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Maria Sibylla Merian and the metamorphosis of natural history

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Known primarily for creating beautiful images of butterflies and flowers, Maria Sibylla Merian (German, 1647–1717) has remained largely unappreciated for her seminal contribution to early modern natural history. Merian was indeed a talented artist, but she clearly thought of herself as a naturalist, and employed both text and images to depict lepidopteran metamorphosis and behavior with unprecedented accuracy and detail. Merian documented larvae and adult insects feeding not only on plants, but also on other animals, and she depicted other creatures preying on insects. An image of battling spiders and ants and the accompanying text in her 1705 *Metamorphosis insectorum surinamensium* illuminated the world of tropical arthropods in a way that was groundbreaking, and set the stage for a new way to envision nature.

Introduction

In 1699 at the age of 52 Merian embarked on a study of insects and plants in Dutch Surinam, and followed this with the publication of *Metamorphosis insectorum surinamensium* [1], a book that established a new standard in natural history.[1] Contemporary field biologists often spend several years studying a handful of species, or even specialize on one organism. Yet Merian, unaided by the tools of modern science, investigated and recorded sixty species of plants and more than ninety species of animals in a period of less than 2 years. Following a process she developed decades earlier for her studies of European insects, Merian collected lepidopteran larvae as they fed on their host plants, and maintained them in captivity through metamorphosis to their adult form. At each stage she recorded her observations by taking extensive notes and making small paintings,[2] and in most cases she also preserved specimens of the insects. Upon her return to Amsterdam in 1701 Merian began writing and illustrating *Metamorphosis,* a work that was unusual in several ways. It was published as a large folio volume with pages 53 cm in height, because Merian thought it important to depict the insects as life-sized. She took care to paint the plants and animals 'from life' (although some were undoubtedly preserved), and offered for sale hand-colored editions, thereby publishing one of the earliest books to show the natural colors of neotropical organisms. The arrangement of the text and 60 plates in *Metamorphosis* was modeled after Merian's first two quarto volumes on European butterflies, moths and their caterpillars, *Der Raupen wunderbare Verwandelung und sonderbare Blumen–Nahrung,* published in 1679 and 1683 [4,5]. For her *Raupen* books Merian invented a much imitated composition in which the life cycle of one or more insects was arrayed around a plant that served as food for one of the species' larvae. Merian's images often have been analyzed by modern scholars in the fields of art history and visual studies but to a lesser extent by historians of science. Hence, the focus often has been on the aesthetic nature of the work, and with a few exceptions the natural history content of her images has not been carefully examined; the text of Merian's books has been investigated by even fewer historians.

The prodigious proboscis

Merian expressed in word and image what she observed when she raised insects in captivity, and was the first naturalist to portray each herbivorous insect with a host plant. Her text delved further into the importance of this relationship, albeit in more detail in the *Raupen* books than in *Metamorphosis*. Whereas the *Raupen* book texts focused on the natural history of the insects, her Surinam album included information on both plants and insects that would have been unfamiliar to most Europeans. The image created for Plate 38 (Fig. 1) in *Metamorphosis* is representative of Merian's work, showing a truncated time-lapse view of the life cycle of the Cecilia metalmark butterfly (*Methone cecilia*), the giant sphinx moth (*Cocytius antaeus*) and both fruit and flowers of the bellyache bush (*Jatropha gossypifolia*).[3] Ever practical, she indicated the edibility and uses of many Surinam plants, explaining for example that *Jatropha* could serve as a purgative. Merian's description of the Cecilia metalmark in Plate 38 was cursory and did not report a host plant, but her account of the giant sphinx moth was similar to the narratives in her *Raupen* books in that she included information on the

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[1] An excellent account of Merian's biography and work on *Metamorphosis* may be found in the commentary to the facsimile volume of the work [2]. This volume also contains the only published English translation of Merian's complete *Metamorphosis* text, and served as the source of translations for this article.

[2] Merian's studies of organisms and notes were later bound into a study journal that is now in St. Petersburg at the Russian Academy of Science. A limited edition facsimile volume with commentary documents her working habits and the history of her journal [3].

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[3] The images used in this article are photographs of original watercolors in the British Museum that were painted by Merian, possibly to serve as models for the printed engravings in *Metamorphosis*. The latter are mirror images of the watercolors with some very small variations, such as the distance of an insect from a flower. Most copies of *Metamorphosis* available for study were not hand-painted by Merian, leaving the accuracy of the coloring suspect, and in some cases, very poorly rendered.

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Fig. 1. Pen and ink with watercolor and bodycolor on vellum by Maria Sibylla Merian, *circa* 1704. This image is the basis of Plate 38 in *Metamorphosis* [1], and includes the Cecilia metalmark butterfly (*Methone cecilia*), the giant sphinx moth (*Cocytius antaeus*) and the bellyache bush (*Jatropha gossypifolia*). The larval and pupal stages of each insect are also shown. Photograph © The Trustees of the British Museum.

transformations of the insect as well as the feeding habits of both caterpillar and adult:

> The large green caterpillar ate the leaves both of this plant and of the sweetsop (described in Plate 14). It ate vigorously and greedily, yet had as little discharge and excrement as the smallest caterpillar; when touched it thrashed around wildly. On 23 June it remained still and shed its skin; the skin it discarded is lying on the leaf; after the molting it was no longer so green but became more reddish in color. The next day it changed into a liver-colored chrysalis with an external protuberance, like the one which can be seen on the stalk below. The chrysalis was very restless, throwing itself to and fro continuously for about a quarter of an hour. On 20 August there emerged a large moth with six orange and yellow spots on its body, whose four wings and six legs were strangely covered with black dots. Its long proboscis consists of two long tubules which in this species of moth are joined together, thus making a small tube through which they can suck honey from the flowers; when they have finished sucking they roll the proboscis up tightly and place it under their head between the eyes, so that it is scarcely visible [1].

This account was typical of Merian's natural histories, in that she described how and on what plants the larvae fed and the events and timing of transformations that occurred during metamorphosis. She usually related some behaviors of the larvae, as in her description of the defensive movements of the sphinx moth caterpillars. As in the image for Plate 38, Merian often drew further attention to the role of plants as larval food by showing damage done to the leaves by the voracious caterpillars. If she found that larvae ate more than one host plant, as was the case with the sphinx moth, she included that information. A novel feature of the insect could merit special attention, and in this species she detailed the astonishing proboscis, which is close in length to the moth's wing span 17 cm or more. Merian's life-sized image of the insect is accurate as to dimensions of both wing-span and proboscis, but she included the seemingly odd statement that the proboscis consisted of two tubules which are joined for feeding. The proboscis of a sphinx moth is formed as she described, but from two half tubules that are present only for a short while after the moth emerges from the pupa, a stage Merian observed and recorded in other moths from the same family. Soon after the emergence of a sphingid moth from its pupa, a single tubular structure is formed from the two halves, and exactly as she described, it is rolled up beneath the eyes when not in use to obtain nectar. Merian first depicted and commented on the split proboscis of a European sphingid moth in Plate 25 of her 1683 *Raupen* book, writing that 'at the front of its head is a very long, chestnut-brown horn, which is split and is sometimes curled in a spiral, sometimes stretched out very long' [5]. She did not explain its function in this earlier work, and it may be that she had not at this point observed the use of the proboscis, as these moths tend to feed at night. In other images of sphingid moths in *Metamorphosis* Merian variously depicts the proboscis as split when the moth is not feeding, or as a single tube when the moth is feeding, again reinforcing her words with clear images. The prominent proboscis in these moths can be seen in the pupal stage as a hooked appendage below the area where the eyes form. The larva as pictured is a late instar, and is rendered with near photographic accuracy by Merian; it would be identifiable to species by any entomologist familiar with tropical sphingid moths. Likewise the pupa and adult are realistically painted, although in nature the pupa would be found underground. Merian arranged her compositions to contain as much information as possible in one engraved plate, and this sometimes resulted in plants shown simultaneously in full flower and fruit, or a molted exoskeleton or pupa balanced precariously on leaves and stems.

A revolutionary image

Even in a book that must have seemed extraordinary for its time, the image portrayed in Plate 18 of *Metamorphosis* is remarkable (Fig. 2) and very different from most of Merian's compositions. In the space of a folio page Merian dramatized the life and death struggles of several species. The eye of the viewer is immediately drawn to the pink-toed tarantula (*Avicularia avicularia*) looming over a doomed hummingbird, its rear leg positioned over eggs in the small nest. Another tarantula of the same species is guarding its egg sac as it captures an ant, while the brown

Fig. 2. Pen and ink with watercolor and bodycolor on vellum by Maria Sibylla Merian, *circa* 1704. This image is the basis of Plate 18 in *Metamorphosis* [1], and includes the pink-toed tarantula (*Avicularia avicularia*), the brown huntsman spider (*Heteropoda venatoria),* an unidentified orb weaver of the Araneid family, a roach (*Blattaria* genus), army ants (*Eciton* genus), leaf cutter ants (*Atta cephalotes*) and a guava tree (*Psidium guineense*). The hummingbird does not match any known species. Photograph © The Trustees of the British Museum.

huntsman spider (*Heteropoda venatoria*) in the upper left attends an egg sac from which her young are emerging. The huntsman spider, a roach (*Blattaria* genus) and the small adult spider in the upper right (an unidentified orb weaver of the Araneid family) are under attack by army ants (*Eciton* genus). The guava tree (*Psidium guineense*) is the final victim here, as it is defoliated by leaf cutter ants (*Atta cephalotes*). The hummingbird does not match exactly any extant species, but has been identified by some as the ruby topaz, *Chrysolampis mosquitus*. Although the coloring is similar to the ruby topaz, a long curved beak is not found in this bird, and it could be that Merian painted a species that is now extinct.

The text accompanying Plate 18 is somewhat atypical in that it was more extensive than most of her entries in *Metamorphosis*, but like her other text it adds greatly to the description of these organisms, and so is included in full here:

> On Plate 18 I depict spiders, ants and humming-birds on a guava branch, because I found the largest spiders on the guava trees. On the following plate, number 19, I again show a guava with insects. For this reason I shall say nothing about it now, but shall proceed to describe the spiders. I found many of these large black spiders on the guava trees. They live in a round nest like the cocoon of the caterpillar depicted on the following plate; they do not spin long threads as some travelers would have us believe. They are covered with hair all over and have sharp teeth, with which they can bite fiercely, at the same time injecting a fluid into the wound. Their habitual form of nourishment is the ants which do not escape from them as they move up the tree, for these spiders (like all others) have eight eyes. With two of them they see upwards, with two downwards, with two to the right and two to the left. When they fail to find enough ants they take small birds from their nests and suck all the blood from their bodies. They shed their skin from time to time like the caterpillars, but I have never seen any of them fly. A smaller variety of spider shown here in its web carries its eggs in a ball under its body, where they hatch. These also have eight eyes, but they are distributed further over the head than with the large spiders.
>
> In America there are large ants which can eat whole trees bare as a broom handle in a single night. They have two crooked teeth, which cross over each other like scissors; with these they cut the leaves from the trees and let them fall so that the tree looks like a European tree in winter. Then the thousands of ants on the ground below carry the leaves to their nests, not for themselves, but for their young which are still worms, for flying ants lay eggs as flies do. These turn into larvae or maggots. These maggots behave variously. Some spin themselves into a cocoon and others, the majority, turn into chrysalises. The ignorant refer to these chrysalises as ants' eggs, but ants' eggs are far smaller; in Surinam they are fed to hens, and are better for them than oats or barley. The ants emerge from these chrysalises, shed their skin and acquire wings. They then 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.
>
> When they wish to go anywhere where there is no pathway they build a bridge; to do this the first ant sits still and bites into a piece of wood; the second places itself behind the first and clings tightly onto it; similarly the third clings onto the second, the fourth onto the third, and so on. And then they let the wind blow them until they have reached the other side. Then all the thousands of ants run over each other like over a bridge. These ants have a perpetual enmity with the spiders and all the insects of the country. They emerge once a year in enormous quantities out of their cellars; they come into houses and run from one room to the next, sucking the blood out of all animals, both large and small. They gobble up a large spider in a flash, for large numbers of the ants attack the spider so that it cannot defend itself. They run from one room to the next so that human beings even have to withdraw. When they have eaten the whole house clean, they move into the next and then finally return to their cellar.

> 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 wings as if motionless in the air; they are, with many brilliant colors, more beautiful even than the peacock [1].

Falsehoods or facts?

The interactions and behaviors of the various species in Plate 18 are mostly correct, but the scientific content of this entry has been called into question almost since *Metamorphosis* was published. An early critic of Merian's Surinam volume, the Reverend Lansdown Guilding, called Plate 18 an 'entomological caricature' [6]. Guilding, who studied natural history in the Grenadines and never set foot in Surinam, expressed doubt about several things. He did not believe that ants could construct a bridge with their bodies, a behavior that has since been well-documented in army ants. Guilding and other critics deemed a 'bird-eating spider' unlikely, and William MacLeay even went so far as to offer birds to a similar large spider to see if it would eat them. MacLeay reported that the spider fled from the birds and concluded that 'Madame Merian has told a willful falsehood. . .' [7]. A number of others were interested in this question, and in the same journal and year W.E. Shuckard summarized the findings of naturalists who agreed that such spiders could and did take small birds as well as insects [8]. Some recent publications on Merian continue to highlight perceived errors in her work while overlooking the copious factual content in the text and images. Reitsma, for example, correctly comments that Merian has mistaken the number of eggs for a hummingbird but then revisits the notion that the *Avicularia* does not eat birds [9], decades after it has been established that this is entirely possible.

Other comments by Merian, such as the reference to flying spiders, might seem puzzling unless the context is known. Martin Lister had written about flying spiders in 1678 and described the phenomenon now known as ballooning, in which young spiders are broadly dispersed by the use of silk threads used to catch air currents [10]. Merian may have been responding to Lister's writings when she stated that the *Avicularia* were not known to fly. She added the facts that they shed their skin (actually an exoskeleton, shed during growth phases) and lived in a cocoon-like nest rather than a web. The feeding behavior of *Avicularia* and distribution of its multiple eyes also are recounted accurately, and together with the text and detailed life-sized images build quite a complete picture of this animal and how it lives. Merian did not write about the egg-sac that she included with the female *Avicularia,* but she did mention that this was how the brown huntsman female carried its eggs and depicted this in the image.

Merian, like every naturalist and indeed every scientist, did get some things wrong. She was mistaken in implying that the huntsman spider builds a web, and she was not entirely successful in rendering ant anatomy, most likely due to their small size and the difficulty in preserving them intact. She exaggerated ant size relative to the spiders, possibly to make these small creatures more visible, and she incorrectly grouped together army ants and leafcutters. However, these errors no more invalidate Merian's work than do well-known misconceptions published by Charles Darwin or Isaac Newton cause their contributions to science to be called into question. In the case of Merian, however, the criticisms of Guilding and others seem to have taken a toll on her reputation as a careful observer of nature [11].

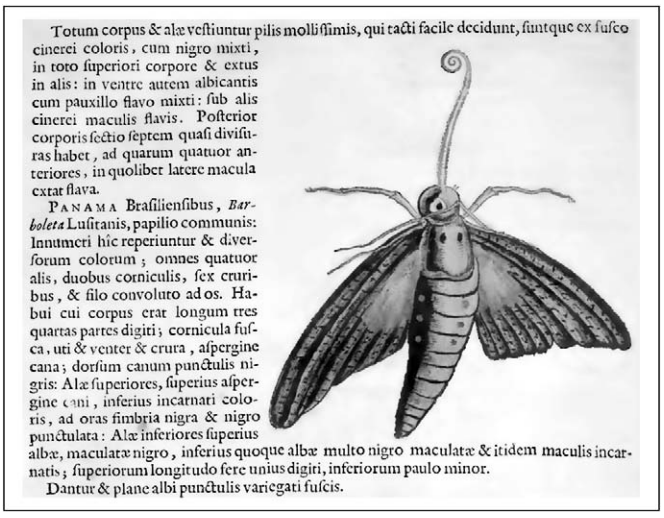
Integration of word and image

Metamorphosis presented a treasure trove of tropical biology to Europeans in both word and image. Merian's portrayal of the Surinam army ants and leaf cutter ants serves as a notable example, being the first published material on the chief behavioral traits of these significant tropical insects. The industrious leafcutter ants were described first, and Merian attempted to delineate their reproductive habits as well as their nocturnal harvesting of leaves with scissors-like mandibles. She described the incredible speed with which leaf cutter ants can defoliate a tree, and told of their deep underground nests. Merian was on the right track in her assumption that the leaf cutter ants feed plant material to their offspring, although they actually use it to culture fungi as larval food. Her account of the rapacious army ants followed, and she reported the migratory foraging raids for which these insects are notorious. Merian's description of the bridge-building abilities of the army ant was particularly detailed. Her account of these ants did not go unnoticed, and was cited by René Antoine Ferchault de Réaumur in his unpublished treatise on ants [12].[4]

Unlike Réaumur, contemporary scholars have tended to focus on Merian's images and the text, essential to understanding image content, has been given little consideration. A contributing factor may be the relative unavailability of her texts in English. A limited edition facsimile volume of *Metamorphosis* [2] is the only published English translation of Merian's full text, and this volume is available in very few libraries. A few passages from her *Raupen* books have been published in English, but the full text of the original 1679 and 1683 editions were published only in German. Several editions and compendia of her books were published after her death in a variety of languages, but all of these have greatly truncated text that conveys little information other than the color and appearance of the insects. Anyone seeing these books as the only representatives of Merian's work would have little idea of the natural history content of her original writings.

Merian's images need no translation and many have been widely reproduced in museum catalogs and elsewhere, making them accessible objects of study. Scholars who have viewed her images but perhaps have not read her complete text have stated that Merian made an error in associations between some plants and insects. Typically when Merian placed an insect on a plant other than its host she wrote that she did not know the host plant (more often

[4] Réaumur, considered the 'father' of French entomology, also applauded Merian for her study of lepidopterans in his seminal *Mémoires pour servir À L'histoire des insectes* [13], in which he referred to her 'amour véritable héroïque pour les insectes.'


Totum corpus & alæ veſtiuntur pilis molliſſimis, qui tacti facile decidunt, ſuntque ex fuſco cinerei coloris, cum nigro mixti, in toto ſuperiori corpore & extus in alis: in ventre autem albicantis cum pauxillo flavo mixti: ſub alis cinerei maculis flavis. Poſterior corporis ſectio ſeptem quaſi diviſuras habet, ad quarum quatuor anteriores, in quolibet latere macula extat flava.

PANAMA Braſilienſibus, *Barboleta* Luſitanis, papilio communis: Innumeri hic reperiuntur & diverſorum colorum; omnes quatuor alis, duobus corniculis, ſex cruribus, & filo convoluto ad os. Habui cui corpus erat longum tres quartas partes digiti; cornicula fuſca, uti & venter & crura, aſpergine cana; dorſum canum punctulis nigris: Alæ ſuperiores, ſuperius aſpergine cani, inferius incarnati coloris, ad oras fimbria nigra & nigro punctulata: Alæ inferiores ſuperius albæ, maculatæ nigro, inferius quoque albæ multo nigro maculatæ & itidem maculis incarnatis, ſuperiorum longitudo fere unius digiti, inferiorum paulo minor.

Dantur & plane albi punctulis variegati fuſcis.

Fig. 3. An unidentified sphinx moth from Piso and Marggraf's 1648 *Historia naturalis Brasiliae* [14].

the case in *Metamorphosis* than in the *Raupen* books) or explained that she wished to avoid repetition of plants when they served as host to more than one type of insect. Others have criticized her unnatural placement of pupae in some compositions, but Merian often described in her text where pupae would be found in nature. Merian did not intend that her book illustrations stand alone; she wrote expressly to clarify the relationships between plants and animals, and described behaviors and timing of events that could not be understood from a still picture. By overlooking her writings an essential element of her work is missed.

Merian's unique contributions

Merian was the first European naturalist to travel to the new world who was not financed by a government or patron with objectives of their own; she therefore was able to produce a work that was aligned with her own particular interests in the workings of nature. Merian's images of tropical flora and fauna are best appreciated by comparison with those that preceded the publication of *Metamorphosis*. Piso and Marggraf's 1648 *Historia naturals Brasiliae* included dozens of species of plants and animals arrayed like the sphinx moth image and descriptive text in Fig. 3 [14], a model unchanged from that seen in natural history encyclopedias from almost 100 years earlier. Charles Plumier published *Description des plantes de l'Amerique avec leurs figures* in 1693 [15] in a style similar to other botanical volumes of the period, showing the plant in isolation on a page (Fig. 4). Prior to Merian flora and fauna appeared separately for the most part, and few connections were drawn to other organisms in either text or image.

In an era of investigation dominated by the collection and classification of organisms, Merian's organic approach to the study of natural history was unusual and was not always understood by her fellow scholars. Merian responded to specimens sent to her by English collector James Petiver with a letter stating that she 'was not looking for any more creatures, but only at the formation, propagation, and metamorphosis of creatures, how one emerges from the other, the nature of their diet…' [2].

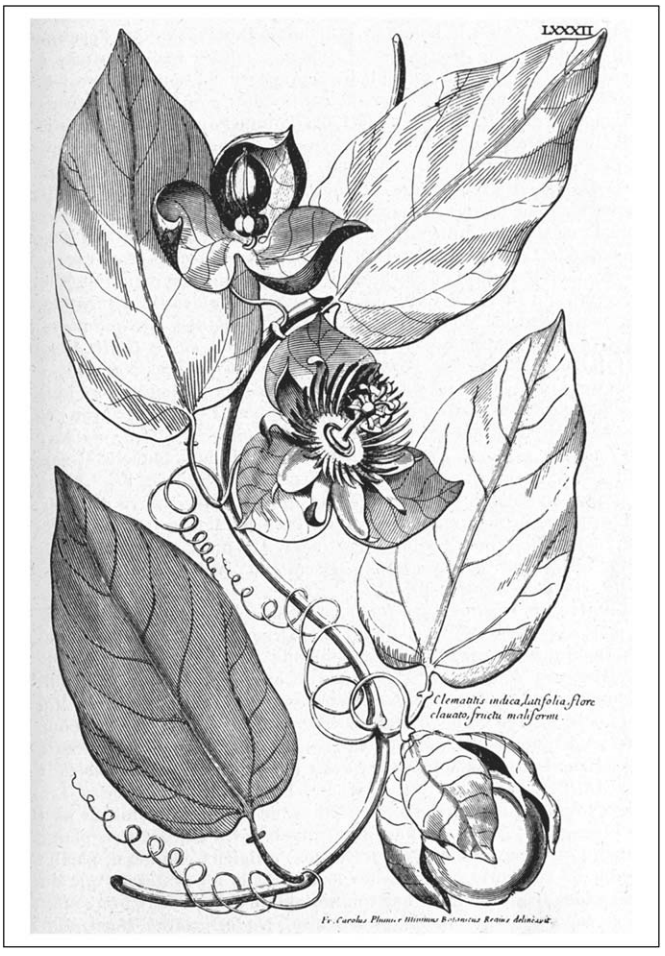


Fig. 4. Plate 82 from Plumier's 1693 *Description des plantes de l'Amerique* [15]. The plant is not a clematis, but is *Passiflora maliformis*, the sweet calabash.

She reinforced this view in the introduction to *Metamorphosis*, in which she described her motivation for undertaking the expensive and perilous journey to work in Surinam. Merian's curiosity was spurred when she saw the 'beautiful creatures brought back from the East and West Indies' in the possession of collectors in Amsterdam in which she 'found these and other insects, but without their origins and subsequent development' [1]. As she did in her *Raupen* books Merian focused on insects primarily and their plant hosts secondarily, but in *Metamorphosis* she broadened the scope to include information on other arthropods and two species each of lizards, snakes and frogs. Her interest in reproduction and development is reflected particularly in the two plates containing frogs, in which she describes their eggs, larval development and metamorphosis, being among the first to represent this accurately for any amphibian [16]. The image composed for Plate 56 of *Metamorphosis* (Fig. 5) also shows predation on a young tree frog (*Trachycephalus venulosus*) by a larval water bug (*Lethocerus* sp.), the second plate in *Metamorphosis* with a striking illustration of a vertebrate being consumed by an arthropod. In the image for Plate 23 (Fig. 6) Merian posed a rainbow whiptail lizard (*Cnemidophorus lemniscatus*) with her eggs and a single tiny hatchling on a banana tree (*Musa paradisiaca*). Merian took the eggs on board ship for her return journey in order to hatch them, but reported in the accompanying text that

Fig. 5. Pen and ink with watercolor and bodycolor on vellum by Maria Sibylla Merian, *circa* 1704. This image is the basis of Plate 56 in *Metamorphosis* [1] and depicts a marbled treefrog (*Trachycephalus venulosus*) adult with eggs, tadpoles and metamorphosing froglets. Also shown are a giant waterbug nymph and adult (*Lethocerus* sp.), and a water hyacinth (*Eichhornia crassipes*). Photograph © The Trustees of the British Museum.

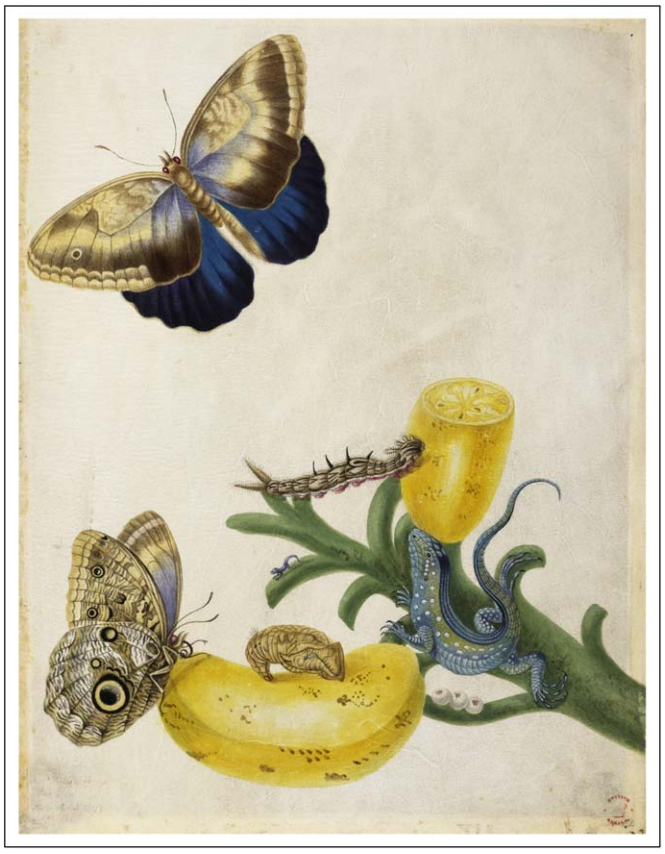


Fig. 6. Pen and ink with watercolor and bodycolor on vellum by Maria Sibylla Merian, *circa* 1704. This image is the basis of Plate 23 in *Metamorphosis* [1] and shows the rainbow whiptail lizard (*Cnemidophorus lemniscatus*) with eggs and a hatchling. Also included are the Teucer giant owl butterfly (*Caligo teucer*) with larvae and pupae and the fruit and stem of a banana tree (*Musa paradisiaca*). Photograph © The Trustees of the British Museum.

'without their mother or the proper nourishment they died' [1]. Due to health problems that have never been specified Merian was forced to leave Surinam earlier than planned, but she returned to her home in Amsterdam with a treasure trove of notes, paintings and specimens that she continued to study in the years leading up to the publication of her *magnum opus*, a work that was to hold a unique and influential place in natural history studies.

Merian's influence

David Freedberg wrote that *Metamorphosis* appeared 'at the apex of a tradition of scientific examination that had been growing for just over a century' [17],[5] and Egerton included a summary of Merian's accomplishments in his survey of the history of ecology [18], but there has been little detailed analysis of Merian's work by historians of science. Schmidt-Loske studied several watercolors and engravings by Merian in the British Museum and made note of many of Merian's observations on insects, but in reference to her lack of formal education comments that Merian 'was not a scholar' and describes her as an 'ambitious artisan' [19]. Ludwig likewise stated that Merian 'was not a scholar,' and added that she 'was among other things a painter, housewife, mother, and lover of nature' [20]. Recent scholarship on Merian often has focused more on her art and intriguing life story than on her contributions to science [*e.g.* 9,21,22] and her volumes on insects were perhaps better known and appreciated by her near contemporaries. Although Merian, like Anthony van Leeuwenhoek and several other early modern naturalists, was not a university-educated 'scholar' her books certainly were considered worthy of study by many who cited and even emulated her work. The quality of *Metamorphosis* and the *Raupen* books was such that Linneaus and his followers used Merian's images and descriptions to name dozens of plant and animal species [2]. In addition to Réaumur, the German naturalist Rösel von Rosenhof is known to have studied *Metamorphosis* and to have cited it in his publications on insects [23]; Rosenhof in fact credited Merian's work with inspiring him to publish *Insecten-Belustigung* [24]. In England, a circle of naturalists and collectors that included Hans Sloane and Richard Mead held Merian's work in high regard [25], and the images and text of those who studied these collections of Merian's books and original watercolors reflected her influence. The similarity of image composition and layout of Mark Catesby's *Natural history of Carolina, Florida, and the Bahama Islands* [26] has been addressed elsewhere [25,27], and this resemblance also is even more evident in numerous 18th- and 19th -century books on lepidopterans by artist-naturalists such as John Abbot, Moses Har-

[5] Freedberg also commented on the traditionally poor regard for natural history illustration, but writes about Merian's *Metamorphosis* that 'It is here, not earlier, that description and art finally come together in perfect accord' [17].

ris, and Jacob Hübner. In his book on English insects Eleazar Albin frequently cited Merian [28], and some of his images of insect metamorphosis closely mirror hers [27].

Both *Metamorphosis* and the *Raupen* books contributed greatly to the understanding of insect development, to classification schemes, and to understanding of the importance of larval host plants. However, it could be argued that the greatest influence of *Metamorphosis* was in its microcosmic vision of nature, for Merian was the first to elucidate through word and art what we now think of as food chains and interactions within ecological communities. Merian depicted small slices of these communities in vivid images such as that seen in Plate 18 – a novel view that presaged Darwin's allegory of nature's 'tangled bank.' Ironically, it may be that the focus on Merian's consummate artistry has diverted attention from the scientific content of both her images and text, and has been a factor in her being overlooked as a significant early modern naturalist.

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