and zoo animals. In a historical sense, these animals thus came to be seen in a new light: they served not just as a kind of ersatz nature or exotic showpieces for the Victorian bourgeoisie, but also as a means to understand the proximity of humans and animals to one another." (p. 217). The statement on the flyleaf states that "This publication accompanies the exhibition "Endless Forms: Charles Darwin, Natural Science and the Visual Arts," which is currently at the Yale Center for British Art.].

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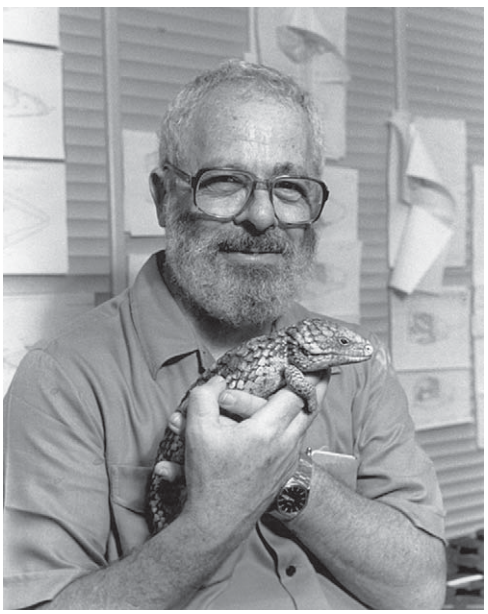
OBITUARIES

Herpetological Review, 2010, 41(2), 142–150.

Carl Gans (1923–2009) and the Integrative Biology of Reptiles

KRAIG ADLER
Department of Neurobiology and Behavior, Cornell University
Ithaca, New York 14853–2702, USA
e-mail: kka4@cornell.edu

Carl Gans, the preeminent specialist on reptilian biology of his generation, died on 30 November 2009 at the age of 86. This occurred after nearly a decade of poor health that followed a stroke in January 2001. Originally trained as a mechanical engineer, Gans made contributions to the systematics, comparative and functional morphology, physiology, biomechanics, and behavior of reptiles and, to a lesser extent, amphibians, all within an evolutionary context. His ability to integrate diverse approaches to life science—a field today called "integrative biology" that he helped to pioneer—was unrivaled, both conceptually and technically, and has laid the foundation for numerous studies across a broad spectrum by other biologists around the world.



In his laboratory at the University of Michigan with an Australian skink, *Tiliqua rugosa* (ca. 1997). Photo courtesy Robert Dudley.

Carl Gans was born in Hamburg, Germany, on 7 September 1923 where he attended the Talmud Thora Realschule. In his early teens while still in Germany, he loved to read books by the German storyteller, Karl May, first-person narratives about overseas explorations, especially in Asia, and collecting exotic animals. May's books were fiction because he never left Germany until very late in his life. Nevertheless, these volumes made a real impression on Carl who later enjoyed extensive international travel in search of unusual reptiles and amphibians. These books were important enough for him to purchase English translations of them that were still in his home library at his death.

The Gans family immigrated to the United States as Jewish refugees in 1939 and settled in New York City where Carl finished his schooling at George Washington High School. They lived in Upper Manhattan near the George Washington Bridge and on Sundays Carl would walk across this mile-long span to the wet undeveloped lands and high cliffs of the New Jersey Palisades along the Hudson River to capture frogs and snakes for his collection. His first herpetological paper, in *Copeia* in 1945, reported on salamanders and snakes he caught near the Harlem River on Manhattan. He discovered a natural population of the Dusky Salamander (*Desmognathus fuscus*) there, the first report on the island since C. S. Rafinesque's in 1820, and he appealed for it to be conserved. (A breeding population was reported from the site as recently as 2005.) Despite this early interest in animals (and conservation), his father insisted that he would financially support him in college only on the condition that he choose a practical career, so he studied mechanical engineering at New York University (B.Mech.Eng. 1944) and then joined the U.S. Army Corps of Engineers. After basic training, he served in the Pacific Theater during World War II, first in the Philippines and then in Japan. It was then the practice of the U.S. Government not to send soldiers overseas unless they were U.S. citizens; accordingly, Gans was naturalized in January 1945, just before departing for the Pacific. He was slated to be part of the invasion of Japan, clearing beaches with the engineering unit to which he was assigned in the Philippines.

After discharge from the army in September 1946, Gans was hired as a mechanical engineer by Babcock and Wilcox Co. of New York City (1947–1955) to install power boilers in electric generating stations in Pennsylvania and Ohio. Through home study courses he completed a graduate degree in mechanical engineering at Columbia University (M.S. 1950), the year his father died. He had begun to publish on herpetological topics in the mid-1940s including notes on the breeding dates of rhacophorid frogs based on observations he had made in Japan, a bibliography of the herpetology of Japan, and an article on adaptations for egg-eating in a Japanese ratsnake, but Gans continued his career as an engineer. He held several patents for devices he had invented. One of his early engineering ideas, never realized, was the development of automobile headlights that would follow the road.

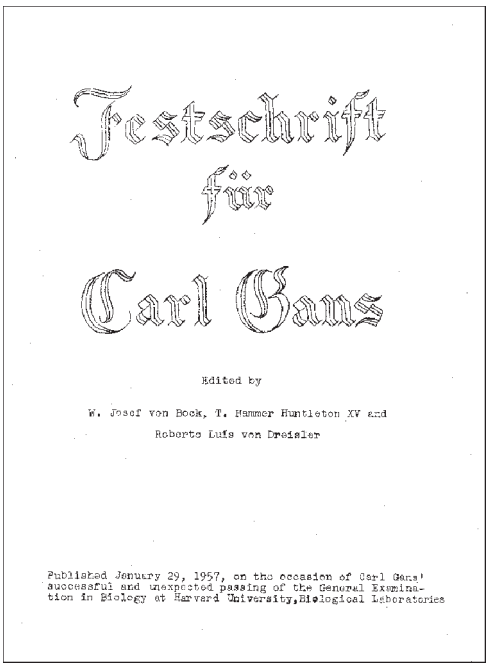
During 1953–1954, Gans took leave from his job to do fieldwork in Brazil and Bolivia supported by a Guggenheim Memorial Foundation fellowship, during which time he was introduced to amphisbaenians, fossorial squamates that were to become one of his favorite subjects for studies in systematics and functional morphology. He duly returned to his engineering position in 1954, but by then his career goals had radically changed. In 1955, he was accepted as a doctoral student in biology at Harvard University by the vertebrate morphologist, paleontologist, and doyen of American zoologists, Alfred Sherwood Romer. At the age of 32, Gans embarked on an entirely new career in biology and on a fast track. Ernest E. Williams, curator of herpetology in the Museum of Comparative Zoology at Harvard, eventually became his doctoral advisor and by 1957 Gans had completed his dissertation.

Because of his relative seniority to the other graduate students and his esteemed position among them, his professors and fellow graduate students played a good-humored prank on him by issuing a booklet of articles—entitled "Festschrift für Carl Gans"—on the occasion of his "successful and unexpected passing" of his general examination. Inside the booklet there was a table showing major events in Carl's life in the first column and corresponding world events in the other. A sampling: "Born 1923 in Germany" vs. "Panic, inflation and great distress in Germany"; "Left Germany in 1939" vs. "World War II starts"; and "Enters Harvard

in 1955" vs. "President Eisenhower has a heart attack." Even Carl's professors had some fun: "He has done so little in his life so far and yet that little has disturbed the world so much (E. E. W[illiams].)."

As a senior graduate student at Harvard University (about 1957). Photo courtesy Kraig Adler.

Gans's dissertation combined his interests in engineering and evolution, as well as his keen observational skills, in a study of the African egg-eating snakes (*Dasypeltis*) from which he drew major insights. (He had begun to publish on the egg-eating adaptations of *Dasypeltis* in 1952, based on his private research.) He described the morphological and biomechanical adaptations that allow these nearly toothless snakes to eat large eggs, crack the shells within the esophagus, empty out the liquid contents, and regurgitate the shell as a cigar-shaped mass. Later, he used vector analysis to describe in trigonometric terms the initial swallowing process, among other actions. He also discovered that the color patterns of these snakes varied geographically and in parallel to those of several small vipers (*Bitis*, *Causus*, and especially *Echis*). These, in addition, display C-shaped coiling behaviors and, in *Dasypeltis* and *Echis*, stridulating warning reactions when disturbed. He recognized that the color pattern and behavioral convergence of these snakes represented an example of Batesian mimicry and then extended this idea to develop a new concept of "empathic learning" that explains how mimicry can evolve even when the model is lethal. This project, integrating Gans's interests in systematics, morphology, biomechanics, and evolution, provided the pattern for his highly versatile research career.



Cover of the spoof booklet, "Festschrift für Carl Gans," prepared by fellow students and professors at Harvard University on completion of his doctoral studies (1957). Photo courtesy Kraig Adler.

On completing his doctoral work, Gans became a postdoctoral fellow at the University of Florida before joining the faculty of the University of Buffalo in western New York State in 1958. His most extensive publication from this period was his book-length monograph, "A Taxonomic Revision of the African Snake Genus *Dasypeltis*" (1959). He quickly rose from assistant professor to full professor and by 1970 was chairman of the biology department. The next year he moved to the University of Michigan, which had long been a prominent center for herpetological research and graduate education, as chairman of the zoology department (1971–1975). He was a hard-driving leader of the department who set very high standards for his faculty and became the nemesis of the botany department, which shared a building with zoology and competed for the same space. After retiring as professor in 1997, Gans moved to Austin, Texas, where he was an adjunct professor at The University of Texas.

Gans's research program covered a very broad scope including functional morphology (mainly of vertebrates), systematics of reptiles, the evolution of early vertebrates, and adaptations of limbless and burrowing tetrapods (mainly caecilians, amphisbaenians, and uropeltid snakes). His pioneering studies on the origin of vertebrates focused on the invention of the head (and thus the neck), which was made possible by the evolution of a new kind of embryonic cell (called neural crest) that he believed led to bone. This project was conducted together with his former zoology colleague at Michigan, R. Glenn Northcutt, and arose from their teaching a course on the comparative anatomy of vertebrates.

Carl took an engineer's approach to studying and experimenting with functional problems such as locomotion, burrowing, feeding (especially chewing), respiration, sound production, and hearing, all studied from an evolutionary perspective. His classic studies on breathing in frogs were conducted primarily in collaboration with a Dutch functional morphologist, H. J. de Jongh. They used sophisticated technologies in their work (electromyography, cinematography, and cinefluorography; monitoring buccal and pulmonary pressures; and recording gas flow in frogs placed in atmospheres with variable concentrations of argon and nitrogen) and demonstrated that relatively pure air was pumped into the lungs. Carl's favorites, the amphisbaenians, provided yet other models for application of biomechanical analysis. These burrowing wormlizards propel themselves underground using concertina and rectilinear mechanisms and he discovered that significantly different digging methods were employed among the families of wormlizards. Gans's textbook, "Biomechanics: An Approach to Vertebrate Morphology" (1974) summarized much of his early work in functional morphology and has become the standard sourcebook for the field.

First and foremost, however, Gans was a naturalist who loved reptiles and was fascinated with the ways in which they lived their lives. He was equally at ease studying them in the lab as he was in the field and regularly made numerous trips overseas to study them in South America, Africa, Australia, and especially in India and Sri Lanka. He collaborated and published regularly with numerous biologists at universities and museums throughout the world. He was also a major proponent of the value of collaborations with herpetologists at zoos. Although relatively few graduate students took their degrees with Carl, many colleagues and their students flocked to work with him on joint projects. His wife, Kyoko A. (Mabel) Gans, who had been the executive secretary of the biology department at Harvard and who he married in 1961, actively supported his research, writing, and editing and she graciously hosted legions of visitors who came to work with Carl. They were a real team until she died of cancer in 1999.

Besides his personal research contributions, Gans served the biological community in numerous ways. He was president of several major societies (American Society of Ichthyologists and Herpetologists, American Society of Zoologists [now called Society for Integrative and Comparative Biology], and Society for the Study of Amphibians and Reptiles) and served as editor of the *Journal of Morphology* for 25 years. While still a postdoc at Florida, he joined SSAR during its first year (1958) and under its former name, The Ohio Herpetological Society. When he discovered that it was run by a bunch of teenagers, he promptly resigned. He rejoined OHS a few years later, however, and in 1967 showed up for the 10th Anniversary Meeting in Columbus, Ohio, and thereafter became a regular participant in society meetings. He became involved in many other society activities and helped to draft the new SSAR Constitution

As president of SSAR, together with the presidents of the American Society of Ichthyologists and Herpetologists (Marvalee Wake) and The Herpetologists' League (Ronald Brandon), at the Joint Meeting of Ichthyologists and Herpetologists at the University of Oklahoma (August 1984). Photo by Kraig Adler.

in 1970. As SSAR president for 1984, he was an activist leader who enjoyed his freedom to innovate without the encumbrance of an overly circumscriptive society constitution.

Carl's supreme achievement in his service to our discipline, however, was the 22-volume series, "Biology of the Reptilia" (1969–2010), which he conceived, edited, and partly wrote. This compendium, covering the behavior, development, ecology, neurology, physiology, and especially the morphology of reptiles, is one of the monuments of modern herpetological and biological science. Some 169 persons from 21 countries contributed 142 chapters to it. After 42 years, the final volume, a comprehensive list and cross-index to the literature on reptilian biology, appeared in March 2010. It was a great honor when Carl entrusted publication of this classic series to SSAR, which had the privilege to issue the final four volumes.

Carl was also one of the most prolific authors in our field and published more than 700 titles including five books, in addition to the 22 volumes of "Biology of the Reptilia." Among them were a photographic atlas of shark anatomy (1964), his highly popular "Reptiles of the World" (1975, later translated into several other languages including Chinese), and a practical manual on electromyography (1986). Most of his taxonomic papers dealt with the systematics of amphisbaenians (on this topic, from 1957 to 2008, 94 titles including 10 major works), but he also authored numerous titles on the evolutionary basis of adaptation, physiology of snake venom, evolutionary origin of vertebrates, mechanics of hearing and sound production, functional significance of muscle architecture, mechanics of limbless locomotion, and feeding mechanisms in tetrapods.

Despite his long list of titles, his distinguished reputation, and his sometimes gruff demeanor, Carl also had a soft heart and a tendency for pranks. At scientific meetings, he could be very tough (and also usually very helpful) during the Q&A period following a graduate student's presentation when he sometimes displayed a trace of his German accent. He would often then invite the student to go swimming with him (he routinely brought his bathing suit if there was to be a pool or ocean nearby). At SSAR's 25th Anniversary Meeting in Raleigh, North Carolina, Carl was scheduled to present a plenary lecture on amphisbaenians, but wanted instead to talk about functional morphology. He hatched a plot in which Steve Arnold, Paul Hertz, Ray Huey, Ken Miyata, and I were conscripted as co-conspirators. After Carl talked about amphisbaenians for a few minutes, Paul stood up to declare, "With due respect, sir, you've been talking about amphisbaenians for years. Do you really have anything new to say about them?" There was an audible gasp from the audience. One of them leaned over to tell Paul that he had just committed academic suicide! Carl, glaring down at Paul over the top rim of his glasses and seeming quite annoyed, continued on with amphisbaenians. One at a time, the rest of us stood up to voice other comments or complaints. More gasps. Finally, one of us asked him to talk about functional morphology instead, which Carl proceeded to do with feigned resignation. (This event was accurately, but cryptically, reported in *Herpetological Review*, 13:107, 1982: "After repeated interruptions by the audience, the author switched his topic to functional morphology.") After the talk, one senior herpetologist and close friend of Carl's, who was completely taken in and who had wanted to hear about amphisbaenians, dressed me down in no uncertain terms for interrupting the talk. Carl's master plan thus worked perfectly and he was absolutely thrilled to have completely fooled the audience!

Carl Gans was, of course, one of our most distinguished herpetologists. Other biologists, however, tend to think of him as a physiologist, behaviorist, bioengineer, comparative morphologist, or an evolutionary biologist. He also became an active conservationist. Above all, he was a naturalist in the most integrative sense of that old-fashioned, yet refreshingly modern label. And he knew every facet of the lives and evolutionary history of his animals. As he once replied to a newspaper reporter's question, "I can look at a reptile and know if it is happy or not." And Carl Gans could probably do it, too.

Acknowledgments.—Leo Gans kindly filled in the early years of his older brother's life. Several academic colleagues have read over and commented on my manuscript, for which I am most grateful. For help in locating some photos, I thank Robert Dudley, Andrew Gans, and Gregory Schneider.

Carl Gans: The Buffalo Years of 1961–1967

HERB ROSENBERG
Department of Biological Sciences, University of Calgary
Calgary, Alberta T2N 1N4, Canada
e-mail: herb.rosenberg@ucalgary.ca

I met Carl in 1961 when he was 38, clean shaven, unmarried, and had completed just three years at the University of Buffalo (UB) as a faculty member in the Biology Department. He was at UB from 1958–1971 and I worked under him for about half his stay there. I was a "floating" grad student at first and enrolled in Carl's course in evolutionary biology. Two things stand out from that course: 1) an evening field trip in the pouring rain searching for spring peepers in roadside ditches while Carl, replete in suit, tie, and raincoat directed the soaked students in their quest; and 2) enlightening discussions about Lee Dice's work on black and white mice in areas of black lava flows and white sand.

During his days as an assistant professor at the University of Buffalo (1962). Photo by M. Graham Netting; courtesy Kraig Adler.

Somehow I scraped through the course and one night Carl wandered into my grad cubicle, handed me a jar of preserved Emerald Tree Boa heads and two papers by Albright and Nel-

son. He challenged me to see what I could make of the snake's head morphology. Thus started a relationship that lasted some 48 years. Carl was my teacher, PhD advisor, mentor, den mother, role model, friend, and anything else he needed to be for this aspiring but clueless kid from Brooklyn whose knowledge of natural history extended from stickball to the Brooklyn Dodgers. Carl's first grad students were A. A. Alexander, Jim Bonin, Aaron Taub, then there was me, followed by Ed Saiff and H. M. Pandit.

Animals kept in Carl's lab: amphisbaenids, cobras and kraits, and *Bitis gabonica*

Carl's grad students were expected to become familiar with all aspects of herp care hence we served as his animal care technicians in those early, lean years. Carl had a great affinity for amphisbaenids and he focused on biomechanical analyses of their burrowing behavior. Many of these limbless squamates tunnel in sand so it was our job to autoclave vast quantities of sand, set up aquaria filled with sand, keep the sand at the proper humidity, feed the amphisbaenids a variety of food, and observe their feeding behavior. In most cases ingestion takes place after the reptiles draw their food back into the tunnel. We spent many hours staring at mealworms and pinks wriggling on a sandy plane but were rarely rewarded by observations of feeding behavior.

Carl had discovered that he had to attack the taxonomy and relationships of the amphisbanids in order to place his biomechanical observations into a meaningful framework. Part of the lab became a museum-like shipping department as parcels containing preserved specimens arrived from all over the world. We learned how to become curatorial assistants unpacking specimens, checking them off the shipping documents, and setting up jars for future study. We went through enough ethanol to pickle the entire campus but filtered out debris and reused alcohol whenever possible.

What does one do with a preserved amphisbaenid? Measure length of body regions, count annuli, record patterns of head and pre-anal shields, plot characters on geographic grids, take photographs (so we learned every aspect of macrophotography and darkroom technique), and then help Charlene (Carl's technician) prepare the manuscript for publication. Much of this work was later summarized (Gans 2005. Checklist and bibliography of the Amphisbaenia of the world. Bulletin of the American Museum of Natural History 289:1–130).

One of my earliest grad projects with Carl was a histological study in 1967 of serial cross sections that I prepared of everted amphisbaenian hemipenes (to be followed up by an SEM study in 1991). I obtained specimens to be sectioned by rummaging through the jars of preserved specimens in Carl's collection. One day Carl called me into his office and began to tear a strip off my hide….I had snipped off the everted hemipenis of a type specimen from the MCZ! Carl phoned Dr. Williams and the tempest was calmed when Ernest suggested that when the type is returned we include the slide box of serial sections as well. This is one of the very few times I saw Carl lose his temper. So somewhere on a shelf of the herp collection at the MCZ, hidden by jars of preserved whole specimens, sits a little box of slides made by yours truly.

At least amphisbaenids are not venomous! Carl focused on ophidian envenomation as an offshoot of his interest in reptilian feeding mechanisms. Aaron Taub worked on the structure and function of Duvernoy's gland, Elazar Kochva from Tel Aviv University spent a long sabbatical with Carl furthering his investigations of viperid venom glands, the late Bill Elliott fractionated and analyzed fresh venom, and I chipped in with a thesis on venom glands of elapids and sea snakes.

Thus Carl began to house all sorts of kraits, cobras, and vipers in his "animal room." Why is it that shipments of live kraits from Thailand always arrive in the middle of the night? Carl and grad students would drive to the airport with snake sticks, Pilstrom tongs, cages, bags, etc. We always offered to open the boxes for customs but somehow they always declined our offer. That's when my true colors began to show. It's one thing to stare at the mealworms in an amphisbaenid's sandy world but it's something else to clean the cage of a cobra or the fattest Gaboon Viper I ever saw. Carl never hesitated to keep these dangerous reptiles but I must say he was very cautious. Thus, he would never order live specimens unless he had a supply of the proper antivenin in his fridge. Carl developed an elaborate protocol with campus security so that each time we had to take dangerous specimens out of their cages, the campus police had to sit in his lab (while the red light was on) prepared to do a hospital run with the "victim" and a stock of antivenin. As far as I know, there never was a mad dash to the Buffalo General but there were several entertaining practice runs.

Formal portrait with Kyoko A. (Mabel) Gans, three years after their marriage and during his period at the University of Buffalo (December 1964). Photo courtesy Andrew Gans.

Caged animals somehow manage to escape. Venomous snakes were not a problem as they were all secured in padlocked cages designed by Carl. I will never forget one Saturday night when some arboreal lizard managed to gain its freedom and Carl was immediately notified as per his instructions. Carl and Mabel arrived dressed to the nines for a night at the theatre. Carl slipped out of his jacket and suspenders, then stepped out of his trousers and took off after the lizard in his boxer shorts, shirt, and tie. Mabel and I averted our gaze not so much out of modesty but to prevent bursting out in laughter. Carl caught the lizard, dressed, and headed off for a night on the town with Mabel.

Work habits in the Gans lab: time, technology, and writing

There is Eastern Standard Time and there was Gans time. Carl had a very different biological clock. He would usually arrive at the lab in the mid-afternoon and work till early morning of the next day. Of course his grad students were expected to be in the lab while he was there but they often had to teach an undergrad lab at 8 AM the next morning! Several times a week Carl would treat us to pizza at 2 AM; he would return to work and we would stagger home with our sleep impeded by a gastrolith of spicy, rubbery cheese and dense dough. Those were our good old days!

Carl would arrive at his office, spend time with phone messages, incoming mail, signing letters that had been typed by his secretary (Gloria) during the morning, and checking on grad students. Then he would settle down to work and revise manuscripts. Each manuscript was kept in a three-ring binder with the most recent version on top. Carl would read and "mark up" the manuscript in a very distinct, almost illegible scrawl for his secretary to retype the next morning. Thus, a manuscript was gone over again and again and eventually honed into a finished product to be submitted for publication. Grad students read the "final" version and were rewarded for any typos we might spot (they were few and far between). When the proofs were sent to Carl we would team up and

the grad student would read every word, punctuation mark, and number (think of all those columns of scale counts!) while Carl corrected the proof. Talk about hands-on learning. We followed the same process as we wrote our theses and prepared them for publication. Carl always acknowledged our help in print at the beginning of each publication we had been involved with.

One pillar of Carl's reputation rightly rests on the huge number of his publications (those written alone and those co-authored with colleagues). He had to rely on the technology of the day and would have been very much more productive if his entire career had been supported by computer-based word processing. When I arrived in Buffalo, Carl was progressing through a wide variety of voice recorders that he would use to dictate letters, memos, and first drafts of the several manuscripts he was working on. He always had a pocket- sized recorder with him to dictate memos to himself, students, et al. and these were constantly being replaced by newer models. Remember, his handwriting was not easy to decipher so his secretary played back his words through earphones while she typed the transcription. Carl would read through what was typed, edit the text, mark up the pages, and return them to the secretary for re-typing. This process would be repeated again and again with total retyping often being required! When I first arrived there was a manual office typewriter, then there was an IBM Selectric, followed by an IBM Magcard Selectric that stored information on magnetic cards, and eventually word processing (after I had moved on). When Carl finished with one typewriter, he would place it in the lab for his students to use; we were always one step behind in IT.

Carl was very innovative when he turned to biomechanical, physiological, and functional morphological investigations. Even before that he constantly sought to improve his efficiency in the lab. Thus, he invented (along with Bill Tanski) a foot pedal device (manufactured by Gomco in Buffalo) that allowed the operator to focus a dissecting microscope and leave both hands free to hold dissecting instruments (U.S. Patent Office 3,350,977). My role in this was to be the male model, sit at the lab bench, and pretend to be dissecting a snakehead for the sake of the publicity photos. While I was decked out in a tie and starched lab coat, my feet were clad in worn-out basketball sneakers. Imagine my surprise when the ad that appeared in *Bioscience* showed me wearing well-polished brogues that had been airbrushed over the sneakers (and this before the advent of Photoshop)! Later, Carl added a second foot pedal that activated a tape recorder so he could dissect with both hands, continue to keep the field of work in focus, and record his observations on tape all at the same time.

Carl became a great proponent of electromyography (EMG) as an analytical tool for functional studies. He spent a sabbatical in the lab of George Hughes learning the basics of EMG and was sure that if Hughes could record electrical activity from branchial muscles of sharks in tanks of water, he could certainly record from muscles used by tortoises in pulmonary ventilation on dry land. Thus started a prolonged series of EMG studies in a great diversity of vertebrates that focused on feeding, locomotion, ventilation of lungs, and other topics. Carl became involved with electrodes, amplifiers, oscilloscopes, all sorts of recording devices, and high-speed movie cameras (in some cases using strobe lights designed for aircraft!). Most of these technical accomplishments were reported in Loeb and Gans (1986. Electromyography for Experimentalists. The University of Chicago Press, Chicago, Illinois. 373 pp.).

Surrounded by the Central Dogma

The molecular biology bandwagon started to roll in the Biology Department at Buffalo in the early1960s. Suddenly, new faculty members arrived on the scene, vast areas of "open space" were occupied (goodbye to graduate cubicles), and the hum of ultracentrifuges filled the air. The nature of seminar programs was altered and traditional graduate pathways were complemented by those that went from DNA to RNA to protein synthesis. Carl more than held his own during this inundation but tended to spend more time with departmental politics. Friendly competition prevailed on the softball field as well as indoors. When Carl invited Professor Romer to deliver a departmental seminar, he requested his grad students to make the arrangements for coffee and cookies. Here was a chance for us to gain on the molecular types; no Oreo cookies for us. We set up a grand spread of bagels, lox, and cream cheese much to Carl's (and the ever-hungry grad students') delight. What a memorable event that seminar was!

Carl's libraries: in the lab, at home

Carl developed one library in his lab and one at home. The scientific library grew as a result of an extensive network of reprint exchanges with friends and colleagues around the world (*Current Contents* was less than five years old then). He also purchased important volumes from book dealers in North America and Europe. Whole sets of reprints had to be located and ordered whenever a new project took shape. The library was organized in a somewhat confusing but logical (to Carl) fashion so reprints could be retrieved from their boxes. First of all there was a geographical level of organization, set up by continent and then country; then the North American reprints were set up alphabetically by journal title; but there were also a variety of special sections that I was never too sure about. Of course in those lean times grad students would be required to learn about the world's literature by refiling reprints. We tried our best but not to worry, periodically we would "go through the collection" with Carl looking on to set things straight.

The collection at home consisted of cowboy novels, detective stories, science fiction, and whatever Carl happened to enjoy. Steel bookshelves in the attic of his Buffalo (and later Ann Arbor) home were lined with hundreds upon hundreds of paperbacks. Students had access to this collection as well but we never had to reshelve these books.

Barbeques galore

Carl was the consummate host and he loved his beef. Thus for summer, outdoor entertaining he typically fired up the barbecue in his backyard while Mabel produced large bowls of salad (that Carl barely glanced at). Grad students, undergrads, technicians, secretaries, colleagues, and visiting firemen were always invited. The beef was plentiful but almost as important Carl would always introduce the students to visiting zoologists from the famous to the infamous and inform them of our research programs. Just a few who stand out were the Belgian herpetologist G. F. de Witte, the Swiss neuroanatomist Werner Stingelin (who spent a sabbatical with Carl), the morphologist from Brooklyn, Paul Maderson, the morphologist Tom Parsons, the Israeli zoologist Elazar Kochva (who spent a prolonged sabbatical and helped mentor me in venom gland architecture), the Dutch physiologist Hank DeJongh (also spent a sabbatical in Buffalo), Toby and Sandra Gaunt, Carl's mother, and of course, A. S. Romer and E. E. Williams. At times it seemed as if there was a steady stream of visitors to Carl's lab and then backyard.

Conclusion

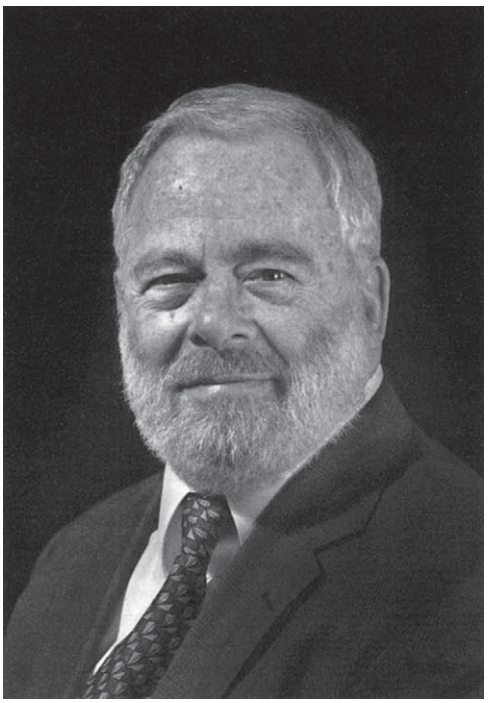
Thus, Carl's grad students received a very full regime of preparation for the real world. If Carl took you under his wing it meant that he took a deep interest in all facets of your education. Carl required me to complete a course in Botany, a full-year course in Human Anatomy in the UB medical school, a summer field course with OTS in Costa Rica (1965), and a post doc in chemical communication of insects at Cornell University with Carl's friend Tom Eisner (who else would accept me?).

Carl taught me many things beyond zoology. He was generous when it came to supporting various charitable organizations. He went out of his way to invite students, post docs, and faculty members to a stint in his lab from all over the globe knowing that their experience would further their careers once they returned home. He gave back to the profession by serving as the editor of the *Journal of Morphology* for 25 years. Carl also went out of his way to help authors rewrite and polish manuscripts

they submitted to the 21 volumes of "Biology of the Reptilia" that he co-edited and edited. Sure, he was demanding and had high standards but we were the ones who gained and eventually passed on the traditions to our students. Thank you, Carl.

Carl Gans: The Ann Arbor Years

R. GLENN NORTHCUTT
Graduate Program in Neurosciences, University of California, San Diego
La Jolla, California 92093-0662, USA
e-mail: rgnorthcutt@ucsd.edu



Formal portrait as Professor of Zoology at the University of Michigan (ca. 1994). Photo courtesy of the University of Michigan and Greg Schneider.

In 1971, at age 48, Carl moved to the University of Michigan in Ann Arbor as Chair of the Department of Zoology. He was near the peak of his scientific powers then and for the next 27 years, during which he continued to edit the *Journal of Morphology* and "Biology of the Reptilia" in Ann Arbor. During his first year as Chair, Carl paved the way for my own move to UM, where we taught, collaborated, ate and drank together, often with our wives, for the next 14 years. Our one-semester course in Comparative Vertebrate Anatomy usually involved around 100 students and consisted of four lectures and six hours of laboratory each week. Carl and I usually divided the lectures equally, and after each class we routinely repaired to a local pastry shop to critique the day's efforts, making sure that our discussion ended on a sweet note. Our papers together on the origin of vertebrates literally grew out of our reorganization of the Comparative Vertebrate Anatomy course at Michigan.

During his first four years in Ann Arbor, Carl provided strong leadership for the department at a particularly difficult time. Higher administrative officials were forcing a merger between Botany and Zoology, an action highly unpopular with both departments. The effects of this imposed merger were exacerbated by a downturn in Michigan's economy, which could have resulted in the loss of the university's non-tenured faculty in many departments. To Carl's great credit, he convinced the tenured members of his faculty to forgo raises in order to keep the entire faculty intact. His principles of fairness continued to be in evidence, as he was very active in correcting salary inequalities for women and minorities, at a time when the justice of such parity was anything but assumed.

While in Ann Arbor, Carl maintained an incredibly active laboratory, including graduate students, postdoctoral fellows, and an endless number of international visitors. Carl was a gruff colleague, however, and—although he was basically kind—he could be remarkably caustic, and he was not an ideal mentor for anyone with a hide less thick than a crocodilian's. I first met Carl while I was a graduate student with Hobart Smith at the University of Illinois. Hobart introduced us, then left to attend to other duties. Carl grilled me for at least 30 minutes on my research, albeit offering some good advice in the process. When he finally stopped, I asked, "And what are you working on now, Dr. Gans?", and Carl replied, "Everything," before leaving the room. Despite being somewhat put off by this reply—which I later decided was not totally inaccurate—I thus began my friendship with Carl Gans.

In addition to his scientific passions—namely morphology, biomechanics, and the biology of amphibians and reptiles—Carl had a passion for life in general, including food, wine, the arts, and travel. He did a great deal of the last in the course of his research, and he was an acute observer of political systems in the countries he visited—such as Australia, India, Sri Lanka—reading extensively on their social systems as well as their fauna. It was also rather a badge of honor with him to have endured fairly primitive field conditions in pursuit of his science. He was intensely fond of numerable art forms, everything from grand opera and early Japanese erotica to "The Cremation of Sam McGee," which he could often be persuaded to recite from memory after the wine had been flowing freely. After dinners at Mary Sue's and my home, he also sometimes led other guests in a rousing chorus of Gilbert and Sullivan songs. Carl was an exhaustive reader, virtually inhaling serious literature and hard-boiled detective stories with equal gusto. As a movie fan, his tastes were similarly catholic. He was particularly fond of Clint Eastwood's "Dirty Harry," who became his alter ego, but he appreciated foreign films and "serious" films. He also once persuaded me to accompany him to a showing of "Deep Throat," after which he remarked, "Oh well, there are only so many orifices in the human body." Always the morphologist, Carl was.

His wife Mabel (Kyoko) shared many of his passions, including travel, though not the deprivations of field work. She was confidant, research assistant, social secretary, and hostess. Regardless of whatever professional or personal pressures the two were experiencing, they were unfailingly gracious hosts, and always demonstrated love and support for one another. Scientifically and personally, Carl and Mabel had a profound effect upon Mary Sue and me, as well as on other academic couples who had the good fortune to interact with them for an extended period of time.

During his years in Ann Arbor, Carl was not always easy, as a colleague or as a friend, but what stands out in my mind is the respect and affection I had for him then and now.

Reminiscences of Carl Gans

AARON M. BAUER
Department of Biology, Villanova University
Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu

Although I never attended a school where Carl Gans taught and cannot claim to have been particularly close to him, he was an important influence on my personal and professional development, as he was for many other herpetologists. Perhaps appropriately, I learned of his death after a week of collecting in the Caprivi Strip of Namibia, which yielded a diversity of organisms that played a role in Carl's career, among them the egg-eating snake *Dasypeltis*—the subject of his doctoral dissertation, and several species of amphisbaenians—the organisms most intensely studied by him.

In the spring of 1980 I was an 18-year-old freshman at Michigan State University and, after taking Comparative Vertebrate Anatomy in the winter quarter, signed up for a graduate seminar in "advanced morphology" taught by Jim Edwards. The course included some lectures and stu-

dent-led discussions of relevant primary literature in vertebrate morphology. Carl's "Biomechanics" was the course text. Each student selected a prominent morphologist and was responsible for selecting and leading the discussion on papers by that author. As a budding herpetologist, I chose Carl Gans, whose work on locomotion in amphisbaenians—a group then practically unknown to me—I found fascinating. The course also featured guest lectures by visiting morphologists, one of whom was Carl. Because of my special interest in reptile morphology and because I was "responsible" for Carl's papers in the course, I was invited to dinner with Carl at the Kellogg Center, just across from my dorm. Although I was clearly out of my depth, I was thrilled to have the opportunity to talk to the great Professor Gans, who engaged me in conversation as if my opinion actually mattered and thus cemented my intention to pursue research in reptile morphology.

I next encountered Carl at my first SSAR meeting (Salt Lake City in 1983). I was in a morphology session, back-to-back with a number of my fellow Berkeley graduate students. Carl was in the audience and all the students in the session were on edge, hoping that he didn't find fault with their presentations and turn the question period into an uncomfortable grilling. For one of the speakers before me it was a worst case scenario. When questions opened, Carl stood up and began by saying "Your premise is fundamentally flawed …." Somehow, seeing that my colleague survived this settled my own nerves and 15 minutes later I gave my first scientific presentation with confidence. Carl's questions were direct and generally on the money and his criticisms were typically valid, revealing either real flaws or inadequacies in presentation that detracted from the arguments presented. Although it could be intimidating to face Carl under such circumstances, his criticisms were typically fair, and his negative opinions, especially in the case of students, were usually aimed at the work and not the individual. However, Carl did make enemies, and close association with those on his bad side could strain relations with him. Carl enjoyed the fact that he was held in awe (or fear) by students (and many more senior colleagues) and that he was taken deadly seriously by nearly everyone. In reality, despite the gruff exterior, he was fond of playing subtle jokes that would be signaled by winks and nods to those in the know.

At the SSAR annual meeting in 1984, Carl, then president of SSAR, had donated several items for the SSAR auction. One was Da Silva's "Snakes of Sri Lanka," which had been published shortly before. The work was not generally available outside Sri Lanka and Carl had picked it up on one of his trips there. For bibliophiles the book was a rare prize and there was spirited bidding. Ultimately I was one of three bidders left when the price exceeded $100 (then more than 10% of my monthly TA salary and more than half my rent). My competitors both had "real" jobs and I eventually dropped out at about $150. Later in the evening Carl came up to me and said "Thanks for driving the bidding up. I'll send you one next week." He did and through the years occasionally remembered my interest and picked up extra copies of obscure titles for me.

After I became gainfully employed, Carl and I began an abortive project on locomotion in limbless skinks of the genus *Acontias*. Having just returned from South Africa with live specimens, I flew to Detroit in the dead of winter and stayed with Carl in Ann Arbor, "running" the lizards on pegboards in his lab and writing in tandem, sitting with Carl at his computer while he typed. Carl's schedule, rising late and working until the wee hours of the morning, was more or less six hours phase-shifted from my own and I could barely stay awake as a new set of animals was introduced to the pegboards at 3 AM. This was exacerbated by an unfortunately timed bout of recurrent malaria. Carl barely noticed that I was sweating and shivering in his single-minded pursuit of the project. However, back at home, he immediately switched modes and became "daddy" to his dog P.C., who brought out his softer side.

Although I would never dare to compare my accomplishments to Carl's, I did end up following in his footsteps in terms of research venues and for many years I have passed in Carl's wake in southern Africa, India, Sri Lanka, Australia, Eastern Europe, and elsewhere. In nearly every place I have visited people know Carl, many personally from his own extensive travels, but certainly at least by reputation. Indeed, Carl was probably the most well-known herpetologist in the world at large for a period of 20 years from about 1970 to 1990. As Carl's health declined and his travels decreased, my foreign colleagues would always ask about him. Many were profoundly affected by him and most considered it a genuine privilege that they were able to interact with him, both personally and professionally. A visit from Carl Gans brought prestige to any researcher or institute.

Carl Gans and field crew in 1978 in the Pilbara region of Western Australia where, on their way back to Perth, the party stopped to see some aboriginal rock carvings at Woodstock Station. Among those present are Gans (crouching) with Harold Cogger on his left (in shorts), Hubert Saint Girons on his right (with cap), and Donald Bradshaw at the wheel of the vehicle Photo courtesy of Donald Bradshaw.

Carl Gans was larger than life. His domination of diverse biological disciplines was unparalleled in the late 20th century. That his was both the first and last word on so many topics is attested to by his bibliography, which lists a score of "prefaces" and "concluding remarks." I only had the opportunity, along with Rainer Günther, to co-author one paper with Carl, in 1997, on the amphisbaenian types in the Berlin Museum. However, my favorite of his 600+ works, or at least my favorite title, is a 1978 paper from *American Zoologist*—"All animals are interesting!" As reflected by his life's work, Carl certainly believed this and helped the rest of us believe it too.

Carl Gans: The Austin Years 1997–2009

CHRISTOPHER J. BELL
Department of Geological Sciences, 1 University Station – C1100
The University of Texas at Austin
Austin, Texas 78712, USA
e-mail: cjbell@mail.utexas.edu

Carl Gans and his wife Mabel retired to Austin, Texas in 1997. Serendipitously, that was the same year I arrived in Austin, but they beat me here by several months. I had maintained a fruitful and entertaining correspondence with Carl for many years, beginning in 1993 with the publication of my first papers on fossil lizards. I sent copies of those papers, as a 'calling card' of sorts, to many people who had published on fossil reptiles, introducing myself and my shared interest in that topic. At the end of the accompanying (and, in retrospect, startlingly naive) cover letter, I included a brief request for copies of all papers the recipient might still have available for distribution. Carl was one of the recipients of that letter. Soon after, I received a reply from him indicating that he was somewhat taken aback by my open-ended request for reprints, but had decided to send me copies of all titles he still had on hand. Even now I cringe a bit when I recall the day I received a large box containing

hundreds of monographs and reprints authored and co-authored by Carl. He apparently was amused by both my initial request and the humble 'thank you' letter that followed, and we continued to exchange letters and publications for several years, but never actually met until I arrived in Austin. A few months after settling here I answered my telephone one afternoon and heard a deep and somewhat gruff voice admonishing me for not having been in contact... "You haven't called me, so I thought I'd better call you." I had no idea to whom I was listening until he identified himself as Carl Gans. He proposed dinner, I accepted, and we met in person for the first time.

Those who knew Carl in his days at the University of Michigan have made clear to me that I knew him in a different way than they did. The descriptions I would provide of my interactions with Carl seemed impossible to some of them, as if I were describing a second person of the same name. A few hints of the sobering interactions that sometimes arose between Carl and graduate students are found in the reflections that accompany my own in this compilation; the rumor mill carries many other stories. Carl even implicated himself one night during dinner with my wife and me, when he joked "I used to eat graduate students for lunch." I knew Carl as a serious scientist, critical thinker, meticulous editor, avid reader, and bibliophile, but also as a genial colleague with a subtle sense of humor who enjoyed a good chuckle, and gave and accepted lighthearted teasing with equal delight. I have no terror stories, no squirming moments of discomfiture as my ideas were dissected and ego bruised in a clash with Carl. Instead, I always received considered advice, support for my endeavors, and a subtle but persistent encouragement toward higher standards in everything. Carl shared his time and expertise freely, along with a seemingly endless supply of reminiscences and anecdotes about his collections, field trips, colleagues from around the world, and parties at the annual herp meetings.

Carl's retirement was not a retreat from science, nor from active engagement with students and his colleagues. He enjoyed acquainting himself with the herpetological fauna of Texas, and took particular delight in announcing his Austin home address on Slow Turtle Cove. He moved here at the invitation of Robert Dudley, a collaborator and colleague who was then on the faculty in the Department of Integrative Biology at The University of Texas at Austin. Carl held the position of Adjunct Professor and maintained a research laboratory in that department, served as a member of PhD student committees, and participated as guest lecturer or discussant in several courses in the departments of Integrative Biology and Geological Sciences. His research activities were truncated shortly after arriving in Austin, when Mabel was diagnosed with cancer. Following her death in 1999, Carl refocused his attention on his scientific and literary pursuits with emphasis on three major projects in herpetology. One was an intensified effort to obtain from authors the final manuscripts for a new volume in the "Biology of the Reptilia" series, and to see those manuscripts through the review and revision process (these were eventually published as volumes 20 and 21 in 2008). The second project was an ongoing collaboration with Ricardo (Ueso) Montero on the cranial osteology and skeletal development of amphisbaenians (published in 1999 and 2008). The third was compiling and editing an updated checklist of the Amphisbaenia of the world, accompanied by an extensive bibliography on the group (2005).

He regularly hired undergraduate and graduate students to help him with research tasks and to work in his libraries. One of those libraries was an extensive collection of paperback novels that were housed in a loft above his master bedroom. His more expansive scientific research library filled a three-car garage and represented an intensely personal collection, incorporating books from his early career as an engineer, and reflecting his broad interests in natural history. He maintained subscriptions to no fewer than 85 serial publications, several of which are rarely seen in personal collections. Carl had a particular fondness for ferreting out what others have called 'obscure' literature, but he was adamant in his denial of the existence of such a category. In his view literature simply exists, and it is our responsibility to seek it out and cite it where relevant. He had an amazing ability to remember exactly what was in his library, as well as how to find it. The latter was no small accomplishment in a library the size of his. Apart from special topics (e.g., mimicry, conference abstract volumes, functional morphology), he generally filed his books, monographs, and reprints geographically. Usually the geographical referent was the topic, but sometimes he filed based on the location of the publisher. For example, Duellman's monograph on the equatorial herpetofauna of Amazonian Ecuador might be filed in South America, or in Kansas, depending on how Carl thought about it at the time he obtained and shelved it. Until you learned to think like he did about the organization, finding particular items could be a challenge.

Carl suffered a debilitating stroke in late January, 2001. After a short period in hospital he returned home, but was confined to a wheelchair. He and his brother arranged for some renovations to his house after the stroke, but among other inconveniences he was no longer able to enter the stacks in his research library. The fixed shelving was spaced to accommodate a maximum of printed material, not the width of a wheelchair. After his return from the hospital, my visits with Carl always included some time in his library, filing newly-received materials and pulling titles that Carl needed or wanted to see as he continued the increasingly frustrating effort to maintain his research activities.

In the years following his stroke a major priority for Carl was making arrangements for the disposition of his remaining collections. Prior to his retirement, most of his skeletal and alcoholic specimens were deposited in the Museum of Comparative Zoology at Harvard University and the Carnegie Museum of Natural History in Pittsburgh. He retained his amphisbaenian and uropeltid snake collections until it became clear that he would no longer be able effectively to work with those specimens. Although a small collection of dry skeletal specimens was donated to the Vertebrate Paleontology Laboratory at UT Austin, the majority of the uropeltid snakes ultimately were deposited at the California Academy of Sciences in San Francisco, and the amphisbaenians went to the Field Museum of Natural History in Chicago.

As far as I know, Carl recognized only two 'subcollections' within his scientific library, constituting materials that were filed and housed independently from the main body of his collection. The first was his lancelet collection, the second his reprints and monographs pertaining to amphisbaenians. His attempt to survey the extensive literature on lancelets included gathering physical copies of the majority of the 2696 titles cited in the published 'bibliography of the lancelets' (1999). That collection was deposited at the Scripps Institute of Oceanography in La Jolla, California. A substantial portion of his literature on the Amphisbaenia was sent to Maureen Kearney at approximately the same time that his specimens went to the Field Museum. The remainder of his library, along with 13 filing cabinets containing his scientific correspondence, was deposited at the Ben Gurion University of the Negev, in Midreshet Ben-Gurion, in the Negev Desert in Israel.

Although he struggled with declining health in his later years in Austin, Carl always enjoyed visits from colleagues and former students, and drew satisfaction from the simple pleasures of a fully retired lifestyle. He especially enjoyed his contact with graduate students, hearing about their projects and offering advice or suggestions for interesting questions or problems. He enjoyed and appreciated letters from other scientists who wrote with data or questions following up on one of Carl's earlier publications. He was especially gratified when he heard the news in 2008 that salamanders had been discovered once again in the parks on Manhattan Island in New York City (see Kraig Adler's account above).

Carl was a connoisseur of fine coffees and chocolates. He pursued these with increasing enjoyment after his stroke, and drew greater satisfaction from the pursuit of favored comestibles as his research activities waned. He maintained an impressive mental list of 'favorite' restaurants in Austin, as well as a slightly more select register of appropriate venues for the consumption of dessert. An evening meal with Carl often was a multi-hour event, and could involve stops at as many as three establishments. Such evenings were always a welcome opportunity for Carl to

enjoy good company, good food, and good conversation. He died on 30 November 2009, and is buried in the Cook-Walden Jewish Cemetery in Pflugerville, Texas.

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Suggested Reading

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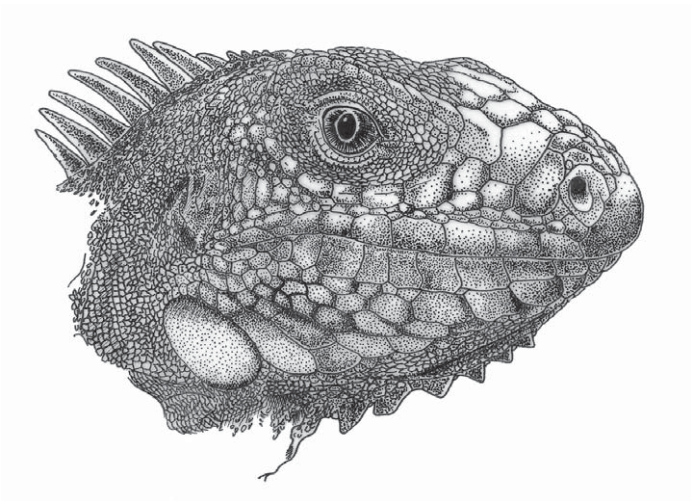

Iguana iguana (Green Iguana). Colombia: Department of Casanare: municipality of Orocue. Illustration by Fernando Vargas Salinas, based on a photograph by Luis Alberto Rueda and Fernando Vargas S.

ARTICLES

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Reconsidering Extinction: Rediscovery of *Incilius holdridgei* (Anura: Bufonidae) in Costa Rica After 25 Years

JUAN ABARCA
Department of Biology, Universidad Nacional de Costa Rica
Heredia, 40101, Heredia, Costa Rica

GERARDO CHAVES*
Zoology Museum, Department of Biology
Universidad de Costa Rica, Mercedes de Montes de Oca
11503, San José, Costa Rica

ADRIÁN GARCÍA-RODRÍGUEZ
Zoology Museum, Department of Biology
Universidad de Costa Rica, Mercedes de Montes de Oca
11503, San José, Costa Rica

and
RODOLFO VARGAS
Department of Biology, Universidad Latina de Costa Rica
San Pedro de Montes de Oca, 11501, San José, Costa Rica

** Corresponding author; e-mail: cachi13@gmail.com*

Amphibian populations are declining around the world (Wake 1991). Of the 6433 amphibians species (Frost 2009), close to 500 species are considered endangered (Stuart et al. 2008). Thirty-eight amphibian species have been declared extinct (IUCN 2008). For Costa Rica, the magnitude of amphibian declines has been so severe that three endemic species were declared extinct: the famous Golden Toad, *Incilius periglenes,* in 2002 (IUCN 2003), and both *I. holdridgei* and *Craugastor escoces* (Craugastoridae) in 2007 (IUCN 2008). The reduced geographic range of these species, their conspicuity, and the substantial search effort invested in areas where they previously were abundant justified categorizing these species as Extinct (IUCN 2008). These disappearances have been attributed to different causes, including climate change (Pounds 1997, 2001) and emergent diseases such as chytridiomycosis (Lips et al. 2006), or the synergistic effect between these two agents (Pounds et al. 2006).

A species is considered extinct when, as defined by IUCN (2001), there is no reasonable doubt that the last specimen has died. Difficulties with this designation may arise for secretive species or when the reproductive behavior of the species changes in relation with the reduction in population density (Mattsson et al. 2008). For example, explosive reproduction is a strategy to reduce the individual predation rate and increase the attraction of females (Duellman and Trueb 1994). When such species decrease in numbers, it is common to assume they are headed to extinction, but it is possible that they use an alternative reproductive behavior. The Costa Rican highland toads represent a classic example of these problems. Most of them are subterranean, emerge during explosive breeding events, and produce little to no audible vocalization. The need to form aggregations during reproduction may