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## About the cover

### *Pipa pipa* from an original watercolor by Maria Sibylla Merian

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The frogs on the cover plate represent a female with young of the Surinam toad, *Pipa pipa*. The original illustration by Maria Sibylla Merian (1647–1717) was prepared as a pen and ink drawing with watercolor and bodycolor on vellum. The image is the basis of Plate 59 in her book (1705) *Metamorphosis insectorum surinamensium*. The author published the book herself in Amsterdam. It contains 60 plates, each accompanied with a text page, most of which focus on insects, but other animals such as frogs, a lizard and a snake were included. The original paintings are now in the collection of the British Museum, London, and the photograph on the cover is copyrighted by The Trustees of the British Museum. Merian's masterpiece set a new standard for natural history books and it was an extraordinary undertaking of the time for her and one of her daughters to travel to South America to study the tropical flora and fauna of Surinam. In an article in this issue Kay Etheridge portrays Maria Sibylla Merian, her paintings, and the frogs she depicted for the book. The cover forms figure 3 in the article.

Linnaeus described the Surinam toad in *Systema naturae X*, the 10<sup>th</sup> edition of 1758 and named it *Rana pipa*. His description in translation reads, "Frog with stubby, four toothed front feet, clawed rear feet. Lives in Surinam. It hatches its young by laying them on its back." [Kenneth Jr Kitchell, and Harold A. Dundee. 1994. *A Trilogy on the Herpetology of Linnaeus's Systema Naturae X*]. Linnaeus actually described it for the first time in 1754, when he catalogued the collection of King

Adolf Fredrik of Sweden. This collection subsequently went to the Swedish Museum of Natural History in Stockholm, where a few specimens of *Pipa pipa* still occur, but one cannot positively attribute all or any one in particular as Linnaean type specimens. In 1745 Linnaeus, then Professor at Uppsala University, received and subsequently catalogued a donation of animals from then Crown Prince Adolf Fredrik, but he did not include all specimens and apparently left out the Surinam toad. Carl Peter Thunberg, who eventually took Linnaeus's post, found a Surinam toad in the collection and listed it in part I of his catalogue of various natural history collections in 1787. This specimen is extant (Lars Wallin. 2001. Catalogue of type specimens. 4. Linnaean specimens). [[www.evolutionsmuseet.uu.se/samling/UUZM04\\_Linnaeus.pdf](http://www.evolutionsmuseet.uu.se/samling/UUZM04_Linnaeus.pdf)]. It ought to be treated as a syntype.

In 2009 the Cologne-based publisher Taschen released a 192-page multilingual book entitled *Sibylla Merian, Insects of Surinam* authored by Katharina Schmidt-Loske. She has an academic background as a herpetologist and in 2008 she was appointed director of the Biohistoricum at the Museum Koenig, Bonn, Germany. The book includes reproductions of Merian's plates in the 1705-work (ISBN: 978-3-8228-5278-1). It is advertised as a reprint but it is not obvious if the 2009-plates are faithfully reproduced, as the size of the original plates are not stated. The original text has been replaced by commentaries. A second edition copy from 1719 with 72 plates was sold at an auction in Sweden on March 25, 2010 with a price including commission of \$124,000.

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## Maria Sibylla Merian's Frogs

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Maria Sibylla Merian (German, 1647–1717) is best known for her magnificent 1705 publication, *Metamorphosis insectorum surinamensium*, although she published earlier works on insect metamorphosis. Merian wrote the text and painted all of the illustrations for her books, and for the early volumes she produced most of the engravings. Contemporary scholarship has focused primarily on Merian's detailed images of lepidopteran and host plant life cycles, but Merian's Surinam album also portrays anuran metamorphosis, including the first European depiction of *Pipa pipa*.

Merian was born into a family of well-known artists and engravers, and there is ample evidence that she was drawing and painting at an early age. Even as she honed her painting skills she began her observations of live insects. Merian recorded in her study journal that she raised silkworms and other insects by the age of 13, and she continued similar studies throughout her life (Merian, 1976).<sup>1</sup> She did not limit her interest in metamorphosis to insects however, and her journal has an entry recorded from Frisia, Germany in 1686 in which she recounted collecting frogs for study: "I cut open the female and found there a 'matrix' like all the other animals have (thus they do not expel them through the mouth as some writers have claimed)..." (Merian, 1976, journal entry 203). In this same entry she wrote that she collected "frog lay" from water and observed it until

... after several days, the little black dots began to show signs of life and were actually feeding on the white slime that surrounded

them. Following that, they acquired little tails and swam in the water like fish. By mid-May they had eyes, and eight days later two little hind legs sprouted, and in another eight days two front legs. Now they looked like little crocodiles. Later the tail withered and they were proper frogs hopping out onto the land.

As was her habit, this text was accompanied by images of the animals meticulously painted on vellum. Merian also included images of two different adult frogs in her study journal. She typically used the images of insects and other animals recorded in the journal as models for the engravings in her subsequent natural history books, and as source images for watercolors produced for collectors (Figure 1 is an example of the latter).

At thirty-two Merian published her first "Raupen" or caterpillar volume. *Der Raupen wunderbare Verwandlung und sonderbare Blumen-Nahrung* contains fifty plates and associated text on European moths and butterflies and their larval host plants (Merian, 1679). The second *Raupen* volume of the same title and format was published four years later (Merian, 1683). After moving from Germany to Amsterdam in 1691 Merian was inspired by exotic specimens from the Americas that she observed in the possession of missionaries, merchants, and other collectors. In 1699 she traveled to Dutch Surinam specifically to study organisms of the tropics, and was the first European naturalist to do so independently. Once there, she worked for 21 months collecting, observing, and painting over 60 plant species and 90 animal species; the latter were primarily insects, although she included

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<sup>1</sup>Merian's study journal was published in a limited edition facsimile volume with commentary (Merian, 1976), which documents decades of natural history study. The original journal is in St. Petersburg at the Russian Academy of Sciences. Czar Peter the Great worked in Amsterdam when he was a young man, and, impressed by Merian's work, collected dozens of her original watercolors as well as the journal.





**Fig. 1.** Frog metamorphosis as depicted by Merian. Pen and ink with watercolor and bodycolor on vellum, 23 by 32 cm. This undated image from the British Museum prints and drawings collection was copied by Merian from entries made in her study journal in 1686. The frogs and tadpoles are most likely *Rana lessonae*, *Rana ridibunda*, or their hybrid. Photograph © The Trustees of the British Museum.

some spiders and vertebrates (Merian et al., 1980–1982).<sup>2</sup> She had intended a longer sojourn in Surinam, but illness forced her to return to Amsterdam, where she worked for three more years to complete her most famous book, *Metamorphosis insectorum surinamensium* (Merian, 1705). Buyers could choose between an uncolored edition and one that was hand-colored by Merian, possibly assisted by her daughters (Reitsma, 2008). Merian was skillful in her use of color and usually worked from fresh rather than preserved specimens, so her images provide a very accurate depiction of the pigmentation of organisms (Merian et al., 1980–1982).

The 1705 edition of *Metamorphosis* contains 60 plates and accompanying text, and it was the first book to offer colored images of neotropical

organisms. Each plate is set on a separate page, and the size of this 54 cm folio volume adds to the dramatic presentation of the organisms. Plates 56 and 59 depict both typical and atypical anuran reproduction in turn. Figures 2 and 3 (see also the cover) are photographed from original watercolors painted by Merian and therefore show the images as she intended them. The watercolors were acquired by Hans Sloane and are part of a complete set of the images from *Metamorphosis* now in the prints and drawings collection of the British Museum. It is not known if this particular series of paintings actually served as models for the engravers working on the plates for the book, because another complete set is housed at the Windsor Royal Library (collected by Richard Mead) and a third partial set is in St. Petersburg at the Russian Academy of Sciences (for a

<sup>2</sup> In 1980 a limited edition facsimile volume of Merian's watercolors for *Metamorphosis* in the Royal Library at Windsor Castle was produced; this was followed in 1982 by a companion volume that included an English translation of Merian's text from *Metamorphosis*, identification of the plants and animals, commentary, an extensive biography, and English translation of several letters written to and from Merian (Merian et al., 1980–1982).

discussion of this conundrum see Reitsma, 2008). Aside from being mirror images, the printed engravings are virtually identical to these original watercolors.<sup>3</sup>

#### Plate 56– *Trachycephalus venulosus*

Merian pictured this tree frog in water, and indeed it would have been found in or near a breeding pond in the rainy season (Savage, 2002). The text accompanying each of Merian's plates is usually a straightforward description of her observations (translated from Merian, 1705):

Many frogs swam in this water, with two ears on the head and a greenish-brownish cloud-like pattern. There was a little ball on each toe of the foot, which Nature has given these creatures in order to be able to move across these swampy waters. They lay their seed on the shore: if one wants to observe them, one should put some of the seed in a jar; one places a sod of grass in the bottom, the seed on this and then fills the jar up with water. The seeds are like little black speckles nestled in white slime. The undeveloped black speckles live off the slime and gradually begin to move. They develop tails and swim in the water after about eight days; five of them are shown here above the frog. They get eyes a few days later and they get hind legs a little later again. They get two front legs at the front, which burst through the skin, eight days later. When they have four legs, the tail rots and falls off and hence you have frogs that walk out of the water towards land. The water and grass sods need to be refreshed every now and then and breadcrumbs added to the water as soon as one observes movement. Everything was in agreement with Mr. Van Leeuwenhoek's previous observations (Leeuwenhoek, Fol. 113. a 126, Missive 25 September 1699).

It is interesting to note that she speculated incorrectly on the function of the toe pads, and it could be that she was not familiar with the European tree frog. She also confused the vocal sacs for "ears," she depicted the larvae

without the external gills that should have been present in this species, and she did not understand that tail is reabsorbed during metamorphosis. It appears that she relied on her 1686 tadpole study (copy shown in Figure 1) to supply the image for the earliest stages of this frog, but she did show toe pads on the froglet being consumed by the Belostomatid water bug. The holotype for *T. venulosus* is from Seba's collection (Laurenti, 1768), but another early name for this animal was *Rana meriana* (Shaw, 1802) so that she was credited at some point for its 'discovery.'

#### Plate 59– *Pipa pipa*

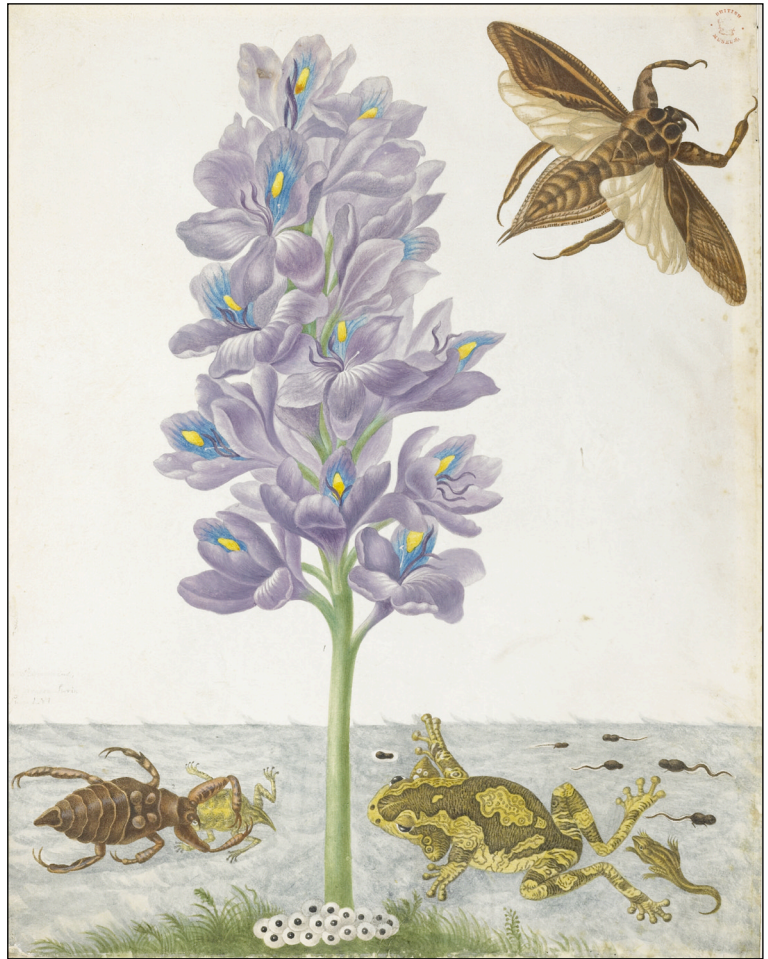
Merian was the first European to record the image of *Pipa pipa* (Merian, 1705: Plate 59). A translation of the text that accompanied the plate reads,

To finish off my work on insects, something that does not fit in well is an aquatic animal or toad. The female carries her young on her back; her uterus runs down along her back and she catches her seeds there and they develop. When they ripen, they work their way out of the skin; creeping out one after the other as from an egg. When I saw this, I threw the old one with her remaining young (some of which had their heads sticking out, others were half out) in alcohol. These toads are eaten by the blacks and apparently highly appreciated. They are blackish-brown in color with front legs like those of frogs but hind legs like those of ducks.

Naturalists viewing this image for the first time were undoubtedly astounded by the idea of an aquatic frog whose fertilized eggs develop and hatch from the dorsal integument. Merian related preserving the adult and her young in brandy, probably in order to have a specimen to observe more closely as she painted it. However, she must have observed one or more specimens over time to have been able to see and paint all of the stages, because she depicted the transformation from egg to free-swimming

<sup>3</sup> I have examined both the Windsor library 'originals' and those at the British Museum, and these watercolors differ only slightly from each other and from the first edition copies of *Metamorphosis* colored by Merian. In some engravings animals are moved slightly closer to a plant, perhaps to fit constraints of copper plate printing, but the colors and details of drawing do not vary much.

**Fig. 2.** *Trachycephalus venulosus* with tadpoles and eggs (circa 1704). Maria Sibylla Merian. Pen and ink with watercolor and bodycolor on vellum. The water hyacinth (*Eichhornia crassipes*) and the large predatory waterbug (nymph and adult, *Lethocerus* sp.) could occur in the same habitat. This image is the basis of Plate 56 in *Metamorphosis* (Merian 1705). Photograph © The Trustees of the British Museum.



form within the single image. The *Pipa pipa* young are more accurately portrayed than those of *Trachycephalus venulosus*. The anomalous hermit crab and the lack of detail in the forefeet do not detract from the information conveyed by Merian's representation of this unusual form of amphibian reproduction. Merian's

watercolors of *Pipa pipa* at Windsor and the British Museum also reveal something absent in the printed books, in that she tinted the eggs with gold to indicate more accurately their true color. The cost of doing this in the editions of *Metamorphosis* that were hand colored may have been prohibitive, so perhaps she sacrificed some color accuracy as a business decision. This species was named by Linnaeus (Linnaeus, 1758) based among others on the four images in Seba's *Thesaurus* (Seba, 1734, Plate 77).

### Merian's contribution and influence

Merian was one of the first artist/naturalists to create an accurate and complete image of

amphibian metamorphosis, both in her study journal and in the plates of *Metamorphosis*. Earlier images of tadpoles with frogs appeared in Guillaume Rondelet's *L'histoire entière des poissons* (Rondelet, 1558). However Rondelet's frogs looked similar to those of medieval bestiaries and the tadpoles are quite amorphous. Konrad Gesner's 1586 animal encyclopedia included a more accurate image of a mature frog that he termed *rana perfecta* as well as an incompletely metamorphosed froglet that he described as *foetus rana caudatus*, but no other stages were shown (Gesner, 1586). Oliger Jacobaeus was one of the first to illustrate the stages of amphibian metamorphosis from egg to adult, but his drawings were primitive and contained many anatomical errors (Jacobaeus,



**Fig. 3.** *Pipa pipa* female with young by Maria Sibylla Merian. Pen and ink with watercolor and body-color on vellum. The plant (*Sesuvium portulacastrum*), mollusk shells and crab are saltwater organisms, and probably were added for decorative effect. This image is the basis of Plate 59 in *Metamorphosis* (Merian 1705). See also the cover. Photograph © The Trustees of the British Museum.

frame, and she showed the developing young from various angles. In her study journal, she also depicted both ventral and dorsal views of the developing froglet. Unlike many earlier images of anurans, Merian's images portrayed well-observed forms that did not rely on old archetypes (e.g. those showing frogs and

tadpoles with a pronounced neck). Merian's images of tadpoles certainly were not as detailed as those by Leeuwenhoek or Swammerdam, and although she mentioned using a hand lens (Merian, 1705), it is not known if she had access to a microscope. Merian was aware of Leeuwenhoek's work, and like him, she understood that frogs did not arise by spontaneous generation, a common belief in the 17<sup>th</sup> century that persisted to some degree into the 18<sup>th</sup> century (McCartney, 1920).<sup>5</sup>

1686). Leeuwenhoek made a detailed drawing of a tadpole and described aspects of metamorphosis<sup>4</sup>, but unlike Jacobaeus he did not depict multiple stages of development. Jan Swammerdam used a microscope to assist in making highly detailed drawings of eggs, larvae and adult frogs, but these images were not published until decades after his death, and well after Merian's 1705 *Metamorphosis* (Swammerdam, 1737–38). Merian's depictions of anuran larvae and adults were different from those of her predecessors in several ways. Notably, she provided color images, she portrayed the complete life cycle in one

After Merian's death in 1717 her daughter Dorothea sold the engraved copper plates

<sup>4</sup> Leeuwenhoek included this information in an unpublished letter to the Royal Society in London (1688, *Missive* 65).

<sup>5</sup> Unlike many of her contemporaries, she also understood that insects reproduced like other animals, writing that "all caterpillars, as long as the butterflies have mated beforehand, emerge from their eggs" (translated from preface of Merian, 1679, iv).



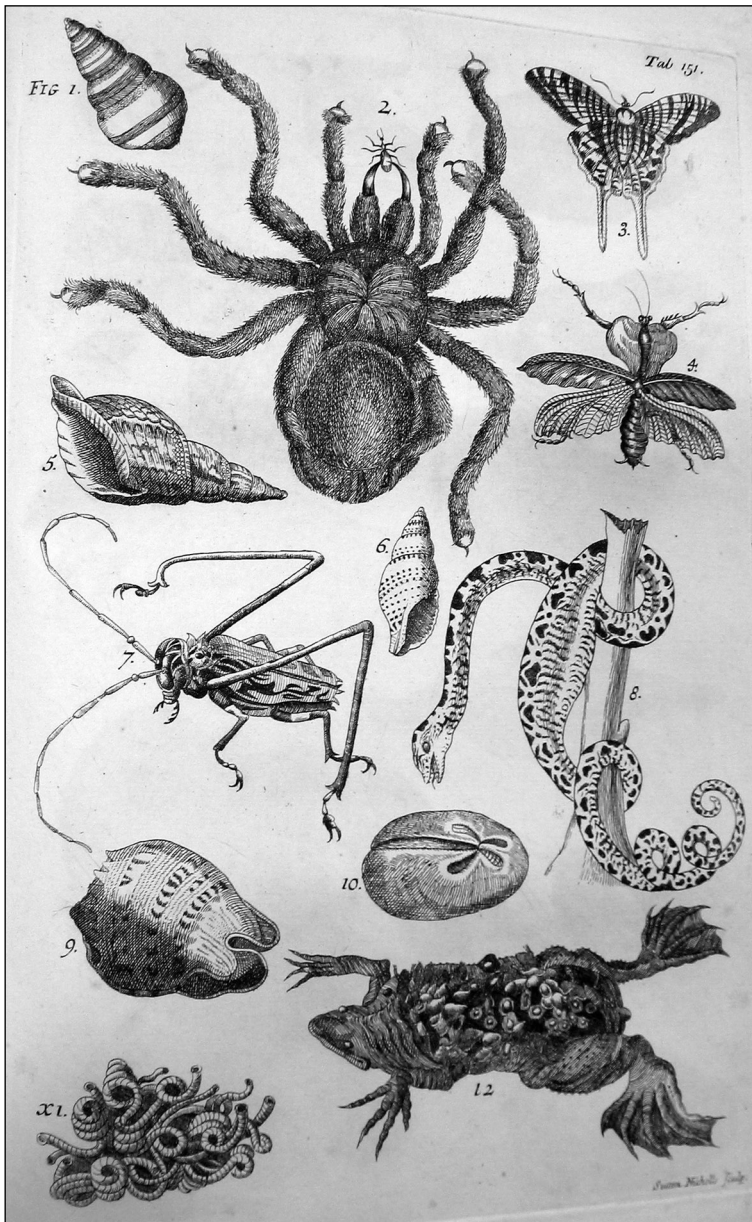
for *Metamorphosis* to the publisher Joannes Oosterwijk, who added twelve additional plates to *Metamorphosis* in the 1719 edition (Reitsma, 2008). Most of the additional plates appear to have been engraved based on images by Merian, but at least two of the plates were not her work (Merian et al., 1980–1982). The additional plates remained in the subsequent 1726, 1730 and 1771 editions, which appeared in Latin, Dutch, German and French. One of the added plates, the ‘frog-fish’ (Merian, 1719, Plate 71), was an image taken from the first volume of Seba’s *Thesaurus* (Seba, 1734, Plate 78). The frog depicted is the paradox frog, *Pseudis paradoxa*, which is known for a tadpole stage that is large relative to the adult frog. However, the Seba plate included a stage in which the tadpole becomes a fish, and this strange process is described in the text accompanying Plate 71 in the posthumous editions of *Metamorphosis*. The textual description was written in the first person by an unknown author, and referred to the ‘drawing’ as being a gift from Seba, thus giving the impression that Merian believed this to be an accurate representation of events. Because many more copies of the later editions of *Metamorphosis* were printed than of the original 60-plate volume, this fabricated sequence of transformations became associated with Merian and subsequently damaged her reputation for accurate observation. In 1759 George Edwards cited Merian in his address to the Royal Society on the “Frog-Fish of Surinam” and expressed skepticism about the image and text, stating that “Nature ... is not accustomed to act in such a manner” (Edwards, 1759). Later authors were more critical, and as one author wrote “the unusual transformations here recorded by the fair author have, of course, no foundation in fact” (Guilding, 1834, p. 375).

James Petiver corresponded several times with Merian about the possibility of publishing an English translation (Merian et al., 1980–82),

but it appears they could not agree on the format or terms. Petiver later settled for using Merian’s animal images in his *Historiam Naturalem Spectantia* (Petiver, 1767) in which animals were organized according to his notions of classification and removed from association with other plants and animals (Figure 4). Even though Maria Sybilla Merian brought two new species of frogs and dozens of species of plants and insects to the attention of European naturalists, her interest was not in naming or classifying, but as she wrote to Petiver<sup>6</sup>, in “the formation, propagation, and metamorphosis of creatures, how one emerges from the other, the nature of their diet...” (Merian et al., 1980–1982). Perhaps for this reason she depicted both species of tropical frogs as swimming underwater, an innovative composition that emphasizes the importance of water in their reproduction. Merian also presented her subjects as part of a food chain, as in the view showing insect predation on the young tree frog. In unpublished watercolors of a European frog with tadpoles she showed the adult about to swallow an insect (see for example Figure 1).<sup>7</sup> Merian’s work influenced many subsequent naturalists, including entomologists like Eleazar Albin, but also August Johann Rösel von Rosenhof and Mark Catesby, both of whom published illustrated books that included amphibians (Etheridge, 2007). In 1728 von Rosenhof was introduced to Merian’s *Metamorphosis*, and was inspired to write the *Historia Naturalis Ranarum* on German anurans, which beautifully illustrates their reproductive cycle from mating through metamorphosis, as well as their external and internal anatomy (Rösel von Rosenhof, 1758). Rosenhof also included small images of frogs in their “habitat,” and the frontispiece of *Historia Naturalis Ranarum* seems particularly influenced by Merian’s imagery. Mark Catesby’s two volume *Natural History of Carolina, Florida and the Bahama Islands* (Catesby,

<sup>6</sup> Merian wrote to James Petiver on 27 April 1705 in response to specimens he sent to her (Sloane 4064, fol. 70, British library Department of Manuscripts).

<sup>7</sup> This scene was produced more than once by Merian, and I examined nearly identical watercolors of the frogs in the print collections at the British Museum and the Minneapolis Institute of Arts. Merian frequently reused images, so other copies may exist.



**Fig. 4.** Images from *Metamorphosis* (Merian, 1705) reproduced in plate 151 of Petiver (1767). The Pipa is from Merian's plate 59, and the tree boia (probably *Corallus hortulanus*) is from Plate 5. Image courtesy of the Department of Library Services, American Museum of Natural History.

Some contemporary scholars view Merian primarily as a skilled artist, but she clearly saw herself as a naturalist. As was the case with many early naturalists she was not formally schooled, but she studied in the collection cabinets and libraries of Amsterdam, and she read and cited the work of Leeuwenhoek, Moffet, Swammerdam, Goedart and others. In the preface to *Metamorphosis* she wrote of her wish to paint and to describe her subjects from life, and stated that she “withdrew from society and devoted myself to these investigations” (Merian 1705). Merian's textual descriptions undoubtedly

1729) is similar to Merian's *Metamorphosis* in design, size and image composition, and it is well established that he was familiar with Merian's work (Meyers, 1997). Like Merian, Catesby detailed the diet and ecological relationships of many of the organisms that he observed, although he did not include any images of amphibian reproduction.

contributed to early modern natural history, but her larger influence came from her pioneering images. Unlike the illustrations of earlier natural history volumes, Merian's portrayals leave viewers with a sense of the animal as a living organism residing in a habitat, rather than as a specimen isolated on a page.

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