

C. Brooke Worth: 19th Century Naturalist in the Space Age

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C. BROOKE WORTH, M.D. and aurelian, sat at the table in a heavily littered room off the kitchen of his dilapidated farmhouse in Eldora, New Jersey. He had pushed his optivisor—essentially, a pair of mini-goggles fitted with 5x magnifying lenses—up on his forehead while he fussed with an outlandish apparatus that was attached to a large, live but inert, strangely beautiful moth. The room's low ceiling bristled with pinned Lepidoptera, all dead, many tattered and faded.

"A couple of years ago I received a letter from the editor of a scholarly publication about one of my papers on the royal walnut moth," Worth was saying. "He had some nice comments about the paper, but he went on to note that I wrote up the material in the style of a nineteenth-century naturalist. Well, why shouldn't I? I *am* a nineteenth-century naturalist!"

An essence of another time sets Brooke Worth apart. With his spare frame, wispy white beard, and gnomish face, he might strike one at first as some relict sage, or perhaps an ancient painter of oriental scrolls (graceful herons in the foreground, three little man-figures making their way toward a mountain shelter in the cloud-softened distance). The concerns of modern life seem to interest him very little. One cannot imagine him leaping out of bed

in the morning to flick on the "Today" show so that he can keep up with the latest in regional wars, labor squabbles, and blockbuster films. For most of his life, Worth has fought against what the time and the place seemed to demand of him.

But usually, when the crunch came, he shouldered his burden. He never turned his back on reality. No Miniver Cheevy, "born too late," who sighed for what was not and kept on talking, Worth instead persisted and endured. Hating every minute of it, he followed his father's urging and earned a medical degree. Unendowed with a vocation for teaching, he taught biological sci-



Propagation of the royal walnut moth (Citheronia regalis) occupies much of Worth's time. "When I bought this place, regalis was considered a rare moth in this part of the country."

ences in college on and off for ten years and, despite a strong aversion to urban life, spent four years on a social service mission, studying the common cold among Philadelphia's slum-dwellers.

Somehow, he got the jobs done and did them reasonably well, but when escape hatches providentially opened he climbed toward the light. When Worth was a boy, his world consisted of animals. He raised pigeons, collected moths, and watched wild birds. He dreamed of pursuing fabulous animals in tropical lands, searching them out in their sun-drenched haunts and perhaps even discovering unknown species.

These dreams were fulfilled briefly on a summer trip to Honduras while he was still in college, and later in middle age during his two long tours of duty with the Rockefeller Foundation, when he was a member of teams studying arthropod-borne viruses in India, South Africa, and Trinidad. Finally, eighteen years ago, he found paradise itself among moths, mice, and domestic pigeons on the edge of a mosquito-infested Jersey marsh.

"I took an early retirement from the Rockefeller Foundation to do my own work, which no one would ever confuse with applied research," Worth said, now wrapping a slender thread around the thorax of the patient moth. "Here in Eldora I'm mainly carrying on projects that I started as a boy."



"Worth was rigging a harness for a royal walnut moth which had emerged only that morning from its pupal case."

If Worth, who is seventy-four years old, traces the origin of his studies to boyhood hobbies, that doesn't mean he relegates them to the level of diddling around with a Rubik's cube. His is disinterested research in the old-fashioned sense. Hunched over the moth on his table, he seemed the very picture of one of those gentlemen naturalists of a century or two ago who called themselves aurelians. (Aurelia, based on the Latin word for gold, was an early name for the chrysalis, the butterfly pupa which in some species has a bright gold case.) Entomology, in their time, was based on a delighted fascination with the form and behavior of insects, before the exigencies of modern agribusiness turned that science into a grim search for the most efficient way to kill them.

There are no grants for the kind of projects Worth carries on. He studies moths (or mosquitoes, or seaside spar-

rows) simply because, in the intensity and variety of their lives, he finds summed up all that he loves about life itself. In this sense he brings to mind A. E. Housman, the English poet and classical scholar who spent almost all his professional life emending the texts of third-rate Latin poets.

But for Worth there are no third-raters in the animal world. Each bird, rodent, moth, no matter how obscure, yields its tidings, its gist, providing sustenance for a man whose appetite for knowledge is insatiable. The results of his investigations—found in such publications as *The Auk*, *Journal of Mammalogy*, *American Journal of Tropical Medicine*, *Mosquito News*, *Journal of the Lepidopterists' Society*, and *Indian Journal of Malariology*—form a small library in themselves, a record for all who share his curiosity.

He spends much of his time at the farm alone. Yet no one who knows Brooke Worth would ever call him a misanthrope, for he is an engaging companion either in the field or relaxing in a pleasantly situated grogshop at the end of the day. At one time, in fact, he was known to take part in the destruction of a pitcher of martinis with the best of them, though now at the cocktail hour he settles for a glass of ice water. In his early seventies he became apprehensive that his fondness for a drink might interfere with his real passion, the study of natural history, and he went on the wagon.

He spoke of that decision now, his face crinkling into a grin as he looked up from his work. "When they tell me I have some fatal disease I'll shout, 'Hooray! I'll drink to that!' And then I'll go out and have a wild old time."

AT THE MOMENT, Brooke Worth was rigging a harness for a royal walnut moth (*Citheronia regalis*) which had emerged only that morning from its pupal case in a huge, wire-covered box at the foot of his bed. ("Sometimes I wake up in the middle of the night thinking that I hear moths working their way out of the pupal cases, but I'm sure it's just my imagination.") The moth on the table was a female, with a wingspan of more than five inches, a deep rust color mingling on its wings with splotches of light yellow.

"When I bought this place—I call it my farm—in 1965, *regalis* was considered a rare moth in this part of the country," he said. "Even where this species was relatively common, collectors had a great deal of trouble mating them. So I rigged up a harness, tying a freshly emerged female to the end of a contraption that consisted of a couple of fishing poles and a record player. Then, after dark, I set her spinning at about fifteen miles per hour, which I judged to be her flight speed. She released her pheromones, or sex attractants, and pretty soon I found a wild male with her.

"I was very excited. But then I found that I didn't even need such a Rube Goldberg contraption. Elsewhere, these moths are so rare they have a hard time finding mates, but I had stumbled into a hotbed. All I had to do was put a female in a harness on a table outside and the males came flocking."

One of Worth's scientific papers, written for the *Journal of the Lepidopterists' Society* in 1980, describes what he calls the "elegant harness" he invented for tethering large moths.

"Like many an enthusiastic young lepidopterist, I used to tie soft strings around the 'waists' of large female moths and then set them out overnight to lure mates," he said. "But if she decided to fly after dark, she might get badly tangled in her tether. Or else she'd try to worm her way through the string, and her abdomen would become so badly deformed that she could never mate."

So Worth put on his thinking cap and produced the ultimate in insect harnesses. The key to his gadget was the fisherman's old device of using a swivel to avoid twisting the line. Assembling a grab bag of materials that included twelve-pound test nylon casting line; thin brass tubing of the sort used by model airplane builders; a bag of beads like those that adorn Indian moccasins; and assorted sewing needles, flat-headed nails, spring clothespins, and paper clips, he made harnesses in which moths can flop about at will without damaging their fragile bodies or frustrating their mating instincts.

I watched him rig the harness. He threaded a needle with the nylon line, passing it through the tubing to prevent snarling; positioned the beads to provide flexible joints; and finally

looped the line around the insect's thorax.

"Now you know why a lot of the locals eye me suspiciously," Worth said. "We've had an epidemic of gypsy moths here the last year or two. People have heard that I perform mysterious experiments with moths, and so there's a rumor around that I'm responsible."

"And what's to prevent some roving predator from gobbling up this fat tethered offering?" I asked.

"The final ingredient—an old peach basket," Worth said, getting up from the table with the harnessed moth in hand. "Follow me."

I followed, glancing up as I did at that extraordinary insect firmament that Worth has composed on his ceiling.

"That idea came out of my South African experience," he told me. "I made an impromptu moth collection when I was at a field station there. When I ran out of storage boxes, I began pinning my finds to the ceiling to protect them from mice and other marauders. I got a lot of comment on it, so I carried on the idea here."

IT IS SAID that children in very cold climates, before the days of school buses, became fast walkers out of an instinct for self-preservation. A visitor to Worth's farm, spurred by a similar instinct, seldom carries along the trails. The density of the local mosquito population must have few parallels anywhere on Earth. On sultry summer days one dresses as if for an autumn hike in the Adirondacks.

"The problem is that salt-hay farming is a tradition in this part of southern New Jersey near Delaware Bay," Worth said as we hurried along. "The local people dike the marshes in spring to keep them flooded so they grow a lush crop of salt grass. The killifish that eat mosquitoes die when the impounded water becomes too warm, and the dikes prevent the tidal action that would bring in more fish. So we have five or six times the mosquito density of the ordinary Jersey marsh, which is hell to begin with."

"Hasn't the state tried draining the marshes, or spraying them at the peak time for mosquitoes?"

"The New Jersey Mosquito Extermination Commission was established in 1906. Need I say anything more?"

I asked Worth why he had bought this place on the edge of the marshes, which presented such a formidable obstacle to outdoor study.

"Mosquitoes were part of the allure, since I was interested in going on with the studies that I'd begun with the Rockefeller Foundation," he said. "I got more mosquitoes than I had bargained for, but from the time I vacationed on the Jersey coast as a boy I've always spent a lot of time in the marshes, and mosquitoes don't bother me very much.

"The house was really a bigger problem. It was in bad shape and too near the road, but on the other hand the land was one of the few large tracts around here that had not been destroyed for my purposes by spraying or lumbering."

He led me to an old shed where, on one of the outside walls, an inverted peach basket hung. A clothespin, pierced by a small, flat-headed nail, was suspended from its center. Using a paper clip, he fastened the swivel on the harness to the nail in the clothespin. The moth would be invisible to passing predators under this makeshift hood but still could send out her irresistible scent to wild *regalis* males.

Worth has provided for the permanent protection of this property, which now amounts to 179 acres, by arranging for its transfer to the Nature Conservancy. It is the first sanctuary that the conservancy has established mainly for rare moths. Several species not found anywhere else in New Jersey inhabit Worth's property, on which he has lifetime tenancy under his agreement with the conservancy.

"But over there is what really made me decide to buy the place when I first saw it in 1965," Worth said. He pointed to a row of small trees in the distance. "That's a row of sassafras. When I was a boy I always found cocoons of marvelous moths such as *cecropia* in sassafras."

It was as if these trees grew there as a promise of the treasures that awaited him in Eldora. Nearby stand other trees and shrubs, their branches hooded with pillowcases. They form the outdoor laboratory on which Worth carries out the heart of his experiments with the royal walnut moth.

"Those are two different plants, persimmon and sumac," Worth explained.

"The genus *Citheronia* is mainly found in Central and South America, and one of its favorite food plants is persimmon, which is a member of the predominantly tropical Ebenaceae. But here *regalis* will sometimes feed on sumac, and I've been making a study of its differential growth on the two species. I've been raising two different populations of *regalis*, one for generation after generation on persimmon, and the other on sumac. The pillowcases keep them on the plant where I want them and also hide them from predators.

"They did very poorly on sumac at first—some even starved to death—and the others were smaller and less vigorous than the persimmon-reared moths. With prolonged breeding I'm trying to see if the species can eventually adapt better to sumac, with which it apparently hasn't had a long association."

Swatting mosquitoes, we walked hurriedly toward the marsh on the edge of the property, where blessed relief awaited us. There stood an old screenhouse into which we dashed, closing the door behind us.

"Now you can see why my wife, Merida, doesn't like to come to the farm," Worth said, grinning as he mashed one or two mosquitoes still clinging to his jacket. "Our permanent home is across the line in Pennsylvania, and we have a summer cottage over in Avalon above Cape May, New Jersey. Merida stays there part of the time, and I join her in the evenings."

Not even the screenhouse on the farm is maintained as an amenity. Worth uses it primarily as a large, outdoor cage in which he mates moths that he has raised from eggs through the caterpillar and pupal stages. When we entered, there were two royal walnut moths joined on the screen, the female clearly larger than her mate. Another male was on the floor, fluttering feebly.

"Well, I'm disappointed," Worth said, surveying the scene. "That male on the floor had mated with fresh females two nights in a row, and I was hoping he would make it three straight. I can tell when they mate because they stay coupled together all the next day as a rule and don't separate until it gets toward evening. But I guess this old boy's not what he was in his prime—two nights ago."

CHARLES BROOKE WORTH was born into a well-to-do family in Coatesville, Pennsylvania, on September 4, 1908, and grew up in St. Davids and other Main Line towns. His paternal grandfather, a successful entrepreneur, had made his money in steel, while his father, an engineer by training, preferred a gentleman's life and unburdened himself of the family business.

"I was one of three boys," Worth said. "My grandfather's characteristics came through, after a lapse of a generation, in my older brother, John, and he went back into steel. My younger brother, Bob, picked up nothing of my grandfather's genes, and he became what used to be called in the old days a wastrel."

The young Brooke, though just as driven as any steelmonger, found his inspiration among other ancestors. His mother's father and brother were amateur naturalists, a strain she hoped to discourage in her own sons because beetles, herbariums, and stuffed birds were all she remembered of dinner-table talk during her girlhood. But with Brooke she was doomed to disappointment, for farther back in the family annals resounded the name John Kirk Townsend.

Brooke has always felt a close bond with this great-great-great uncle, sometime physician and lifelong ornithologist, friend of Audubon's and traveling companion of Thomas Nuttall's, and author of *NARRATIVE OF A JOURNEY ACROSS THE ROCKY MOUNTAINS, TO THE COLUMBIA RIVER, AND A VISIT TO THE SANDWICH ISLANDS, CHILI, ETC.*, Philadelphia, 1839. Townsend's warbler and Townsend's solitaire are both named for him. Since Townsend's son never produced children, it gives Brooke Worth great satisfaction to believe that he is the illustrious naturalist's closest living descendant.

Brooke's family often traveled when he was a boy, and his mother must soon have become aware of his proclivities. On the eve of a departure she would ask her sons, one by one, if they were packed. "Yes," would come John's reply. "Yes," would come Bob's. And then Brooke: "Yes—everything but my clothes." By that time there was barely room in his bag—what with his collecting materials, binoculars, guide books, and storage boxes—for even a

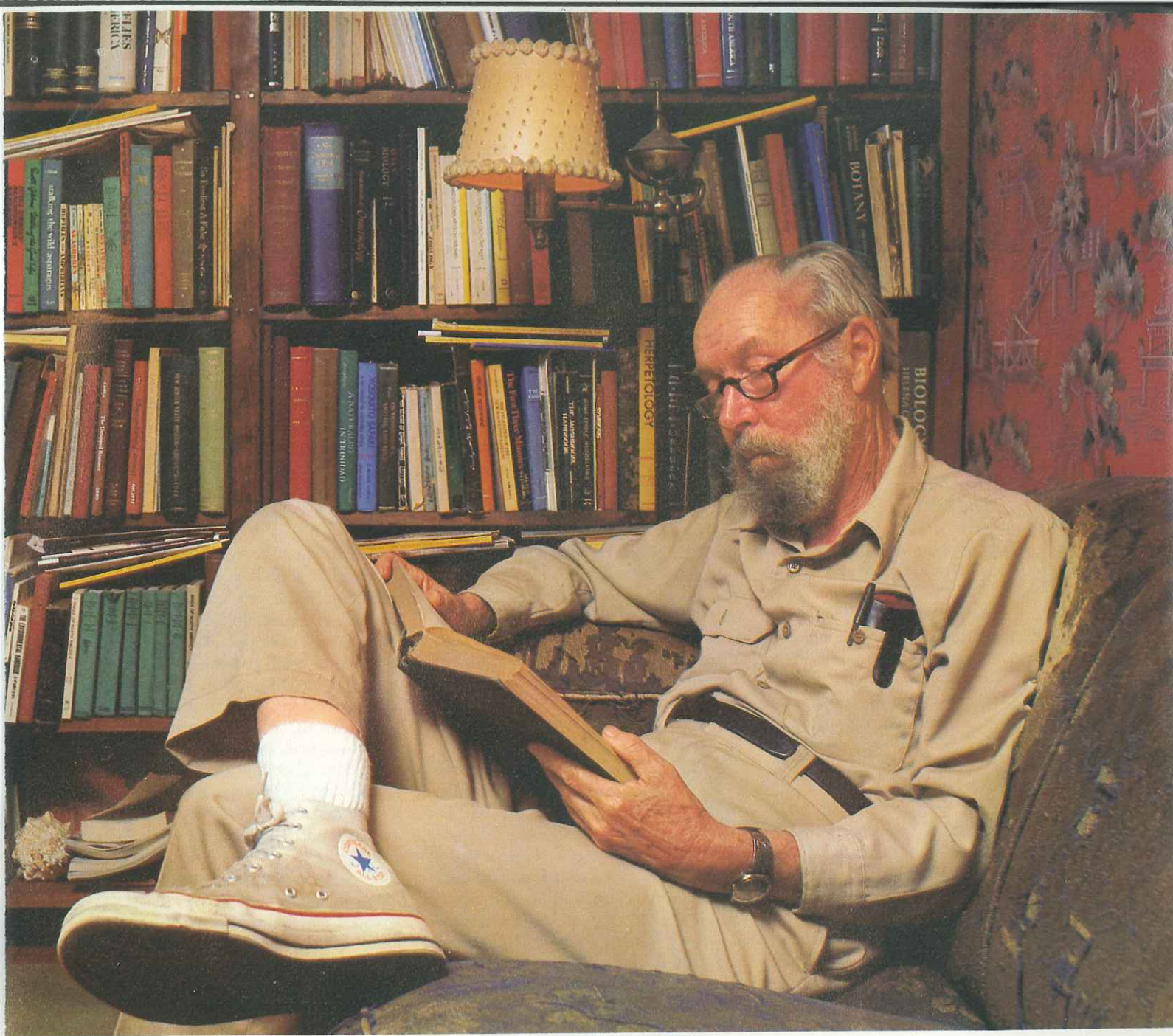
clean shirt.

There were the annual summer vacations on the Jersey coast, where Brooke watched the birds of marsh and shore, jotting his observations in a little brown book. Frequent outings with the Delaware Valley Ornithological Club sharpened his birding skills. When Brooke was about fourteen, his father took the family on a cruise to the Caribbean, during which they landed at Nassau. The boy was immediately smitten by the tropics, and he never got over it. Soon afterward he was sent away to prep school at Andover, where his older brother was already a student.

"I thought I could tag along with John and get to know the ropes," he recalled. "But it didn't work out. He was a sharp dresser, quite a dandy, and even if I wasn't covered with mud from scrounging around in a marsh, I was sure to have on the wrong tie or a shirt that didn't go with the rest of my outfit, and John was ashamed of me. He spent most of his time trying to lose me."

After he entered Swarthmore College in 1927, Brooke apparently began jotting names other than those of birds in his little brown book, for he courted and eventually married a fellow student, Merida Grey. (Mérida, accent on the first syllable, is the name of the city in Yucatán where her parents spent part of their honeymoon.) Brooke's aim at the time was to go on to Cornell for a doctorate in ornithology, for dreams of discovery still filled his days.

"In my teens I had made my first contact with professional biologists at the Academy of Natural Sciences in Philadelphia," he wrote later in his book *MOSQUITO SAFARI*. "Although I did not realize it then, this was just before the end of a long era during which the chief function of natural history museums was to announce the discovery of new kinds of animals and plants to the world. Thus the people I met—and immediately worshiped—were practically all of the 'old fossil' school, some of them with hundreds of discoveries to their credit. When these scientists had been relatively young men, each had chosen a certain fairly restricted field in which to specialize, so that he could entertain reasonable hopes of becoming an authority in it on a hemispherical or even global basis.



Who, in his young right mind, would not want to be like those masters?"

A marvelous opportunity to taste of their experience came Worth's way during the summer vacation following his junior year at Swarthmore. One of the preeminent ornithologists of the day was Witmer Stone, author of *BIRD STUDIES AT OLD CAPE MAY* and at the time director of Philadelphia's Academy of Natural Sciences. Stone was looking for additional financial support for the academy. Knowing that several young men of prosperous families (including Worth and his friend John Emlen, a student at Haverford College) showed a keen interest in birds, Stone approached their fathers with a proposi-

tion: in return for a contribution to the academy, he would arrange for the boys to take part in a natural history expedition to Honduras, led by the academy's curator of insects, James A. G. Rehn, in the summer of 1930.

Taking his binoculars, butterfly net, and collecting gun, Worth explored the fog-shrouded cloud forest, the dry pine belt, and the arid valley of the Rio Choluteca. His love for the tropics and their wildlife was confirmed. Best of all was the lowland rain forest on the north coast. Everything seemed new to him, and in most cases it was, including a huge owl butterfly that he pursued to the point of exhaustion but never caught, because the moth when

it settled always did so on the handle of his net.

Another day Worth was standing on a bridge over a stream when he spotted a small fish. Idly he fired at it, and when it reappeared belly-up he plunged into the water and secured his prize. He had no idea what the fish was, but when experts looked it over back in Philadelphia they discovered it was a new species. (The academy's experts named the fish *Cichlasoma cutteri* for Victor Cutter of the United Fruit Company, who had provided free passage for the expedition to Honduras on one of the company's banana boats.)

But there was an even more exciting discovery for the bird-loving Worth

among the San Juancito Mountains.

"One day I found a nest of wrens in an embankment where the trail crossed over the ridge of the mountain," he wrote afterward. "I had seen a mud-colored bird dart out of a small hole in the embankment, and on digging a bit of earth away so as to reach into the hole, I found that I had disturbed a whole nestful of wrens. One, two, three, four, five, six—still the family of little ones popped out before my astonished eyes. They were just full-fledged, but I managed to catch a couple. They appeared as commonplace as any young wrens I had ever seen. Yet these very birds were later found to be unknown to science, and Witmer Stone fulfilled a lifelong ambition by naming [this new subspecies] humorously for the leader of our expedition, Rehn's mountain wren!"

On returning to the United States, Worth could think of nothing but ornithology, yet America was already well into the Great Depression. His father argued that there was no way for him to earn money in ornithology. Why not make use of his background in biology by studying medicine?

"My friend John Emlen went on from Haverford to Cornell and became an outstanding ornithologist," Worth said. "But I was married, with a family on the way, and we bought our vegetables in a store where the clerk sported a Phi Beta Kappa key. Times were really hard, so when I was accepted at the University of Pennsylvania School of Medicine, I decided to take my father's advice."

He found the courses interesting enough but was disturbed by the almost complete lack of curiosity around him. He felt hopelessly out of place.

"Most of the other medical students wanted to know only two things: how to diagnose an ailment and how to cure it," he said. "With those two bits of knowledge, a fellow could make real money. I liked to investigate all sorts of things. While taking anatomy, for instance, I thought it would be a good idea to dissect a chicken and note the exact differences in the human body and the fowl. I got a very grudging approval from my professor, but he thought it was a crazy idea. This sort of thing is done more often now."

The worst was yet to come. After earning his medical degree, Worth spent a year as an intern at a hospital

in Philadelphia.

"It was a nightmare," he said with a shudder. "I didn't really like poking around at people, taking their blood, and prescribing for their illnesses. I couldn't sleep at night for fear of having given them the wrong medicine. I was told at the time that I was a good intern. If I was, it was because I was so careful, so conscious of other people's pain."

In despair, he fled back to Swarthmore, where he took up teaching biology. No one among his family or friends was able to understand why he had turned his back on a prestigious profession to teach biology to freshmen. But he did the best he could to impart his enthusiasm for living things to his students and, meanwhile, spent as much time as possible in the field, watching insects or banding birds. He and Merida had three children, Valerie, Douglas (both of whom became poets!), and Michael. In the late 1930s, hoping to work more directly with animals, Brooke served briefly as assistant pathologist at the Philadelphia Zoo.

WORLD WAR II became the great watershed of his life. When he entered service, he was assigned to teach at the Army Medical School in Washington, D. C. One of the most important topics for doctors who would soon be on duty in the South Pacific or other tropical regions was malaria, and Worth addressed the subject to the best of his ability. One day the school's commandant drew him aside.

"How many cases of malaria have you seen, Worth?" he asked.

"None, sir," replied the abashed instructor.

"Well, we'll have to do something about that," the commandant said dryly.

The Army dispatched him to Gorgas Hospital in Panama for a month, where he had the chance to see a number of malaria victims in the flesh. Although he passed up no opportunity to observe the tropical birds and insects, he returned to Washington a more knowledgeable medical instructor. Meanwhile, he was making contacts with doctors who were coming home from tropical countries with all sorts of stories about endemic diseases and the attempts to find cures for them. When the war ended, Worth went back to teaching at Swarthmore.

"But I felt out of it there," he said. "I had met so many interesting people and had heard so many interesting things about what was going on in tropical medicine that I wanted to be a part of it myself. I wanted to see some of those places. I contacted friends I had made in the Army who were now with the Rockefeller Foundation, and through them I found an opening on a foundation project that was studying murine typhus in Tampa, Florida."

Murine typhus is one of the rickettsial diseases, caused by a microorganism that has a life cycle in which it alternates between rodents (hence its name) and fleas. The flea transmits the microorganism to a human being not directly by its bite but by its feces, which may be scratched or rubbed into the wound. The Rockefeller Foundation team in Tampa was interdisciplinary, consisting of specialists in epidemiology, entomology, mammalogy, and the like. Worth was assigned to breed rodents in the laboratory and, in the process, cultivate flea colonies and the microorganism as well.

For Worth, it was another of the many instances in his life where he was obliged to adapt quickly to the circumstances. He had never seen a louse or a flea under the microscope, and there was still much he had to learn about rodents.

"But the Rockefeller name was an 'open sesame,'" he said. "If I was stumped about the identity of a mite I found on a cotton rat in Alabama, I simply had to mention the name Rockefeller and some expert at the Smithsonian or any other important institution would give me his full attention. There was a lot of visiting back and forth between our laboratory and these institutions. I got to know all the big shots in the relevant fields and learned a great deal in a very short time."

Worth trapped various rodents, chiefly the roof rat, which was the most common rat in the Tampa area, and performed tests and experiments to determine the levels of murine typhus in wild populations. He also made detailed behavioral studies on captive populations. (Rice rats, secretive, combative with the opposite sex, and prone to cannibalize their young, he found unsuitable as all-purpose laboratory animals; Florida wood rats, though their reproductive rate was relatively low, were clean and docile, and seldom

fought each other even when adult males and females and young were crowded together in cages.)

It was the Rockefeller Foundation's practice to initiate and organize research projects in various fields and then pull out when local institutions had become competent enough to work alone. By 1950 the foundation was withdrawing from research in rickettsial diseases and turning its attention to malaria. The insect vector in malaria is the anopheline mosquito, a genus comprising many species around the world.

The foundation assigned Worth to a research team in Bangalore, India, where he had to become an instant expert once more, this time on *Anopheles*. Family logistics might have posed further complications in this case, for the Worths now had three teen-age children, but the foundation was equal to any occasion.

"You simply had to put on your hat and coat and walk out the door," Worth recalled, still marveling at the efficiency. "The Rockefeller people arranged for everything to be packed, even my son Doug's rock collection. When we got to India, all our belongings arrived right after we did."

The sole casualty was Brooke's piano, which arrived smashed, its eighty-eight keys scattered on the floor of the crate. Known among his friends as a man who will rush for the piano whenever he is invited to play, and often when he isn't, Worth was disconsolate. But he soon learned about a little shop on a side street in Bangalore where the workers were reputed to be able to fix any musical instrument, and they lived up to their reputation. They returned the piano to the Worths' house, all the parts in working order, even properly tuned.

"In America, everything seems to happen to pull the generations apart," Worth said. "It was a great family experience in India, where we were all drawn together. I was a member of a jazz trio with my boys—I played the piano, Mike played the drums, and Doug the clarinet and sax. We were always being asked to play at parties or at the local British-style club."

When he was not identifying mosquitoes or compiling summaries of their annual population cycles, Worth ransacked the countryside for birds. Ban-

galore is in Mysore, a state in southern India that ornithologists had tended to neglect in the past, and he was able to furnish many original observations to the *Journal of the Bombay Natural History Society*. Some of his records were firsts for the state, including that of a pied harrier which he happened to notice by following the glance of a pet pigeon. ("I recommend the keeping and close observation of domestic poultry to those who wish to spot high-flying birds—no better lookouts exist.") He made a sporadic year-round study of a colony of pratincoles, or swallow plovers, that nested on a sometime sandbank in the volatile flow of the Hemavati River. An example of his "nineteenth-century" prose style appears in his note on the local status of the greenshank, submitted to the journal just before he left India.

"My experience with greenshanks

seems obviously to illustrate the lacunae that exist in the knowledge of birds of Mysore State," he wrote, "gaps that cannot possibly be filled by brief collecting or observational surveys, but that can be bridged only by prolonged residential studies. Alas that I cannot serve further in this respect, and that birdwatching in Mysore State seems to have no other advocates!"

Once more, the Rockefeller Foundation changed its focus. India was developing its own programs to fight malaria, and the foundation was looking for new areas of research, particularly among the many new viruses that had come to light as a by-product of its work on yellow fever in tropical countries. Now Worth was faced with a vital decision. The foundation offered him another assignment in the tropics, but after three years in southwestern India, Merida was in poor health; Brooke re-



signed to return to the United States with his family.

There followed four dispiriting years in Philadelphia, where Brooke took part in research on the common cold among the urban poor for the Wistar Institute and the University of Pennsylvania. The urge to see more of tropical life had not dimmed. The children were grown, and he knew that it was time for a change. In 1958 he got in touch with the Rockefeller Foundation again and received the exciting reply: Would he be interested in joining a team of virologists in South Africa as a mosquito expert?

Wild horses could not hold him back from this new adventure. He was soon on his way, though Merida elected to stay in Pennsylvania, except for a brief visit to Johannesburg.

"In a sense, I was a fraud," Worth said. "I was not a specialist in any of the jobs I ever did in the tropics. I was a non-specialist, and perhaps that was why I was valuable to them. I had to be a parasitologist, an entomologist, a mammalogist, and an ornithologist as well.

"I formed a kind of bridge among the staff members, who were mostly specialists, and this integration was important in getting to see the whole picture, in

seeing just how the disease organism passed from a mammal to an insect to a human."

THE WORK IN South Africa was concentrated on arboviruses, shorthand for arthropod-borne viruses. The most important of the world's virus-transmitting arthropods are mosquitoes. What kind of mosquitoes were most likely to transmit viruses in South Africa? What were the most likely sources from which they picked up viruses? Few answers could be arrived at until large numbers of mosquitoes had been collected and identified.

This was the job assigned to Worth by the project director, who insisted that no final identifications be made by anyone who did not have a doctoral degree of some sort. Everyone else's work depended on precise identification. While Worth had gained some knowledge of anopheline mosquitoes in India, he was wholly unfamiliar with the culicine group in South Africa. Given six weeks to become an expert, he threw himself into the work, and with the aid of insect collections, detailed biological keys, and the advice of resident authorities he mastered the assignment.

Other scientists might have found

the task onerous, not only because of the long hours of extremely detailed yet routine work under conditions that were often primitive, but also because of the nature of the beast itself. Scientists, in fact, have cloaked mosquitoes permanently in infamy with the names they have given them. Among the specific names of mosquitoes Worth has culled from the *Aedes* and *Culex* genera are *vexans*, *irritans*, *excrucians*, *horridus*, *infectus*, *invidiosus*, *perfidiosus*, *abominator*, and *inadmirabilis*. But for Worth, who has known these insects well since his boyhood days in the Jersey marshes, familiarity has bred tolerance, not contempt. He finds them endlessly interesting in form and behavior. This admiration perhaps is enhanced by gratitude, for a mosquito has given Worth a grip on the only kind of immortality he has ever sought.

Although he spent much time in the field collecting mosquitoes (and sneaking in interludes of birdwatching), most of the collecting was done by native boys who were so adept that they could distinguish males from females in the bush with the naked eye. Mosquitoes were brought to Worth in little glass vials at whatever field station he happened to be at the time, and then he laboriously identified them.



Even when the collections were narrowed down to the *Aedes* and *Culex* groups in which the researchers were interested, Worth was eventually confronted by 118 species in ten genera. He spent weeks examining tarsal claws, various stripes and bristles on thoraxes, and bands (or the lack of them) on leg segments. Fortunately, he had an adequate microscope, and the dusty old insect collection he had learned on so painfully turned out to be a blessing. When he was given fresh insects in the field, what had been obscure markings before fairly leaped out at him in all their vibrancy. During his two years in South Africa, he looked at 81,702 specimens of one species alone, *Aedes circumluteolus*.

"I was in just the position I wanted to be," Worth said. "Most of the staff preferred working in the lab, where it was clean and there were no biting bugs. I wanted to be out in the bush. I pleaded not to be confined to the lab or to administration, so I was popular because I was no threat to anyone."

Research for the team was not simply counting claws and bristles. There was a need to know exactly what animals were being bitten by mosquitoes and infecting them with viruses. It would have been an insurmountable task to find wild animals harboring the obscure viruses for which the team was looking. Antibodies made the job a great deal easier.

"When birds and mammals pass the stage of viremia—when they no longer circulate viruses in the peripheral bloodstream—they have become immune," Worth wrote in his book *A NATURALIST IN TRINIDAD*. "Their blood then contains various antibodies that can be recognized in the laboratory by a number of tests. The very multiplicity of antibodies thus far discovered attests to the variety of ways in which vertebrate organisms combat infection. Thus one can easily make antibody surveys to determine the past distribution of known viruses in populations of all kinds of creatures—human beings, domestic animals, including chickens, wild birds, and everything from rats to lizards."

Another of Worth's duties, then, was to investigate wild animals for the presence of antibodies. This meant capturing and bleeding birds and mammals. Predictably, Worth enjoyed immensely the opportunity to see wild

things in their native habitats; the observations he made on their habits contributed to the picture the research team was putting together on the structure of populations that might harbor obscure viruses. Sometimes he would detect a rare butterfly or moth—a flicker of silent bravado in the gloom of the forest. As an inveterate birdbander, he also enjoyed trapping and closely examining wild species that until then he knew only in books.

Collecting mosquitoes or trapping wild birds was not always a matter of laboring in sweaty marshes. One of the places suspected of harboring viruses was a reedbed adjacent to a fashionable golf course. The manager took a keen interest in the collecting and asked Worth and his colleague if he could be of service to them.

"He was disappointed to be informed that we were self-sufficient, so he simply created his own method for showing appreciation," Worth wrote later. "When the sun lowered in the west and the air began to feel shivery, he would henceforth send a white-jacketed waiter across the fairway to inquire whether we preferred martinis or Manhattans this time. Subsequently the servant returned with a small table covered with a cloth, a generously filled pitcher, canapés, glasses, serviettes, etc. This was mosquito collecting at its acme."

WORTH REVELED in *all* the species he found in South Africa that were new to him, as he was to do later in Trinidad, but he enjoyed one supreme moment. He was sorting mosquitoes at the Ndumu field station on a January day in 1959 when he came across a specimen that at first seemed to be his old friend *Aedes circumluteolus*. But, having examined so many thousands of that species, he was not ready to accept it as such. He wiped his eyeglasses and his 5x eyepiece magnifier, then looked again.

"The mosquito was definitely 'different,'" he wrote in *MOSQUITO SAFARI*. "What drew my attention in the first place had been the uniformly yellow *unstriped* dorsum of the thorax, though that might still be a rarely permissible variation in a somewhat unorthodox member of the species. But at the limits of vision with my weak lens I

thought I could see that the wing veins bore all sorts of yellow scales that far exceeded even marginal propriety."

Worth set the specimen aside, but shortly afterward found one identical to it. He suspected that he had discovered a new species. The next time he was in Johannesburg, he carried his two specimens to Botha de Meillon, South Africa's leading authority on mosquitoes, and asked for an opinion. The entomologist checked his collections for a look-alike without success but suggested that Worth wait to see if he could find more specimens. Additional "evidence" would help to dispel any suspicion that the two present specimens were merely aberrant varieties of a species already known to science.

It was ten months before he saw another of the "aberrant" mosquitoes, and once more he found two on the same day. Botha de Meillon now agreed that Worth had strong documentation for his find and urged him to publish the mosquito's description at once.

"I wrote the paper that day, and it appeared not long thereafter in *The Journal of the Entomological Society of Southern Africa*," he recalled. "I had to find a name for the new species, but that was easy. Golden-scaled wing veins were its outstanding characteristic, so it must be *aurovenatus*. As taxonomists do so often, they had recently discarded the subgeneric designation *Banksinella* in favor of *Neomelanicion*, which was belatedly found to have priority in published entomological literature. Thus I came to occupy an immortal niche with the following inscription: *Aedes (Neomelanicion) aurovenatus* Worth. Greetings, my deceased mentors at the Philadelphia Academy!"

When his two years of duty in South Africa were up, Worth might have applied for an extension, but now there was another consideration. The government's apartheid policy appalled him. The tension between the races, he found, was almost unbearable. The veneer of acquiescence with which blacks carried on their daily work often masked a smoldering hatred for whites, and in turn he saw whites ridicule and physically abuse even the blacks working for the foundation.

"There are times when it is not shameful to run away from distasteful things, one of those occasions being when you are a foreigner and con-

sequently have no voice in the laws of a country," he wrote, and decided to accept a staff appointment with another arbovirus research team in Trinidad. He spent five years there, mainly working with birds, reptiles, and mammals (and their antibodies) before taking an early retirement in 1965.

"Those were rewarding years from both a professional and a personal standpoint," Worth said. "Our research teams found a number of viruses new to science, but fortunately few of them pose any significant threat to humans."

LIKE THE SAILOR home from the sea, full of years and tales of adventure, Brooke Worth has been content for nearly two decades to survey the natural world as it exists on his Eldora farm. Aside from a study of nesting seaside and sharp-tailed sparrows in a small coastal marsh near Stone Harbor, New Jersey, he has found more than a lifetime's study on his own acres. He may not have Africa as his front yard, but he has the freedom to choose his own projects and pursue them to his heart's content.

He was sitting now on the lumpy old sofa in the living room at the farm, shelves of nature books at his elbow. Some of the books are his own: *MOSQUITO SAFARI* and *A NATURALIST IN TRINIDAD*, both descriptions of his experiences while with the Rockefeller Foundation, and *OF MOSQUITOES, MOTHS, AND MICE*, which is a report of his first half-dozen years on the farm. He writes of even the most technical matters in a light, conversational manner, as if he were recounting the day's activities to an old friend.

"I have the ability to keep very good friends whom I almost never see," he said. "I don't have to feed on constant contact."

As an example, he mentioned a boyhood friend, Jim Rice, who went on to become an insurance salesman and a prominent falconer. Rice visited him at the farm recently, and before they knew it, the two men had slipped back into the patois of their childhood hobbies—and their gross mispronunciation of scientific names.

"As boys we were both involved in rearing moths, and we couldn't wait to phone one another in the mornings to exchange news about whether our prize

specimens had mated overnight," Worth recalled. "Our parents imposed some conditions on our calls—we couldn't use the phone before seven, and we had to get off in a hurry. So we devised a code, and our conversations would go, 'Hello? Heck,' or 'Hello? Yea!'"

The old interests remain alive. In a coop behind the farmhouse are the pigeons Worth still raises, including three surviving fantails from a study on pigeon genetics he concluded several years ago. On a desk across the room lie the typewritten pages that describe the results of his sparrow studies in the coastal marshes, which he hopes to have published soon. Upstairs stand the heavy wooden cabinets holding moth collections he made both in the tropics and on the farm.

"Sometimes a study doesn't really lead anywhere," he said. "I had always noticed that the eyespots on the wings of polyphemus moths were not identical. Some looked like an open eye, and others like a slit eye, so I decided to make some experiments to find out if there was a genetic basis for the difference, which I had never seen explained in any book. Well, I quickly discovered that the difference is simply sexual—males have the 'slit eye' and females the 'open eye.'"

His chief concern in recent years is a life-history study of the royal walnut moth. In a sense, this is a year-round project though, like the moths, it has its dormant period in winter. Worth takes the eggs from his mated females in early summer and watches them hatch about eight or nine days later into larvae that soon fatten themselves on his foliage into heavily bristled, rather fierce-looking caterpillars that are popularly called hickory-horned devils. Some experts have written that the spines of this caterpillar impart a bad sting, but Worth, who has handled hundreds of violently lashing hickory-horned devils, replies that they are absolutely harmless.

This insect is technically one of the silk moths, but the caterpillar uses no silk when it pupates. At the end of summer it merely burrows into the ground, where it sheds the skin of its final instar. Slowly it yields itself to the urgency of metamorphosis, the body contracting and rearranging itself, the head, in Worth's description, "seeming

to nestle or snuggle down until flush with the general convexity." The pupal skin darkens and hardens as the creature settles in for the winter.

"When my captive caterpillars are ready to pupate, I put them in individual pint-size plastic freezer-boxes that I line with a folded paper towel," Worth said. "I didn't know how deep wild caterpillars burrow into the soil at this latitude, so I made a guess and dug holes for the boxes about a foot down. This seems to be about right, because my pupae generally make it through the winter."

In late spring he digs up the boxes and keeps them in wire-covered cubicles scattered throughout the farmhouse. By late June the moths begin to emerge, one or two a night perhaps, clinging to the wire until their wings are ready for flight. ("Sometimes you read that their wings unfold, but the wings are really quite small when the moth emerges and it must wait for them to expand.") He usually tries to mate his moths the night following their emergence, and soon he will have a new colony of caterpillars for his differential feeding studies.

Not all of the pupae emerge in any one year. At first Worth feared that some of them had died over the winter, but he found that when he scratched its abdomen an apparently moribund pupa would move. A number of these pupae, when buried for a second winter, emerged the following summer and displayed normal vitality. Those that overwintered a third time, however, were clearly less vigorous.

"Recently I have had one emergence from a quadruply overwintered pupa, a male that was so depleted that only one of his wings expanded fully," Worth said. "I have mounted the specimen as testimony of its unprecedented accomplishment."

Worth, his lively and inquiring mind never at a loss for new projects, already has a further study planned for *regalis*, which has begun to show its adaptability to feeding on sumac. He hopes to raise some caterpillars on poison ivy, a plant that is classified with sumac in the genus *Rhus*.

"The moths, the sparrows, and the pigeons are always doing something new, so I guess I can never quit," said Brooke Worth, who is one of the last of his own species: aurelian. ♠