis*. Photograph © The Trustees of the British Museum.**

> all observed and painted from life in America by me, with the exception of a few which I have added on the basis of reports by the Indians.

In her quest to understand one small part of nature, Merian followed on her earlier European works in grand style with the Surinamese plants and insects pictured in *Metamorphosis.* The book measured almost half a meter in height, making it possible to portray most organisms as life-sized. For an

additional cost to the buyer, plants and animals could spring to life in full color.[15] Unlike the static images drawn by earlier artists, Merian's scenes of tropical life revealed a microcosm of nature within a page: animals feed and are fed upon, life cycles of plants, frogs, and insects transpire.

To understand how revolutionary the images in *Metamorphosis* were, it is instructive to consider earlier depictions of New World flora and fauna; as was the case for books on European flora and fauna, the organisms typically were isolated from what we now think of as their "habitat." Hans Sloane's *A voyage to the islands* (1709 and 1725) was published after *Metamorphosis* but was based on his 1687 stay in the West Indies, and the design of his two volumes was typical for the period predating Merian's work.[16] Sloane's images conveyed form but little else about the plants and animals depicted. Organisms were arranged in a variety of ways; for example, the four hummingbirds included in plate 264 of his second volume are arranged around a large centrally placed heron, and in other plates butterflies were laid out in rows similar to those in Johnston. Plants were depicted separately from insects and other animals, as was traditional before Merian's *Raupen* books were published.[17] Images in these earlier volumes were generated by artists of widely varying skills, and some, like the tarantula depicted in Willem Piso and Georg Marggraf were simplified woodblock prints surrounded by textual descriptions.[18] Merian's vivid display of interacting organisms in plate 18 of *Metamorphosis* (figure 3.3) is compelling even today, and it certainly generated a strong response in European viewers not used to such a scene.

Considering the Source

The information in Merian's books on European insects came from her own observations and occasionally those of fellow European naturalists. But in Surinam, a place alien to her, servants, slaves, and others who lived and labored in the colonized area served as important sources of information. Merian directly observed many organisms as she searched the tropical forest for specimens; certainly she knew from raising the larval insects to adults which food plants were consumed. But Merian, like naturalists before and after her, often relied on her "servants," particularly regarding the uses of local plants. A typical description of a plant by Merian often included its reported medical uses or its value as a local food, such as the trunk of the fan palm, which when cooked "tastes better than artichoke hearts."[19] In one poignant entry, she described how the seeds of the peacock flower can

promote labor, and that "Indians, who are not well treated when in service to the Dutch, use it to abort their children so that their children should not become slaves as they are."[20] Such information comes from a relationship involving a degree of respect and perhaps even trust. Ironically, respect may have developed between her and the African slaves and Amerindians with whom she interacted, but something quite the contrary arose between her and the Dutch living in Surinam. She appears to have received little help other than lodging from the colonial planters, writing that they "have no desire to investigate anything like that [referring to a plant similar to tobacco]; indeed they mocked me for seeking anything other than sugar in the country."[21] Conversely, Merian frequently acknowledged the aid of slaves and "her Indian," writing that she had the plant in question "dug up by the roots by my Indian and brought back to my house and planted."[22] It is not known what incentive or motivation generated this help from her local sources; perhaps in part it was her gender or the fact that she did not seem to be in the good graces of the colonists who subjugated them.

Some of Merian's most intriguing images and text can be traced back to information she either states or infers that she received from local sources. In one case they led her astray by presenting her with some sort of chimeric specimen that they assured her developed into lantern flies, which would glow and at night produce "a bright light like a candle, bright enough to read the paper by."[23] Merian was much criticized by later naturalists, particularly in the late nineteenth century, for believing her native sources on this and other entries, the most controversial of which was the bird-eating spider central to plate 18 (figure 3.3). Herein Merian depicted the life and death struggles of a roach, two species of spiders, two types of ants (although she combines their characteristics), and a doomed hummingbird with its recently deserted nest and eggs. Even the guava tree, being defoliated by the leaf cutter ants, is involved as a victim in the story played out on the page. About the spider and the bird Merian wrote that "These spiders catch humming-birds from their nests as already stated above. Humming-birds are the staple diet of the priests in Surinam, who (so I was told) eat nothing but these birds. They lay four eggs like all other birds and hatch them. They fly very fast. They suck the honey from the blossom with outstretched winds as if motionless in the air; they are, with many brilliant colors, more beautiful even than the peacock." The potential for new life also is evoked by the egg sacs of the two female spiders as well as her narrative, which describes the leaves as being carried by the ants to their offspring. She wrote that the ants "lay eggs that produce maggots which the ants supply with

incredible industriousness, for in warm countries ants do not need to make provision for the winter, because winter never comes there. The ants build cellars under the ground, a good eight feet deep and so well made that they might have been made by human beings."[24] Although she does not state that she learned about the leaf cutter ant behavior from the Amerindians, they would seem the likely source of much of the information in this complex and detailed entry.[25]

As with the lantern fly account, Merian was given incorrect information about the number of eggs produced by the hummingbirds (usually two). She also confused two species of ants for one, but most of her descriptions are strikingly accurate and indeed provided new information about several species to a European audience. But this entry generated vehement criticism by the Reverend Lansdown Guilding, who called plate 18 an "entomological caricature."[26] He expressed doubt about the ability of the spider to catch and eat a bird and did not believe that ants could construct a bridge with their bodies that is then used to travel from branch to branch as "thousands of ants run over each other."[27] Hermann Burmeister followed Guilding's lead and dismissed plate 18 as "incredible" even though Linnaeus had named the spider *Aranea avicularia* (now *Avicularia avicularia*) for its bird-eating habits.[28] Guilding and Burmeister assumed that Merian was naïve in reporting accounts from the "Indians." Burmeister thought she "gave far too easy belief to the reports of the Indians," and that plate 18 and text were likely "suggested by the idle stories of the natives." He concluded that the entire entry was "to a considerable extent fabulous."[29] The controversy generated so much interest that William MacLeay conducted an experiment in which he offered birds to a similar large spider and then reported that the spider fled from the birds, concluding that "Madame Merian has told a willful falsehood."[30] In the same journal in the same year W. E. Shuckard argued such spiders could and did take small birds.[31] The final vindication came from Henry Walter Bates (English, 1825–1892) in his account of his travels in the Amazon. Bates wrote of seeing a similar tropical spider that had captured a finch, as "recorded long ago by Madame Merian," and his support for Merian's reputation was reported in *Scientific American*, the *London Gazette*, and even *Harpers New Monthly Magazine*.[32] Bates included an image of the spider attacking a finch in his popular book along with other lively drawings that reflected Merian's illustrations.[33]

European visitors to the West Indies displayed a range of responses to local sources. Nicolas-Louis Bourgeois (French, 1710–1776) found that *les nègres* had more knowledge of "marvelous cures" than the colonists,

while the French botanist Pierre Barrère (1690–1755) thought little of Amerindian medicine and assumed that what they knew they learned from Europeans.[34] European attitudes toward "native" knowledge had become increasingly chauvinistic and even racist by the nineteenth century. Kathleen Murphy's insightful analysis concludes that European colonists saw themselves as using their more sophisticated expertise as needed to convert the observations of the slaves and Amerindians into useful and meaningful science.[35] European naturalists such as Mark Catesby relied heavily on Native Americans for information about the many uses of New World plants.[36] On the other hand, Catesby complained that Native Americans were ignorant of anatomy, and Hans Sloane denigrated the knowledge of slaves and Amerindians in Jamaica as unsystematic, even while depending upon them to provide specimens and to report their uses of plants for cures and remedies to him.[37] He described the content of his *Voyage to Jamaica* as the "best infomations [*sic*] I could get from Books, and the Inhabitants, either Europeans, Indians or Blacks."[38] Merian differed from Sloane and Catesby in that she tended to offer the gleanings from her servants, slaves, and assistants without comment, but this was her style of information presentation in other areas of potential controversy as well. In one example she wrote about a maggot given to her by a "black slave woman who told me that beautiful grasshoppers would emerge from it." Merian then stated she did not see this herself, but that she "did not want to pass over it in silence in order to give other amateur naturalists the incentive to find out about it for themselves."[39] But in Merian's Surinam volume as well as in the books of Sloane, Catesby, and others, the indigenous and enslaved contributors to the flow of information from the colonies to Europe remained anonymous. Merian returned to Amsterdam with one such Amerindian servant, and even her name was unrecorded. However, the burgeoning natural history literature of the eighteenth and nineteenth centuries was awash with unattributed content, from unnamed illustrators (often women) and uncited sources, both published and anecdotal. So anonymity of contributors other than the primary authors was the order of the day and not necessarily attributable to the status of the sources.

It is also interesting to note that Merian was not singled out for criticism; Sloane's *Voyage to Jamaica* was satirized and critiqued by both Europeans and Jamaicans.[40] Linnaeus was frequently critical of naturalists such as Catesby and others, even while using their images to name and order plants and animals. Linnaeus in turn was criticized by others such as the comte de Buffon. Controversy over information in natural history

accounts was not uncommon, as subsequent naturalists wished to establish their own authority. Likewise, misinformation contained in the accounts flowing into Europe from explorers and naturalists abroad was not limited to indigenous sources, and natural history volumes are rife with images and accounts that today seem quaint if not ridiculous.[41] Yet natural history books about exotic organisms were still an essential tool of both colonists and explorers who followed these early European naturalists. In preparing to circumnavigate the globe as a naturalist on a voyage from 1789 to 1794, Antonio Pineda considered the fifty-seven volumes of natural history he brought along to be essential tools of his trade.[42] These subsequent explorations often led to more publications, and the cycle of knowledge accumulation became one of positive feedback.

Influence of the Naturalist/Artist

Pamela Smith argues that European art and artisans were "motors of the Scientific Revolution" and helped to change what comprised knowledge by accurately portraying natural objects.[43] This idea is similarly stated in Victoria Dickenson's treatise on science and art from the New World.[44] Naturalistic depictions of flora and fauna certainly were a critical part of the collections of scholars who were keen to organize and know the natural world. Preeminent among these were Carl Linnaeus and his students, and they relied heavily on images as well as specimens from artists working abroad. Ironically, given her disinterest in taxonomy, Merian's illustrations and descriptions were used by Linnaeus and his students to name and classify at least one hundred species.[45] As William Stearn has pointed out, explorer/naturalists such as Merian were critical to the endeavors of Linnaeus, who never traveled to the neotropics.[46]

Although natural history art was used to portray types of organisms for comparison of form and structure, in time the work of the catalogers and classifiers led to questions about the diversity of flora and fauna around the globe. Merian's contribution was the added dimension of organismal interactions that so interested Darwin when he explored the "struggle for existence." She was the first to portray nature "red in tooth and claw" to a growing audience of Europeans interested in natural history, and her eye-catching and dramatic compositions influenced generations of naturalist/artists who followed her.[47] Merian's role has been overlooked by many, including Christopher Iannini in his 2012 book on the rise of natural science and the relationship to the Caribbean plantation system.

Iannini touts Hans Sloane and Mark Catesby as the preeminent natural historians and developers of a "rich repertoire of linguistic and pictorial techniques for cultivating a vivid understanding of the region and its natural productions," omitting Merian even though her inclusion would have strengthened his premise.[48] Kay Kriz also skipped from Sloane to Catesby without mention of Merian in her accounting of major American natural histories.[49] Hans Sloane in fact owned a copy of *Metamorphosis* and avidly collected Merian's original watercolors, which are in his collection at the British Museum. Sloane's own work on the West Indies, compiled before Merian's Surinam volume but published after it, was illustrated by others, often from preserved specimens. Mark Catesby on the other hand illustrated and even engraved the plates for his *Natural History of Carolina, Florida, and the Bahama islands* (1729–1747); he was clearly influenced by Merian's work and his Natural History closely mirrored *Metamorphosis* in layout and style.[50]

The role of naturalist/artists such as Merian, Catesby, and those who followed (e.g., John Gould and John James Audubon) in the development of natural history has only recently been addressed by scholars. Diana Donald and Jane Munro's catalog for the Fitzwilliam exhibition explored how Darwin was influenced by natural history art and illustration as well as ways in which his ideas may in turn have molded subsequent art.[51] Darwin and other nineteenth-century naturalists could view variations on Merian's bird-eating spider in books such as Alfred Brehm's encyclopedia (see figure 3.1), and similar types of images and information in other natural history books from the early modern period were used and reused in later publications.[52] Merian's depiction of the bird-eating spider, conceived over a century earlier in the wilds of Surinam, was an early precursor to countless images of interactions between animals involving struggle and conflict. Such dramatic scenarios inherently generate interest, and the public was hooked.[53] As printing became less expensive and natural history publications proliferated, information painstakingly collected by explorers, naturalists, and artists from around the globe began to flow into some new and even unlikely places.

Popular Science

In the seventeenth century a number of seminal natural histories were published, but these were often in Latin and well beyond the means of most amateur naturalists as well as the general public. By the first half of

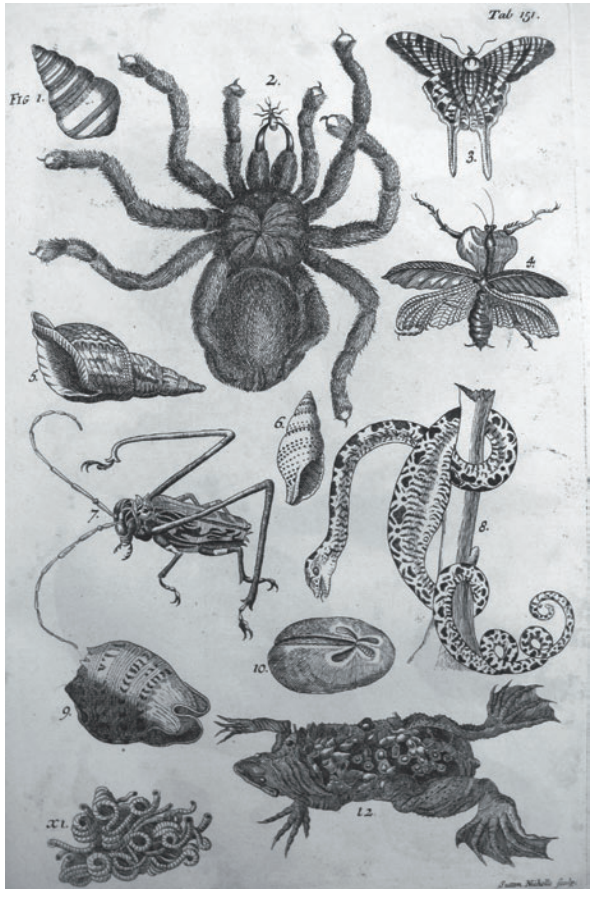

Figure 3.4. Images from Merian's *Metamorphosis* reproduced in *Historiam naturalem spectantia* (Petiver, plate 151, 1764). Petiver's title page includes the information that 112 of Merian's insects are shown within.

the eighteenth century, the number of such works expanded and included more books published in French, German, and English. However, these were still very expensive, and even Linnaeus complained about the cost of Merian's books. Additionally, these books were issued in small numbers, and although some—like Merian's *Metamorphosis* and Catesby's *Natural History*—were reprinted in several editions, they still remained rare and unavailable to most people. One of the earliest to address cost in an attempt to popularize natural history in England was James Petiver (1663–1718). His *Historiam naturalem spectantia* made liberal use of images by Merian and others (figure 3.4).[54] Petiver was unusual for the time in his crediting his sources and in his interactions with female naturalists such as Hannah English Williams (South Carolina, d. 1722), with whom he corresponded about specimens for his collection.[55]

By the second half of the eighteenth century, more affordable natural history publications began to proliferate. Buffon's *Histoire Naturelle* appeared in 1749, and English translations of the multivolume work were soon available.[56] *Histoire Naturelle* was quickly followed by a number of popular natural history books that copied liberally from predecessors; these were generously illustrated, and typically the original artist/naturalists went uncredited. The eight-volume *History of the Earth and Animated Nature* was a star among this type of work, thriving for decades after the death of creator Oliver Goldsmith.[57] He preferred to excite his readers rather than emphasize the dry and "mechanical" ordering and naming of species. A page of "Arachnides. Myraipoda" in the 1840 printing of Goldsmith's second volume featured a crude copy of Merian's spider feasting on a hapless bird, undoubtedly included to spice up a page of otherwise lifeless arthropod images.[58] In Friedrich Bertuch's encyclopedia for children, Merian's bird-eating spider is a close replica of the original in *Metamorphosis* and, similarly to that in Goldsmith, serves as the centerpiece of an array of arthropods.[59] Close copies of Merian's images of pineapples and a guava fruit also occupy full plates in Bertuch's twelve-volume set, which followed the convention of including no mention of the source of text and images and also exemplified the seemingly random organization of such volumes. Over a thousand hand-colored illustrations of a "delightful collection of animals, plants, flowers, fruits, minerals, costumes and many different informative articles from the realm of nature" are paraded through the pages without any system, possibly to cause wonder in the reader much in the way of Renaissance curiosity cabinets.[60] Others, like Thomas Bewick, attempted to decrease the cost of their publications, and his *General History of the Quadrapeds* relied on wood engravings and small size rather than the larger copper-plate images reproduced in more expensive books.[61] Certainly Bewick's charming images were modest in light of those published by Georges Cuvier (French, 1769–1832), who employed artists like Thomas Landseer to animate images of lions and tigers in jungle settings.[62] The market for these more luxurious publications, although small, remained intact, as evidenced by the success of works like those of John Gould and John James Audubon. It could be argued that Gould's and Audubon's bird images were influenced by those of their predecessors in depicting organisms interacting within their habitat. Certainly Audubon's image of mockingbirds reacting to an attack by a rattlesnake echoes the drama evoked by Merian's bird-eating spider.[63]

Harriet Ritvo reviewed the British market in popular natural histories

and described the diversity of the consumers of such material, who extended beyond the middle class.[64] Those who could not buy books often had access to popular natural histories through the clubs and non-circulating libraries that sprang up in Britain, which numbered at least sixty-five hundred by 1821. Children and women were part of this growing audience for natural histories, although perhaps not members of clubs that met to discuss natural history in pubs in late eighteenth- and early nineteenth-century England.[65] By the early 1800s the market in Britain was such that some booksellers specialized in natural history, and publishers expanded their offerings by producing natural history periodicals as well as books.[66] Other European countries exhibited similar trends, and natural history was far from the only area of science that fascinated the public.[67] Natural history also "made a vigorous claim on the culture of the United States" and this was promoted by lending libraries that made materials available to a broad audience.[68] The proliferation of natural history publications that fed the public appetite was dependent upon much recycling of information from earlier works. Merian's bird-eating spider along with other images of hers and countless other artist/naturalists made regular appearances in various forms and incarnations (e.g., see figure 3.5). In this way, knowledge about the plants and animals of exotic locales gleaned from direct observation and communication with indigenous people and slaves was passed to new generations decades and even centuries later.

From Curiosity to Commerce

Nature images could be amplified by reprinting or copying, but the information conveyed changed when illustrations were removed from their original context, redrawn in new forms, and separated from ancillary text. Examination of many of the popular natural history volumes reveals that the quantity of information being circulated was not necessarily correlated in a positive way with the accuracy of the natural history descriptions conveyed. However, it is clear that during the eighteenth and nineteenth centuries, the public was increasingly interested in natural history, and this was reflected in a growing number of menageries, zoos, and botanical gardens.[69] Curiosity awakened is a powerful force, and many middle-class and even working-class consumers of natural history culture went on to make their own important contributions. Well-known examples of naturalists who were largely self-taught include Henry Walter Bates and Alfred Russel Wallace, just two of many who represent the increase in "human capital"—

Figure 3.5. A bird-eating spider inspired by Merian's 1705 image in *Metamorphosis*. *Popular Science Monthly* 33 (October 1888).

those who became invested in the development of science by virtue of their curiosity. Merian is an even earlier example, motivated by what she read and by exotic specimens from the New World.

A number of science historians have related the boom in the knowledge of nature to the economic growth of Western Europe; several such are cited by Londa Schiebinger, who wrote that botanical exploration in particular was "big science and big business."[70] The importance of such knowledge appears to have been understood very well on both sides of the Atlantic by disseminators of Enlightenment science. One such, John Desaguliers (French, 1683–1744), professed that natural philosophers were to "contemplate the works of God, to discover Causes from their Effects, and make Art and Nature subservient to the Necessities of Life."[71] Charles Willson Peale (1742–1827), a great popularizer of nature in Philadelphia, stated in a public lecture that investigation of nature was "a national priority; it held the potential to propel the nation toward economic independence."[72] Peale himself learned natural history from a variety of sources that likely included Merian (for whom he named one of his daughters). He created the first natural history museum in America, and his influence was extensive.[73]

Artist/naturalists such as Maria Sibylla Merian were integral in the acquisition of natural history information from around the globe. Julie Berger Hochstrasser has articulated very well the importance of personal experience to these mediators of nature: "no amount of verbal description could ever communicate the complexity of their [Merian's specimens'] patterns, so meticulously recorded in Merian's image; this remains decidedly within the realm of perceptual knowledge."[74] However, indigenous contributors and colonial slaves, usually uncredited, were also an essential source of the information that flowed from the colonies into Europe. Ironically, increased understanding of nature quickened the pace of colonization and exploitation of the New World, as it was directly useful for development of medicines and new crops. In addition, the dissemination of exciting and provocative pictures of new life-forms, both accurate and exaggerated, stimulated a positive feedback loop that further broadened the sector of the populace actively participating in the study of natural history, accelerating the growth rate of knowledge across the globe.

66. James E. McClellan, *Colonialism and Science: Saint Domingue in the Old Regime*, 2nd ed. (Baltimore: Johns Hopkins University Press, 2010), 163.

67. On meteorological infrastructures of the nineteenth century, see James Rodger Fleming, Vladimir Jankovic, and Deborah R. Coen, *Intimate Universality: Local and Global Themes in the History of Weather and Climate* (Sagamore Beach, MA: Science History , 2006), x–xi.

68. Theodore S. Feldman, "Late Enlightenment Meteorology," in *The Quantifying Spirit in the Eighteenth Century*, ed. Tore Frangsmyr, J. L. Heilbron, and Robin E. Rider (Berkeley: University of California Press, 1990), 146, 149.

69. Isaac Greenwood, "A New Method for Composing a Natural History of Meteors Communicated in a Letter to Dr. Jurin, R. S. & Coll. Med. Lond. Soc. By Mr. Isaac Greenwood, Professor of Mathematicks at Cambridge, New-England," *Philosophical Transactions* 35 (1727): 391, 398.

70. Feldman, "Meteorology," 158.

71. Andrés Poey y Aguirre, "A Chronological Table Comprising 400 Cyclonic Hurricanes Wich Have Occurred in the West Indies and in the North Atlantic within 362 years, from 1493 to 1855," *Journal of the Royal Geographical Society (London)* 25 (1855).

72. See, for example, William Reid, *An Attempt to Develop the Law of Storms* (London: J. Weale, 1838); Piddington, *Sailor's Horn-Book*.

73. On the condescending behavior of the Weather Bureau toward Cuban hurricane forecasts under Willis Moore, see Erik Larson, *Isaac's Storm: A Man, a Time, and the Deadliest Hurricane in History*, 1st ed. (New York: Crown, 1999), 93–97.

Chapter 3. The History and Influence of Maria Sibylla Merian's Bird-Eating Tarantula

1. Diana Donald and Jane Munro, *Endless Forms: Charles Darwin, Natural Science and the Visual Arts* (New Haven, CT: Yale University Press, 2009), 132. The encyclopedia Darwin owned was Alfred Brehm, *Illustrirtes Thierleben: Eine Allgemeine Kunde Des Thierreichs* (Hildburghausen: Bibliographischen Instituts, 1864–1869).

2. The first edition of the book was Maria Sibylla Merian, *Metamorphosis insectorum Surinamensium* (Amsterdam: M. S. Merian, 1705), but Figures 3.2 and 3.3 in this chapter are from a very fine copy in the Artis Library, which is the 1719 edition: Maria Sibylla Merian, *Metamorphosis insectorum Surinamensium* (Amsterdam: Joannem Oosterwyk, 1719).

3. Her father, the renowned engraver Matthäus Merian, died soon after she was born, but her stepfather Jacob Marrel (Dutch, 1613–1681) as well as her half brothers appear to have encouraged her art and trained her in engraving. For more on Merian's biography see, for example, Florence F. J. M. Pieters and Diny Winthagen, "Maria Sibylla Merian, Naturalist and Artist (1647–1717): A Commemoration on the Occasion of the 350th Anniversary of Her Birth," *Archives of Natural History* 26, no. 1 (1999): 1–18; Ella Reitsma and Sandrine Ulenberg, *Maria Sibylla Merian and Daughters: Women of Art and Science* (Amsterdam: Rembrandt House Museum; Los Angeles: J. Paul Getty Museum; Zwolle: Waanders, 2008).

4. John Johnston, *Historiae naturalis de insectis Libri III* (Frankfurt-am-Main, 1653).

5. Maria Sibylla Merian, *Der Raupen wunderbare Verwandelung und sonderbare Blumen-Nahrung* (Nuremberg: M. S. Merian [J. A. Graff] 1679); Merian, *Der Raupen wunderbare Verwandlung und sonderbare Blumen-Nahrung . . . Anderer Theil* (Frankfurt and Leipzig: M. S. Merian [D. Funken], 1683).

6. Pieters and Winthagen, "Maria Sibylla Merian," 10; Kay Etheridge, "Maria Sibylla Merian and the Metamorphosis of Natural History," *Endeavour* 35 (2011): 15–21.

7. Merian was married and had two daughters, but the marriage was dissolved around the time she moved to Amsterdam in 1691. Her husband, Johann Andreas Graff, may have assisted with the engravings in her first *Raupen* book, but her investigations of metamorphosis appear to have been conducted entirely on her own. The role of Merian's daughters in the production of some later art attributed to her has been discussed elsewhere (see Reitsma and Ulenberg, *Maria Sibylla Merian*), but the science was all Merian's—as, it seems, was the artwork in her books.

8. Merian wrote, for example, that "These two large caterpillars, so unlike each other in their form and color . . . were sent to me a number of times by several esteemed amateurs" (Merian, *Der Raupen* [1679], plate 17).

9. Merian was not unusual in this. Through the middle of the eighteenth century, the naturalist "observers" who described organisms and those scholars interested primarily in classification virtually ignored one another. See Jacques Roger and L. Pearce Williams, *Buffon: A Life in Natural History*, ed. L. Pearce Williams, trans. Sarah Lucille Bonnefoi, Cornell History of Science series (Ithaca, NY: Cornell University Press, 1997), 71.

10. Johannes Goedaert, *Metamorphosis Et Historia Naturalis Insectorum*, 3 vols. (Middleburg: J. Fierenes, 1662–1669).

11. Unlike wealthier collectors, Merian was more apt to sell her specimens than to trade them. As Neri points out, this went against the "code" of collectors and put her in an "ambiguous and problematic position within the networks of exchange" even while she was respected for her work. See Janice Neri, *The Insect and the Image: Visualizing Nature in Early Modern Europe, 1500–1700* (Minneapolis: University of Minnesota Press, 2011), 166.

12. Maria Sibylla Merian, Elizabeth Rücker, and William T. Stearn, *Metamorphosis insectorum Surinamensium* (London: Prion, 1980–1982), 72. The collector in question was James Petiver, who greatly admired her work and wanted to publish an English version of *Metamorphosis.* Unfortunately, this never came to fruition.

13. See Merian, *Metamorphosis*, preface: "However, in Holland I marveled to see what beautiful creatures were brought in from the East and West Indies, particularly when I had the honor of seeing the fine collection of the Most Honorable Heer Meester Nicolaas Witsen, mayor of the city of Amsterdam and director of the East India Company, &c., as well as that of the Honorable Heer Jonas Witsen, secretary of that city. In addition, I saw the collection of Heer Fredericus Ruisch, MD, Anatomes et Botanices Professor, that of Heer Livinus Vincent, and of many others."

14. Merian's trip was singular in its time for one of her sex and age (fifty-two at the

time of sailing), but also in that she traveled at her own behest. Throughout the age of exploration, virtually all naturalists and artists traveling to new lands were underwritten by the powerful and wealthy. Merian primarily financed the endeavor by the sale of specimens and ultimately her books, but she did suffer health consequences (possibly from malaria) for the remainder of her life.

15. Merian's atelier hand-colored some copies of the first edition of *Metamorphosis* and possibly her early European *Raupen* books. Unfortunately many first editions and virtually all later editions were colored by less skilled hands.

16. Hans Sloane, *A voyage to the islands Madera, Barbados, and Jamaica*, 2 vols. (London: Hans Sloane, 1701–1725).

17. For a fuller discussion of this and more images, see Kay Etheridge and Florence F. J. M. Pieters, "Maria Sibylla Merian (1647–1717): Pioneering Naturalist, Artist, and Inspiration for Catesby," in *The Curious Mister Catesby: A "Truly Ingenious" Naturalist Explores New Worlds*, ed. E. Charles Nelson and David Elliot (Athens: University of Georgia Press, 2015), 39–56.

18. Willem Piso and Georg Marggraf, *Historia Naturalis Brasiliae* (Amsterdam: Franciscum Hackium, 1648).

19. Merian, *Metamorphosis*, plate 43.

20. Merian, *Metamorphosis*, plate 45.

21. Merian, *Metamorphosis*, plate 36.

22. Merian, *Metamorphosis*, plate 36.

23. Merian, *Metamorphosis*, plate 49.

24. Merian, *Metamorphosis*, plate 18.

25. See Etheridge, "Metamorphosis of Natural History," 16–18, for a more complete account of the biological information contained within this first published account of these extraordinary ants.

26. Landsdown Guilding, "Observations on the Work of Maria Sibilla Merian on the Insects Etc. Of Surinam," *Magazine of Natural History and Journal of Zoology, Botany, Mineralogy, Geology and Meterology* 7 (1834–1834): 355–75 (plate 18, p. 362).

27. Merian, *Metamorphosis*, plate 18. The description of army ant bridging behavior is quite accurate.

28. Hermann Burmeister, Kritische Bemerkungen Über M. S. Merian "Metamorphoses insectorum Surinamensium" *Adhandlungen der Naturforschenden Gesellschaft zu Halle*, 2 (1854): 58–65.

29. Burmeister, "Kritische Bemerkungen."

30. William S. MacLeay, "On Doubts Respecting the Existence of Bird-Catching Spiders," *Annals and Magazine of Natural History, Zoology, Botany and Geology*, 8, no. 52 (1842) 324–25.

31. William E. Shuckard, "On Bird-Catching Spiders, with Remarks on the Communication from W. S. MacLeay, Esq. upon that Subject in the January Number of the Annals," *Annals and Magazine of Natural History, Zoology, Botany and Geology* 8, no. 53 (1842–1844): 435–38.

32. Henry Walter Bates, *The Naturalist on the River Amazons*, 2 vols. (London: J. Murray, 1863), 10.

33. See, for example, the leaf cutter ants, or hummingbird and hawkmoth feeding from the same plant. Bates, *Naturalist*, 101.

34. Londa L. Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, MA: Harvard University Press, 2004), 120–24.

35. Kathleen S. Murphy, "Translating the Vernacular: Indigenous and African Knowledge in the Eighteenth-Century British Atlantic," *Atlantic Studies* 8, no. 1 (2011): 39.

36. For several examples see W. Hardy Eshbaugh, "The Economic Botany and Ethnobotany of Mark Catesby," in Nelson and Elliiot, *The Curious Mister Catesby*, 205–18.

37. Murphy, "Translating the Vernacular," 37.

38. Sloane, *Voyage to the islands*, preface.

39. Merian, *Metamorphosis*, plate 27.

40. James Roberston, "Knowledgeable Readers: Jamaican Critiques of Sloanes's Botany," in *From Books to Bezoars: Sir Hans Sloane and His Collections*, ed. Alison Walker, Arthur MacGregor, and Michael Hunter (London: British Library, 2012), 86–88.

41. See Julie Berger Hochstrasser, "The Butterfly Effect: Embodied Cognition and Perceptual Knowledge in Maria Sibylla Merian's *Metamorphosis insectorum Surinamensium*," in *The Dutch Trading Companies as Knowledge Networks*, ed. Siegfried Huigen, Jan L. de Jong, and Elmer Kaolin (Leiden: Brill, 2010), 94. Hochstrasser also recounts the controversy over the "false" versus "true" nutmeg.

42. For a review of the use of natural history books by naturalist/explorers, see Daniela Bleichmar, "Exploration in Print: Books and Botanical Travel from Spain to the Americas in the Late Eighteenth Century," *Huntington Library Quarterly* 70, no. 1 (2007): 129–51. Bleichmar also describes the faults found by such naturalists in the work of their predecessors.

43. Pamela H. Smith, "Science and Visual Culture in Early Modern Europe," *Isis* 97 (2006): 95.

44. Victoria Dickenson, *Drawn from Life: Science and Art in the Portrayal of the New World* (Toronto: University of Toronto Press, 1998), 230.

45. Merian, Rücker, and Stearn, *Metamorphosis insectorum Surinamensium*, 18.

46. William T. Stearn, "Carl Linnaeus's Acquaintance with Tropical Plants," *Taxon* 37, no. 3 (1988): 777.

47. Merian's European caterpillar books influenced natural history compositions even before *Metamorphosis*, but the latter had a much wider audience (over more than a century it was reprinted in a number of editions and languages) and more visually compelling images. See Kay Etheridge, "Maria Sibylla Merian: The First Ecologist?" in *Women and Science: Pioneers, Activists and Protagonists*, ed. Donna Andreolle and Veronique Molinari (Newcastle upon Tyne: Cambridge Scholars, 2011), 39–44.

48. Christopher P. Iannini, *Fatal Revolutions: Natural History, West Indian Slavery, and the Routes of American Literature* (Chapel Hill: Published for the Omohundro Institute of Early American History and Culture, Williamsburg, Virginia, by the University of North Carolina Press, 2012), 9.

49. Kay Kriz, "Curiosities, Commodities, and Transplanted Bodies in Hans Sloane's 'Natural History of Jamaica,'" *William and Mary Quarterly* 57, no. 1 (2000): 78.

50. For further discussion and more images, see Etheridge and Pieters, "Maria Sibylla Merian."

51. Donald and Munro, *Endless Forms*.

52. Brehm, *Illustrirtes Thierleben*.

53. Victorian popularizers of science "used visual images to attract their readers and to illustrate the wonder in nature." Bernard Lightman, "Marketing Knowledge for the General Reader: Victorian Popularizers of Science," *Endeavour* 24, no. 3 (2000): 104. This means of attracting and engaging an audience is still very much in use. For a discussion of how vivid and dramatic images in nature films arouse wonder and curiosity, see Gregg Mitman, "Cinematic Nature," *Isis* 84, no. 4 (1993): 657.

54. James Petiver, *Jacobi Petiveri Opera, Historiam Naturalem Spectantia: Containing Several Thousand Figures of Birds, Beasts . . . To Which Is Now Added Seventeen Curious Tracts*, 2 vols. (London: Printed for John Millan Bookseller, 1767).

55. Susan Scott Parrish, "Women's Nature: Curiosity, Pastoral, and the New Science in British America," *Early American Literature* 37, no. 2 (2002): 208.

56. Georges Louis Leclerc comte de Buffon, *Histoire Naturelle, Générale Et Particulière Avec La Description Du Cabinet Du Roi* (Paris: De l'Imprimerie royale, 1749–1804).

57. Oliver Goldsmith, *An History of the Earth, and Animated Nature*, 8 vols. (London: J. Nourse, 1774).

58. Oliver Goldsmith, *A History of the Earth and Animated Nature* (Glasgow: Blackie and Son, 1840), vol. 1, iii.

59. Friedrich Justin Bertuch, *Bilderbuch für Kinder* (Weimar: im Verlage des Industrie-Comptoirs, 1790). This encyclopedia was published in German and French through 1830.

60. From the very descriptive subtitle of Bertuch, *Bilderbuch für Kinder.*

61. Thomas Bewick, *A General History of Quadrupeds* (Newcastle upon Tyne: Printed by S. Hodgson, 1790).

62. Donald and Munro, *Endless Forms*, 124.

63. John J. Audubon, *Birds of America* (London, 1827), plate 21.

64. Harriet Ritvo, *The Animal Estate: The English and Other Creatures in the Victorian Age* (Cambridge, MA: Harvard University Press, 1987), 8–9.

65. Members of various British artisan botanical societies contributed to a fund for shared botany books and the liquor consumed at pub meetings. Anne Secord, "Artisan Botany," in *Cultures of Natural History*, ed. Nicholas Jardine, James A. Secord, and E. C. Spary (Cambridge: Cambridge University Press, 1996), 378–93.

66. Ritvo, *Animal Estate*, 9–10.

67. For a review, see Susan Sheets-Pyenson, "Popular Science Periodicals in Paris and London: The Emergence of a Low Scientific Culture, 1820–1875," *Annals of Science* 42, no. 6 (1985): 549–72.

68. William Leach, *Butterfly People: An American Encounter with the Beauty of the World* (New York: Pantheon, 2013), xxiii.

69. Ritvo, *Animal Estate*, 206–8.

70. Schiebinger, *Plants and Empire*, 5.

71. John T. Desaguliers, *A Course of Experimental Philosophy*, 2 vols. (London:

Printed for John Senex, W. Innys and Richard Manby, and John Osborne and Thomas Longman, 1734), vol. 1, unnumbered [p. i].

72. Charles Willson Peale, "Introduction to a Course of Lectures on Natural History," delivered in the University of Pennsylvania, November 16, 1799 (Philadelphia: Francis and Robert Bailey, 1800).

73. For a review of Peale's education, museum history, and his influence, see Robert E. Schofield, "The Science Education of an Enlightened Entrepreneur: Charles Willson Peale and His Philadelphia Museum, 1784–1827," *American Studies* 30, no. 2 (1989): 21–40.

74. Hochstrasser, "Butterfly Effect," 69.

Chapter 4. Linnaeus's Apostles and the Globalization of Knowledge, 1729–1756

Much of this chapter is based on research first published in Hanna Hodacs and Kenneth Nyberg, *Naturalhistoria på resande fot: Om att forska, undervisa och göra karriär i 1700-talets Sverige* (Lund: Nordic Academic Press, 2007), esp. chs. 2, 6, 7 by Kenneth Nyberg; and in Kenneth Nyberg, "Linnaeus' Apostles, Scientific Travel and the East India Trade," *Zoologica Scripta* 38 Suppl. 1 (2009): 7–16. That work was funded by the Swedish Research Council (Vetenskapsrådet), whose support is gratefully acknowledged. I would also like to thank Patrick Manning and Daniel Rood for the opportunity to contribute a chapter to this book, and the Riksbankens Jubileumsfond for the grant that made it possible for me to bring it to completion.

Epigraph: Mary Louise Pratt, *Imperial Eyes: Travel Writing and Transculturation* (1992; London: Routledge, 2008), 25–26.

1. Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, MA: Harvard University Press, 1999).

2. See, for example, Sten Lindroth, *Kungl. Svenska Vetenskapsakademiens historia 1739–1818* (Stockholm: Kungl. Vetenskapsakademien, 1967), part 1, vol. 2, 630–31; Koerner, *Linnaeus*; Kenneth Nyberg, *Bilder av Mittens rike: Kontinuitet och förändring i svenska resenärers Kinaskildringar 1749–1912* (Göteborg: Göteborgs universitet, 2001), 44; Staffan Müller-Wille, "Walnuts at Hudson Bay, Coral Reefs in Gotland: The Colonialism of Linnaean Botany," in *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*, ed. Londa Schiebinger and Claudia Swan (Philadelphia: University of Pennsylvania Press, 2005), 36, 39; Sverker Sörlin and Otto Fagerstedt, *Linné och hans apostlar* (Stockholm: Natur och Kultur/Fakta etc., 2004), 16–17; Daniela Bleichmar, "The Geography of Observation: Distance and Visibility in Eighteenth-Century Botanical Travel," in *Histories of Scientific Observation*, ed. Lorraine Daston and Elizabeth Lunbeck (Chicago: University of Chicago Press, 2011), 380. See also more generally the perspective in *The Linnaeus Apostles: Global Science and Adventure*, series editor Lars Hansen, 8 vols. (Whitby: IK Foundation, 2006–2012); in vol. 1 of the series, *Introduction* (2010), Sverker Sörlin offers a more nuanced interpretation in his chapter on "The Apostles," 151–79.

3. Mary Terrall, "Following Insects Around: Tools and Techniques of Eighteenth-