

T H R E E

Life Imitates Life

A river always leads to some inhabited place. If we do not meet with agreeable things, we shall at least meet with something new.

—Cacambo in *Candide*, Voltaire (1759)

“It was the best of times, it was the worst of times . . .” So began Charles Dickens’ famous novel of 1859, *A Tale of Two Cities*. Returning from the Amazon that same year, Henry Walter Bates could begin his tale with the same words.

The best of times was certainly daily life in a naturalist’s paradise:

I rose generally with the sun, when the grassy streets were wet with dew, and walked down to the river to bathe: five or six hours every morning were spent in collecting in the forest . . . the hot hours of the afternoon . . . and the rainy days were occupied in preparing and ticketing the specimens, making notes, dissecting, and drawing. I frequently had short rambles by water in a small *montaria* [type of canoe] . . . the neighborhood yielded me . . . an uninterrupted succession of new and different forms in the different classes of the animal kingdom, but especially insects.

The worst of times was perhaps the first year on his own upriver, after separating from his companion Alfred Wallace in March 1850:

Twelve months elapsed without letters or remittances. Toward the end of this time my clothes had worn to rags: I was barefoot, a great inconvenience in tropical forests, notwithstanding statements to the contrary that have been published by travelers; my servant ran away, and I was robbed of nearly all my money.

Broke, lonely, unsure of his prospects and pressed by letters to return home to the family hosiery business, Bates went fourteen hundred miles downriver to the port town of Pará intending to find a boat home. Yellow fever had ravaged the place, and soon after arriving, Bates too was stricken.

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But Bates did not go home. He turned around and spent eight more years in the Amazon, eleven years in total. *Eleven years!* Why did he stay, and for so long? How did he bear it?

The answer to the first question is that Bates received a timely dose of fresh funds and a letter from his agent in London saying that the specimens he had sent were being very well received. One new butterfly species, *Callithea batesii*, had been named after him. He changed his mind and renewed his determination to go far upriver as he had originally planned.

The length of his adventure was dictated by the massive scope of the Amazon. With more than one thousand tributaries draining about 2.7 million square miles, the Amazon is the largest of any river system (see Figure 3.1). Bates roamed up and down about two thousand miles of the main river in the course of these years. (The ten largest rivers in the system span fifteen thousand miles.) Travel was almost exclusively by water and was slow — very slow. Powered by only paddles or sails, pounded by storms and rain, and subject to changing winds, or no wind at all, Bates was often a passenger in some small trading vessel plying the river, or a canoe belonging to members of one of the many local tribes. Here’s a scene from a typical crossing Bates made so that he could hunt for a monkey on the opposite bank:

We were about twenty persons in all, and the boat was an old rickety affair . . . In addition to the human freight we took three sheep with us . . . Ten Indian paddlers

carried us quickly across . . . When about half-way, the sheep in moving about, kicked a hole in the bottom of the boat. The passengers took the matter very coolly, although the water spouted up alarmingly, and I thought we should inevitably be swamped. Captain Antonio took his socks off to stop the leak, inviting me . . . to do the same, whilst two Indians baled out the water . . . We thus managed to keep afloat.

By managing only a few miles or so at a stretch, the branches and twigs of the Amazon system would seem endless. Bates wanted to see all of the expansive river's treasures. That passion and determination, and the rewards of dashing into the forest at nearly every bend, seem to have offset the unrelenting heat, malaria, yellow fever, fire ants, biting flies, and intense loneliness that he endured.

Those rewards were many — river dolphins, anteaters, frigate birds, anacondas, hummingbirds, bird-eating spiders, all sorts of monkeys, jaguars, caimans, blue hyacinthine macaws, parrots, eagles, five species of toucans, and butterflies — flocks of butterflies. Bates collected 14,712 animal species in all, of which more than 8,000 were new to science.

Eventually, the grueling work, bad and insufficient food, and overall deterioration of his health convinced Bates to return home to England. The parting was bittersweet:

On the evening of the third of June [1859], I took a last view of the glorious forest for which I had so much love, and to explore which I had devoted so many years. The saddest hours I ever recollect to have spent were those of the succeeding night, when the mameluco pilot left us free of the shoals and out of sight of land . . . I felt that the last link which connected me with the land of so many pleasing recollections was broken . . . Recollections of English climate, scenery, and modes of life came to me with a vividness I had never before experienced during the eleven years of my absence. Pictures of startling clearness rose up of the gloomy winters, the long grey twilights, murky atmosphere, elongated shadows, chilly springs, and sloppy summers . . . To live again amidst these dull scenes I was quitting a country of perpetual summer . . . It was natural to feel a little dismayed at the prospect of so great a change . . .

Returning in the summer of 1859, Bates' timing was quite fortunate. Within months Darwin's *Origin of Species* would appear and give Bates a concrete framework for thinking about all he had seen and collected.

The Butterflies of Ega

No group of animals made a greater impact on Bates than the butterflies of the Amazon. They were, of course, highly prized back home for their beauty. Because Bates made his living by selling specimens, he paid careful attention to the varieties in each locale he visited.

The variety was overwhelming. In the vicinity of Ega alone, in the Upper Amazon where Bates spent more than four years, he found 550 distinct species of butterflies. This figure towers over the just sixty-six species in all of Britain and the three hundred or so in all of Europe.

The butterflies at Ega and throughout the Amazon presented several puzzles to Bates' expert eye. For example, despite years of experience he could never tell some species of *Leptalidae*¹ from those of *Heliconidae* while they were in flight. Their wing markings were very similar and they flew together in the same parts of the forest. Only upon close inspection after capture could Bates tell from finer details of the wing vein and color patterns which species was which. One species, *Leptalis theonoë*, in its different varieties, resembled several different species of *Ithomia* butterflies.

Bates was very careful in noting where certain varieties were present or absent. He noticed that none of the particular *Leptalis theonoë* types that resembled a particular *Ithomia* species was found in any other district or country. The *Leptalidae* "counterfeits" were only passing themselves off where the real *Ithomia* species existed in abundance. Bates termed this phenomenon "mimetic analogy," or mimicry.

When Bates read *The Origin of Species*, he was one of the few immediate adherents. As he contemplated his butterflies, he realized the significance of mimicry as evidence for the process of natural selection. He struck up a correspondence with Darwin in 1860, just as the firestorm of controversy was erupting over the elder's great book. Bates wrote to Darwin, "I think I have got a glimpse into the laboratory where Nature manufactures her new species."

¹ Bates' original term for the group has been changed to *Dismorphia*.

Darwin was positively thrilled. Bates, who had no formal scientific position, was feeling a bit discouraged at the time at not being part of the scientific establishment. For the first three years after returning from the Amazon, he lived back in Leicester with his family.

But Darwin rooted him on. He urged Bates to present his work to the most important scientific societies, to publish in the most influential journals, and to write an account of his journey as a travel narrative, as Darwin had done for his *Beagle* voyage. Bates gobbled up Darwin's advice. Theirs was a warm, symbiotic friendship.

One of the Most Remarkable and Admirable Papers

Bates set to work on both the formal scientific description of his Amazon collections and a book on his travels. Both were massive tasks. Bates would later remark that he would rather spend another eleven years in the jungle than go through the ordeal of writing another book.

But the same discipline that brought him success in the jungle brought him success as a scientist and author. His most important paper, with the misleadingly dull title, "Contribution to an Insect Fauna of the Amazon Valley, Lepidoptera: Heliconidae," laid out the evidence and a mechanistic explanation for the phenomenon of mimicry.

Bates noted that several species of *Dioptis*, a genus of moths, also mimic species or local varieties of *Ithomia* butterflies. He explained that a series of mimetic relationships also occurred in the Old World, between Asiatic and African *Danaidae* butterflies and species of other families of butterflies and moths. Most importantly, he underscored that no instance was known in these families of a tropical species of one hemisphere counterfeiting a form belonging to the other hemisphere. In other words, these were not accidental resemblances of butterflies with different ranges, the mimicry occurred among species found in the same area (Figure 3.2).

Furthermore, Bates knew firsthand that mimicry occurs among other insects. Along the banks of the Amazon he found parasitic bees and flies that

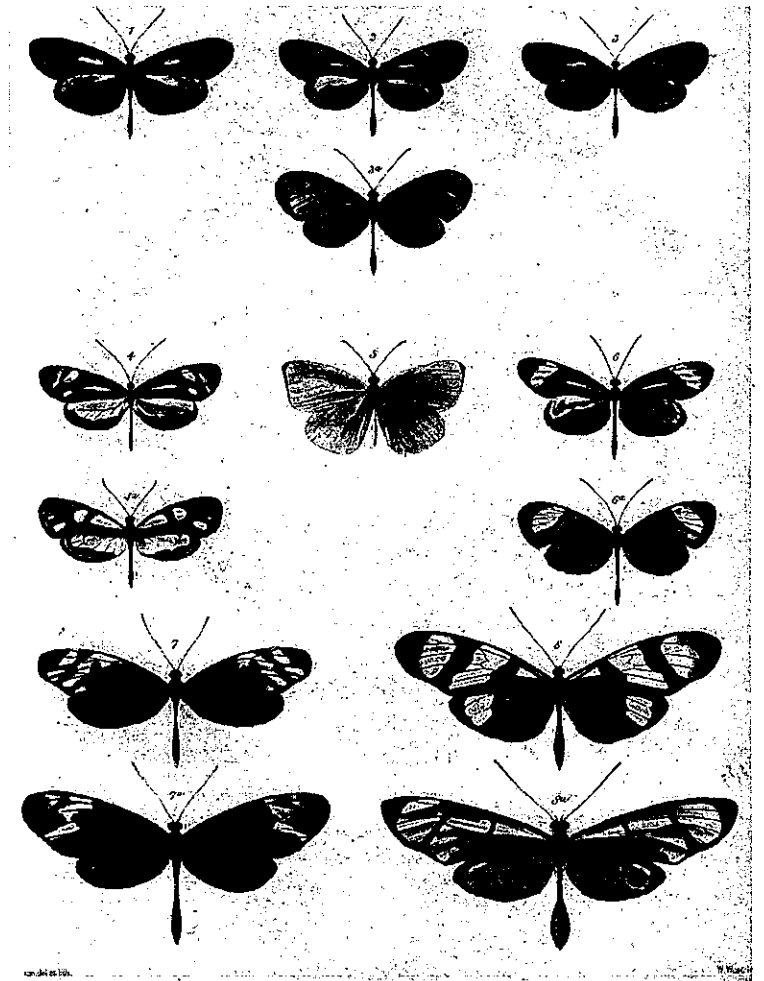


FIGURE 3.2 *Mimicry in butterflies.*

This is an original plate from Bates' 1862 paper reporting the discovery of mimicry. The butterfly at the center (5) is *Leptalis nehemia*, the typical butterfly of the family.

The other *Leptalis* butterflies (1–8) deviate greatly from this pattern, as they are mimics of other species. Each pair (3/3a, 4/4a, 6/6a, 7/7a, 8/8a) illustrates mimicry between *Leptalis* and species of other families. Specimens 3a, 4a, and 6a are members of the genus *Ithomia* that mimic varieties of *Leptalis theonoe* found in the area of Sao Paulo. Specimens 7a and 8a are members of the *Mechanitis* and *Methona* genera that mimic *Leptalis amphione* and *Leptalis orise*.

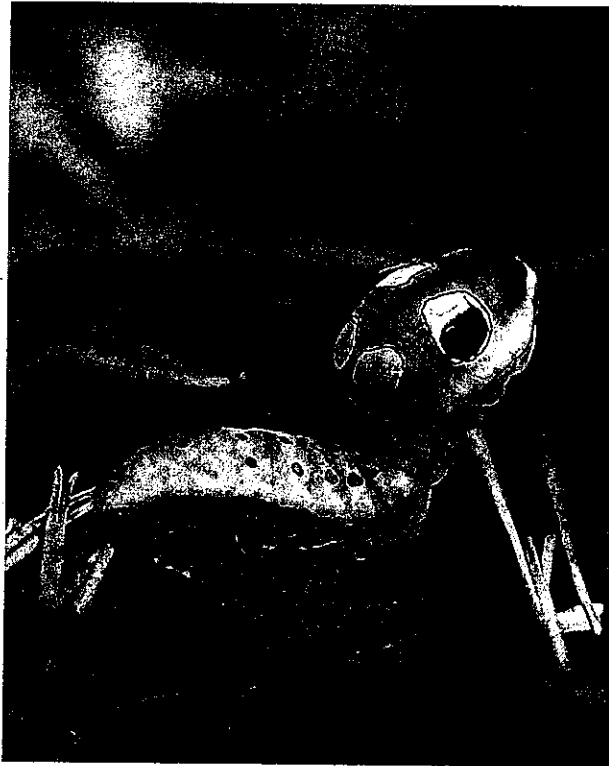


FIGURE 3.3 *Caterpillar mimic of snake head.*
 First discovered by Bates, a number of species mimic the appearance of snake heads. This is the Spicebush Swallowtail caterpillar (*Papilio trollus*).
 Photo by Mary Jo Fackler.

do not build nests but mimic the forms of nest-building bees to live “all expenses paid” in their nests. He found a cricket that was a good imitation of a tiger beetle and always found on trees frequented by the beetle. The most striking example of imitation was a very large caterpillar he found that, when stretched in the foliage of a tree, startled him by its resemblance to a small snake. The caterpillar had black spots on segments of its head which when expanded resembled the head of a viper (Figure 3.3). When Bates carried the specimen into the local village it frightened everyone who saw it.

Bates saw mimicry in a Darwinian light and proposed that the specific mimetic forms of insects were adaptations. He witnessed, in the Amazonian jungle, that every species maintained its existence by virtue of some traits that enabled it to withstand “the battle of life.” He knew hundreds of examples of how animals conceal themselves from their enemies. Clearly, one species disguising itself as another was one of these self-preservation strategies, or in Bates’ words, “The adaptive resemblance of an otherwise defenseless species to one whose flourishing race shows that it enjoys particular advantages.”

The advantages of mimicking a poisonous snake were obvious, but what advantages did the *Heliconidae* butterflies possess that made them so abundant, and the objects of imitation? It was not obvious what might help them escape the many insect eaters of the forest. Bates, though, had a good and ultimately correct idea. He knew too well that some butterflies secreted foul-smelling fluids and gases when he handled them. He noticed that when he laid such specimens out to dry, the various jungle vermin were less likely to carry them off. Bates also never saw the flocks of slow-flying *Heliconidae* pursued by birds or dragonflies, for which the butterflies would be easy prey. Nor when resting were the *Heliconidae* attacked by lizards or predacious flies, which pounced on other butterflies. Bates surmised that the *Heliconidae* must be unpalatable, and that other palatable species disguise themselves by mimicking the wing patterns of the *Heliconidae* and are thereby protected from predators.

Bates saw the origin of mimicry in general terms — as the same process that involves the origin of all species and adaptations. The case of *Leptalis theonoë* and *Ithomia* was most telling. The form of the *Leptalis theonoë* species in each region depended on the form and colors of the *Ithomia* butterflies in each region, which varied from place to place. Bates asked in his paper: How are local races formed out of the natural variations of a species?

The explanation of this seems to be quite clear on the theory of natural selection, as recently expounded by Mr. Darwin in the ‘Origin of Species’ . . . If a mimetic species varies, some of its varieties must be more and some less faithful imitations of the object mimicked. According, therefore, to the closeness of its persecution by enemies, who seek the imitator, but avoid the imitated, will be its tendency to become an exact counterfeit, the less perfect degrees of resemblance being, generation after generation, eliminated, and

only the others left to propagate their kind . . . To exist at all in a given locality, our *Leptalis theonoë* must wear a certain dress and those of its varieties that do not come up to the mark are rigidly sacrificed . . . I believe the case offers a most beautiful proof of the theory of natural selection.

So did Darwin. He called it “one of the most remarkable and admirable papers I ever read in my life,” and he assured Bates, “It will have lasting value.” For Darwin and other proponents of natural selection, Bates’ work was a powerful display of the process. Darwin’s evidence in *The Origin of Species* had relied heavily on the analogy of natural selection to the domestication of animals. With Bates’ observations, Darwin had rich, independent evidence of natural selection in nature.

Argument and Evidence

Mimicry became a focal point of the debate between proponents and opponents of the theory of natural selection. The debate was, for several decades after the publication of Bates’ paper, mostly a matter of different interpretations of the same observations. Of course, the better approach was to gather more evidence that would weigh for or against natural selection as a cause. Such evidence has unfolded as biologists studied mimicry in greater depth.

One of Bates’ key inferences was that the species being mimicked is unpalatable to predators and that the palatable species gains protection by imitating the unpalatable species’ appearance. This would imply that predators learn or inherently know to avoid the unpalatable form.

There were many subsequent investigations of this suggestion, but the most notable controlled studies were conducted by Jane van Zandt Brower beginning in the late 1950s. Using wild caught birds, Brower showed that many butterfly species thought to be unpalatable were rejected and avoided by birds. Furthermore, birds showed a tendency to learn rapidly from experience to recognize unpalatable butterflies, and to reject those resembling them.

A second key aspect of mimicry is the expectation that protection from predators should break down where the unpalatable form is not present. This prediction has recently been tested in a fascinating example of mimicry among snakes.

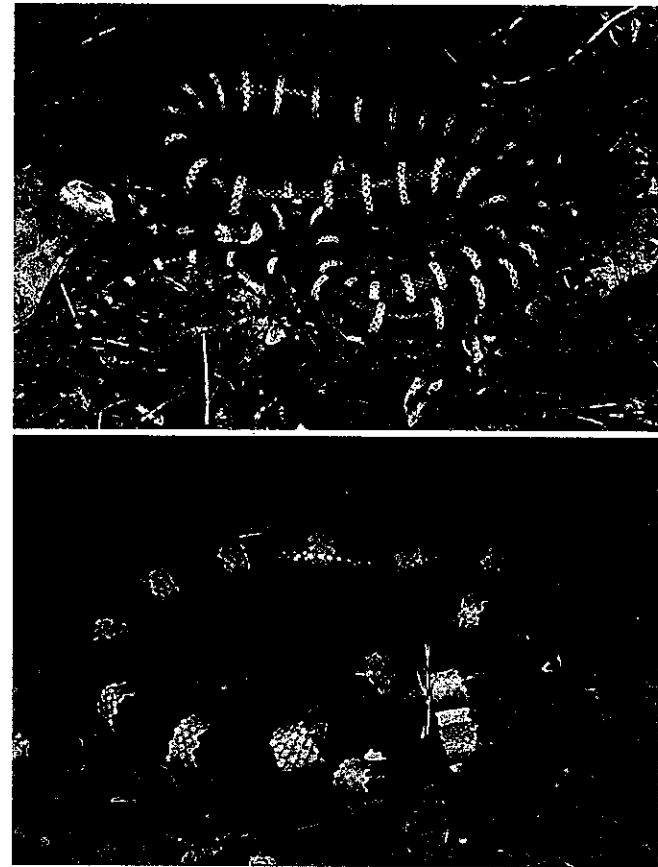


FIGURE 3.4 *Mimicry in snakes.*
Arizona Mountain kingsnake (*top*) and Arizona coral snake (*bottom*).
Photos by Gary Nafis.

The harmless and very beautiful scarlet kingsnake and Sonoran mountain kingsnake superficially resemble poisonous coral snakes in that each species possess red, yellow, and black ring patterns (Figure 3.4). The sequence of color bands differ between the harmless and poisonous snakes according to the helpful rhyme memorized by many snake enthusiasts: “Red touch yellow, kill a fellow. Red touch black, friend of Jack.”

David and Karin Pfennig and William Harcombe of the University of North Carolina (Chapel Hill) identified dozens of sites in North Carolina, South Carolina, and Arizona where both coral snakes and king snakes occur together, and where the coral snake does not occur. At each site, they left ten sets of three snake replicas made of cylinders of plasticene (a soft, non-toxic clay): one with a tricolor ringed pattern, one with a striped pattern of identical colors, and one with a plain brown pattern. After weeks in the field, the plasticene replicas were collected and scored for predator bite and scratch marks by an individual who did not know whether the replicas had been placed in areas where the snakes overlap or where the poisonous species was absent.

It was found that at the Carolina sites, the proportion of kingsnake replicas attacked was high (68 percent) in areas where coral snakes do not occur, but low (8 percent) in areas where coral snakes do occur. Similar results were found at the Arizona sites, confirming that predators avoid coral snake mimics in areas where coral snakes live.

As Darwin predicted, Bates' work has had lasting value and biologists to this day refer to the imitation of unpalatable or poisonous forms by palatable, harmless species as Batesian mimicry.

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Bates never returned to the Amazon, but he did manage to finish the book of his travels, *The Naturalist on the River Amazons* (1863). When it was published, Bates sent a copy to Darwin and anxiously awaited the verdict from the famous author of *The Voyage of the Beagle*. Darwin replied, "My criticisms may be condensed into a single sentence, namely, that it is the best work of Natural History Travels ever published in England."

It is still a great read today—full of tales of adventure and great descriptions of the animal and human residents of the Amazon. When describing butterfly wings, which became to Bates what the Galapagos finches represented to Darwin, Bates achieved the level of poetry. He wrote, "It may be said, therefore, that on these expanded membranes nature writes, as on a tablet, the story of the modifications of species."

CHAPTER QUESTIONS

1. What was the "glimpse" that Bates had "of how nature manufactures her species?"
2. What evidence did Bates assemble to argue that mimicry was due to natural selection and not mere coincidence?
3. Why was Darwin so delighted by Bates' discovery of mimicry?

For more on this story, go to the *Into The Jungle* companion website at www.aw-bc.com/carroll.