ZOO VIEW

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Conservation Initiatives and Studies on Tortoises, Turtles, and Terrapins Mostly in Zoos and Aquariums. Part II— Suborder Pleurodira, Suborder Cryptodira, Sea Turtles

TWO HUNDRED MILLION YEARS AGO THE REPTILES, NEWLY ARISEN FROM AN UNCOMMONLY DOUGHTY SET OF AMPHIBIANS, WERE ON THE VERGE OF GREAT ADVENTURES. THEY BORE THE MARK OF DESTINY IN THE SHAPE OF IMPERVIOUS SCALES AND THE NEW CUNNING TO LAY SHELLED EGGS, AND THESE DEVICES INSURED THEM AGAINST THE AGE-OLD DISASTER OF DRYING OUT, BOTH BEFORE BIRTH AND AFTER, AND LET THEM GRATIFY THEIR GROWING CURIOSITY ABOUT THE VAST AND ALMOST EMPTY LAND. ALONG WITH THE NEW EQUIPMENT THEY HAD IMAGINATION AND NO END OF NOTIONS FOR NOVEL BODY DESIGNS. TODAY WE CALL THESE OLD BEASTS COTYLOSAURS, OR STEM REPTILES, BECAUSE ALL THE LINES OF VERTEBRATE LIFE ABOVE THE AMPHIBIAN LEVEL LEAD BACK TO THEM AS BRANCHES CONVERGE IN THE TRUNK OF A TREE.

—ARCHIE CARR, *HANDBOOK OF TURTLES*, 1952

When Archie Carr wrote *Handbook of Turtles* in 1952, there was no chapter on conservation but only a brief discussion on economic uses and methods for collecting turtles. Today, virtually every book and many papers include this conservation topic, reflecting the reality that the future for chelonians is so uncertain (Fig. 1). In fact, it is dramatic that so many books and articles written now on amphibians and reptiles stress environmental degradation, crashing populations, and threatened status. See Bonin et al. (2006) as an example. Who could have predicted years ago that titles might now include these sobering three words—*Sixth Mass Extinction*? Part I (concerning tortoises) was published in the previous issue of *Herpetological Review.*

SUBORDER PLEURODIRA
FAMILIES CHELIDAE, PELOMEDUSIDAE, PODOCNEMIDAE

New World and Old World snake-necked turtles (named for their ability to bend the neck to the side) are popular exhibits (Fig. 2). At Smithsonian National Zoo, a group of Common Snake-necked Turtles (*Chelodina longicollis*) is kept in a large semi-aquatic display with a breeding group of small, colorful rainbow fishes of the family Melanotaeniidae. Visitors flock to see them, especially when hatchling turtles hiding in the plants are suddenly discerned. Murphy and Lamoreaux (1978) described courtship and mating behavior in three Australian chelid turtles (Common Snake-necked Turtle [*Chelodina longicollis*], Northern

JAMES B. MURPHY
Division Amphibians & Reptiles, National Museum of Natural History, 10th and Constitution Ave NW, Washington, DC 20013-7012, USA
e-mail: murphyjb@si.edu

FIG. 1. The tragedy we now face is how many chelonians will disappear forever from the face of the earth during our lives? Plate 89-Testudo from *Kunstformen der Natur* by Ernst Heinrich Philipp August Haeckel, 1899–1904.

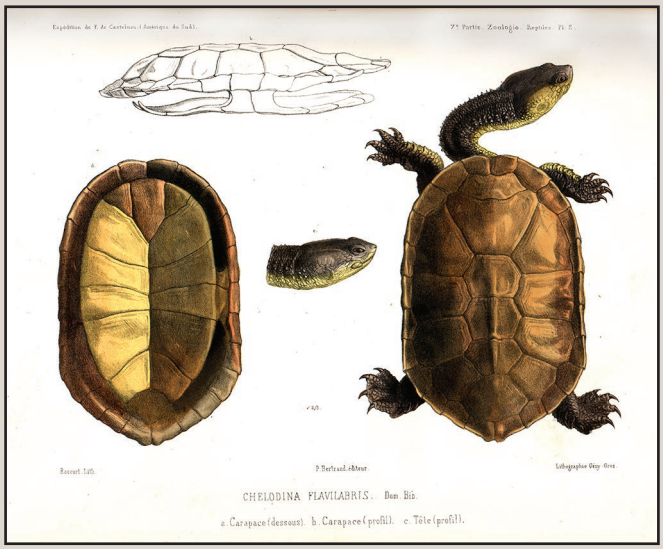

FIG. 2. Maximilian's Snake-necked Turtle (*Chelodina flavilabris* now *Hydromedusa maximiliani*) from *Expédition dans les parties centrales de l'Amérique du Sud, de Rio de Janeiro à Lima, et de Lima au Para; / exécutée par ordre du gouvernement français pendant les années 1843 à 1847, sous la direction de Francis de Castelnau* ... 1855. Zoo visitors find turtles with long necks particularly fascinating.

FIG. 3. Murray Tortoise (*Chelemys Macquaria* now *Emydura macquari*) from *Natural history of Victoria. Prodromus of the zoology of Victoria* by Frederick McCoy, 1878–1890. This turtle has unusual courtship behavior. See text.

Australian Snapping Turtle [*Elseya latisternum*], Murray River Turtle [*Emydura macquarii*]) at Dallas Zoo. Corwin (1986) studied the reproductive behavior of two Australian chelid turtles, *Emydura macquarii* and *Elseya latisternum*, at Dallas Zoo. John Legler sent a note several years later after watching wild turtles, which reinforced the behavioral descriptions of the *Emydura* observed in the Dallas captives (Fig. 3). At Leipzig Zoo, Fritz and Jauch (1989) elaborated on mating behavior and reproduction of Parker's Snake Neck Turtle (*Chelodina parkeri*), which included courtship, breeding, development, and ontogenetic color pattern change. Fritz (1993) provided notes on the courtship behavior of the Australian Snake-necked Turtle (*Chelodina expansa*) at Wilhelma Zoo. Fritz et al. (1991) provided long-term observations on husbandry and reproduction of the Red-bellied Sharp-snouted Turtle (*Emydura albertisii*) at Wilhelma and Cologne Zoos. Kuchling (2013), Kuchling and Dejose (1989), and Kuchling et al. (1992) created a captive breeding operation at Adelaide Zoo to rescue the critically endangered Western Swamp Turtle (*Pseudemydura umbrina*) from extinction. One of the rarest turtles is the Madagascan Big-headed Side-necked Turtle (*Erymnochelys madagascariensis*), considered to be among the top 25 endangered chelonian species (Fig. 4; Kuchling and Mittermeier 1993; Castellano et al. 2013). A successful captive-breeding program has been established in Madagascar (Velosoa et al. 2013).

The Fitzroy River Turtle (*Rheodytes leukops*) was described by John Legler and John Cann in 1980. Later, Legler sent a pair of adults to Dallas Zoo for behavioral observations. The aggressive pair had to be separated, so they were placed in large aquaria with heavy filtration and aeration. Although some turtles are known to absorb oxygen through the cloaca, this turtle "breathes" by pumping water through the cloaca and shoots a continual stream of water through the cloacal sphincter so powerful that one can discern a strong current. Since herp curators have little to do during work hours and are easily distracted, I watched for hours with coffee in hand to see if these chelonians ever surfaced to breathe air; neither turtle ever did. When Legler was told of this phenomenon, he felt that it was an adaptation to avoid predation by saltwater crocodiles; presumably the turtles would be at risk if they had to rise through the water column to breathe surface air.

At San Antonio Zoo, Bonefield (1979) hatched the Argentine Snake-necked Turtle (*Hydromedusa tectifera*), Kardon (1981) bred Geoffrey's Side-necked Turtle (*Phrynops g. geoffroanus*), and Holmback (1987) described reproduction of the New Guinea Side-necked Turtle (*Emydura australis albertisii*). Wicker (1984) followed captive breeding, nesting, incubation, and hatching over several generations in Geoffrey's Side-necked Turtle at Frankfurt Zoo. Goode (1988) discussed reproduction and growth of the chelid turtle *Phrynops gibbus* (= *Mesoclemmys gibbus*) at Columbus Zoo. Lucia Da Silveira and Andre (1986) provided preliminary notes concerning lesions to the plastron of *Phrynops gibbus* caused by fungi and bacteria. At Dallas Zoo, South American turtles were represented by several Twist-neck Turtles (*Platemys platycephala*), a pair of Red-footed Amazon Side-necked Turtles (*Rhinemys rufipes*) (Fig. 5), a small group of Red-headed Amazon Side-necked Turtles (*Podocnemis erythrocephala*), Yellow-headed Sideneck Turtles (*P. expansa, P. unifilis*), and Six-tubercled Amazon River Turtle (*P. sextuberculata*). Thorbjarnarson and da Silveira (1996) described nesting in *P. unifilis*.

Richter (1989) bred the Matamata Turtle (*Chelus fimbriatus*) at Hamburg Troparium (Fig. 6). At Smithsonian National Zoological Park and New York Zoological Park, Matamata eggs were successfully incubated (Rosscoe and Holmstrom 1996). Holmstrom (1978) from Bronx Zoo described prey-herding behavior, but these findings were disputed by Wise et al. (1989).

SUBORDER CRYPTODIRA
MOST FAMILIES OF EXTANT TURTLES DISTINGUISHED BY RETRACTION OF NECK IN A VERTICAL PLANE

On 4 December 1849, the London Zoo received its first pair of Alligator Snapping Turtles (*Macroclemmys temminckii*). Painted Turtles (*Chrysemys picta*), acquired in 1838, were bred for the first time in Great Britain between 1860 and 1861 (Coote 2001). Irwin and Thomson (1995) described captive breeding in the Alligator Snapping Turtle (*Macroclemys temminckii*) at the Queensland Reptile and Fauna Park (now Australia Zoo). Netten and Zuurmond (1985) mentioned offspring of the Common Snapping Turtle (*Chelydra serpentina*) in the reptile zoo Iguana (see also

FIG. 4. Madagascan Big-headed Side-necked Turtle (*Erymnochelys madagascariensis*) is one of the rarest turtles in the world. Image from *Histoire physique, naturelle, et politique de Madagascar* by Léon Vaillant & Guillaume Grandidier in 1910. A captive breeding facility is in place in Madagascar.

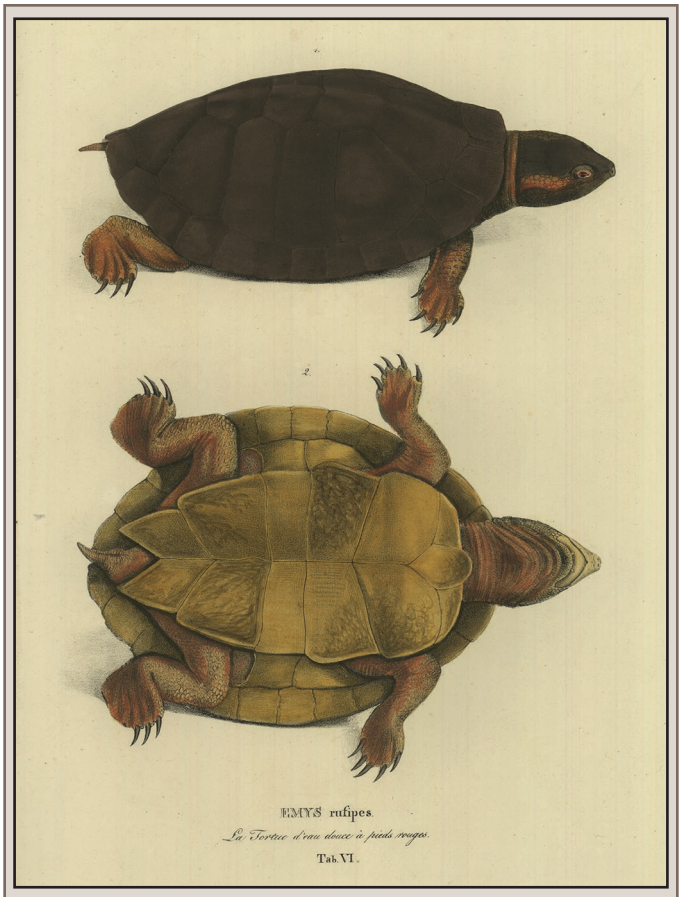

FIG. 5. Red-footed Amazon Side-necked Turtles (*Rhinemys rufipes*) from *Animalia nova sive species novae Testudinum et Ranarum* by Johann Baptist von Spix, 1824. This beautiful turtle is rarely seen in zoo collections.

Steyermark et al. 2008). When I was in high school, I found a massive adult snapping turtle on land with its mouth agape, revealing a large stick jammed inside; the end had been broken off by some miscreant. Nervously, I tried to pull the stick out with my fingers as I had no pliers or other tools available but only the part I could see was all the way inside its mouth. Since my fingers were the only way to grasp the stick and remove it, I was worried about being bitten so I placed my fingers on both sides of the stick to avoid digits being crushed. To my surprise, the turtle remained completely calm and never was the least aggressive as my fingers were inserted into its mouth. After the stick was removed which took many minutes, the turtle crawled slowly to the water and submerged. The whole experience reminded me of the old folktale of *Androcles and the Lion* describing the nature of mercy.

Giles et al. (2009) stated "Only the young of an aquatic Asian species, *Platysternon megacephalum*, has been observed to 'squeal,' particularly when disturbed. Loss of this ability to vocalize appears to be related to a certain level of maturation corresponding to a change in appearance, i.e., loss of bright colors, when the carapace length measures around 3 in. and when jaw development was such that they could bite (Campbell and Evans, Herpetologica 1972, p. 277)." For many years, an adult Big-Headed Turtle always responded to human disturbance when handled at Dallas Zoo by opening its mouth to try and bite while jumping toward the threat, raising its body off the substrate and tilting its shell toward the human, and producing a low guttural sound reminiscent of a growling vocalization. This turtle was kept at 70°F (21°C) and rarely used a small "hot spot" as a basking site. See Gad (2007) for captive management recommendations.

Korolev et al. (1984) described husbandry of soft shell turtles at Moscow Zoo. Burghardt et al. (1996) and Burghardt (2005) documented evidence of play behavior in a large captive Nile Soft-shelled Turtle (*Trionyx triunguis*) named Pigface at Smithsonian National Zoological Park (Fig. 7). This solitary turtle was provided with sticks, balls, hoops of hose, and other objects. He would nose, bite, grasp, chew, push, pull, or shake with his mouth but lost interest unless toys were rotated; this behavior involved much time and shows the value of an enriched environment. Herpetologists from Wildlife Conservation Society discovered an animal that is almost certainly one of the last remaining East Asian Giant Softshell Turtles (possibly *Rafetus swinhoei* or an undescribed species) in Hoan Kiem Lake in the center of Hanoi, Vietnam, in March 2003. There is little information on the Flap-shelled Turtles of the genus *Lissemys* (Fig. 8). Vyas (1996) provided breeding data on *Lissemys punctata* from western India and a pair lived at Dallas Zoo for many years but never bred. A specimen at Smithsonian National Zoo has coexisted with an adult female True Gavial for many years and often tries to snatch food fish from its mouth. The gavial completely ignores this turtle and several river turtles (*Batagur*). Vyas and Patel (1992, 1993) studied reproduction of the Indian Soft Shell Turtle (*Aspideretes gangeticus)* and captive breeding of the Indian Roofed Terrapin (*Kachuga tecta*). The Chinese Softshell Turtle (*Pelodiscus sinensis*) is bred in staggering numbers in China for the food market. Some accounts estimate that over 200 million are slaughtered annually for that purpose. A decade ago, hundreds of these living turtles were regularly offered for sale in Asian markets and restaurants in Washington, DC, and surrounding areas (pers. observ.). Occasionally, other softshell turtles, Diamondback Terrapins, sliders, and Common Snapping Turtles (*Chelydra serpentina*) from North America were available as well. When I asked where these turtles had been purchased, without exception the employees refused to divulge the source.

At Dallas Zoo in 1970, Victor Ashe examined the righting reflex of 63 turtles representing 50 species. The chelonians were tested under two conditions: inversion and suspension. Ninety-two percent performed the righting reflex under inversion and

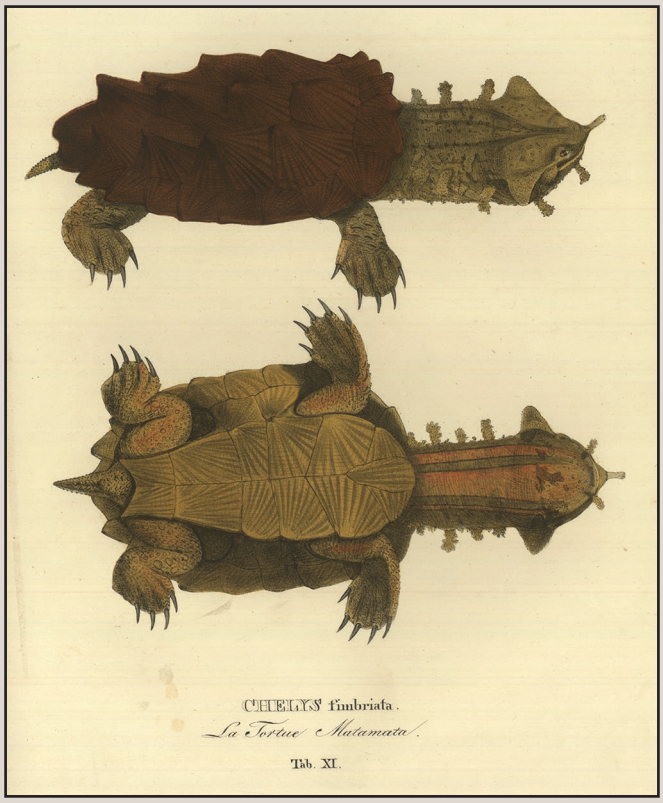

FIG. 6. Matamata (*Chelus fimbriata*) from *Animalia nova sive species novae Testudinum et Ranarum* by Johann Baptist von Spix, 1824. There are reports of young turtles herding fishes but other authors discredit these observations.

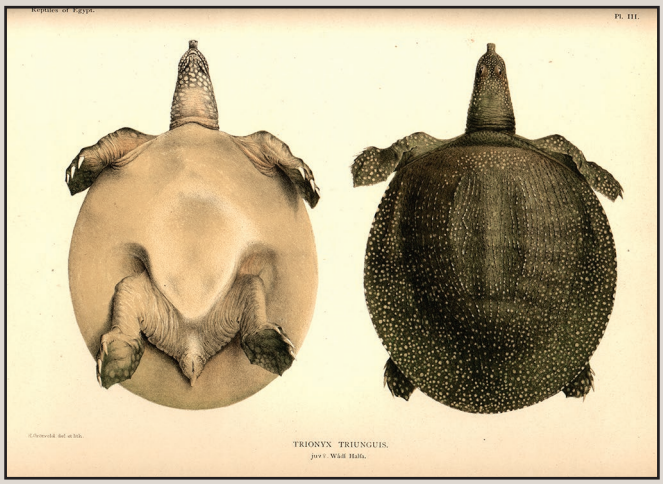

FIG. 7. Play behavior was recorded in the Nile Soft-shelled Turtle (*Trionyx triunguis*) at Smithsonian's National Zoo. Image from *Zoology of Egypt. Reptilia and Batrachia* by John Anderson, 1898.

67% under suspension. Differences in the righting reflexes were noted and discussed in terms of natural selection and evolutionary relationships of the species sampled.

Herman (1993) described reproduction and management of the southeastern Asian Spiny Turtle (*Heosemys spinosa*) and Herman and George (1986) outlined research, husbandry, and propagation of the Bog Turtle (*Clemmys muhlenbergii*) at Zoo Atlanta. Tryon and Hulsey (1977) described breeding and rearing of the Bog Turtle at the Fort Worth Zoo. Wallace (1978) described enclosure utilization and activity patterns. The late Bern Tryon from Knoxville Zoo worked with Bog Turtles for over 25 years. At the 8th Annual Symposium on The Conservation and Biology of Tortoises and Freshwater Turtles, he received a Lifetime Achievement Award from TSA and IUCN. He donated his library to TSA for sale, which has since raised over US $50,000 for Bog Turtle conservation. In 1978, he published two papers on breeding and raising aquatic chelonians. Collins (1989) from Burnet Park Zoo, Syracuse, New York, offered a perspective on the captive propagation of Bog Turtles from western New York State. Brenner et al. (2002) performed health surveys of wild and captive Bog Turtles in North Carolina and Virginia. In 2004, Spotted Turtles (*Clemmys guttata*) hatched for the third time at Detroit Zoological Institute. Trooper Walsh (pers. comm.) keeps a breeding group at his home outside of Washington, DC, and the turtles hibernate successfully in large tubs and produce hatchlings each year; he observes that it is critical to prevent the water from freezing.

Müller (1970) bred the Red-eared Slider (*Trachemys scripta elegans*) at Leipzig Zoo. Kramer and Fritz (1989) outlined courtship in the Florida Red-bellied Turtle (*Pseudemys nelsoni*). Connaughton and Paine (1989) described captive management and reproduction in the Venezuelan Slider Turtle (*Pseudemys scripta chichiriviche*) at Buffalo Zoo. In a large lemur exhibit with an extensive pool at Smithsonian National Zoo, a mixed group of sliders, red-bellied turtles, painted turtles, and map turtles regularly reproduce. Visitors sometimes slip into the zoo unseen with their unwanted pets and drop them from the elevated public walkway above into the water. Fritz (1990) provided an extensive overview of the care and breeding of the Jamaican turtle (*Trachemys terrapen*) with additional notes on the reproductive strategy of Neotropical turtles of the genus *Trachemys*. His account described courtship, breeding, nest construction, hatching, reproduction, and teratology. Odum (1985) described deformity in a Red-eared Slider at Toledo Zoo**.** In 2004, Barbour's Map Turtle (*Graptemys barbouri*) reproduced at the John G. Shedd Aquarium in Chicago. At Dallas Zoo, various *Graptemys* species were displayed during the 1970–80s: Barbour's Map Turtle, Cagle's Map Turtle (*G. caglei*), Yellow-blotched Map Turtle (*G. flavimaculata*), False Map Turtle (*G. pseudogeographica*), Northern Map Turtle (*G. geographica*), Black-knobbed Map Turtle (*G. nigrinoda*), Texas Map Turtle (*G. versa*), Alabama Map Turtle (*G. pulchra*), Cagle's Map turtle (*G. caglei*), Ouachita Map Turtle (*G. ouachitensis*), and Ringed Map Turtle (*G. oculifera*). All did well in captivity and were a popular display (Fig. 9). See Peter Lindeman's beautifully illustrated book on the group (2013).

Retired curator Frank Slavens from Woodland Park Zoo in Seattle and his wife Kate have been and continue to be involved with conserving the Pacific Pond Turtle (*Actinemys marmorata*). They live on a large tract of land along the Columbia River that supports a healthy population of these turtles, which they carefully monitor. A head-starting program continues at Woodland Park Zoo and Oregon Zoo, in part with hatchlings from the Slavens' project. A breeding group of Wood Turtles (*Glyptemys insculpta*) were kept in a large outdoor enclosure throughout the year at Dallas Zoo where hatchlings were found each summer. At Smithsonian National Zoo, a team of researchers led by Tom Akre is doing a long-term monitoring project in Vances Cove, West Virginia. They track all Wood Turtles but have a primary focus on nesting females. When I was young, my patient

parents allowed me to purchase three adult Wood Turtles and a group of adult Eastern Box Turtles, which had the run of the house. Whenever we sat at the dining table, these Wood Turtles would lumber from all directions to the table before food was served and wait patiently until the food arrived. My family loved to serve them by holding bits of food in their fingers; kernels of corn seemed to be the favorite dish. I was surprised as to how quickly the Wood Turtles made the connection between humans sitting at the table and potential food availability, while ignoring the family sitting in other parts of the house. The Wood Turtles learned in a few weeks whereas the Box Turtles took several months to accomplish the same task.

Murphy and Mitchell (1984) reproduced the aquatic Coahuilan Box Turtle (*Terrapene coahuila*) in a large outdoor exhibit at Dallas Zoo. The young were brought indoors during the winter. Cerda and Waugh (1992) reviewed status and management of this endangered species at Jersey Wildlife Preservation Trust. In Maryland, Rich Seigel at Towson University and some of his students are studying Eastern Box Turtle (*Terrapene c. carolina*) populations and the negative effects of the new Inter-County Connector highway construction in Washington, DC, and surrounding areas (Fig. 10). Some animals were translocated as part of the study. During this study, they noticed death and disease becoming an issue and quickly refocused the study to include searching for the presence of the pathogen ranavirus in the Maryland population. The situation is disastrous and the team has documented many cases and observed many deaths.

A Box Turtle (*Terrapene carolina*) owned by Hugh McCrystal may have been the most aggressive chelonian ever encountered by me, including snapping turtles. This biting machine may have been called Nureyev, although these encounters were decades ago and my short-term memory for names is fading. This creature had full run of his house and chased visitors continually at breakneck speed with open mouth, biting without pause. It was hazardous to remove shoes as this dreadful turtle would immediately try to nip one's toes or fingers, and if successful, caused a substantial amount of pain. Of course, Hugh rarely alerted his guests beforehand that they were in considerable danger, especially if they decided to take a nap on the floor before dinner. Three box turtle taxa—Three-toed (*Terrapene mexicana triunguis*), and Ornate (*T. o. ornata, T. o. luteola*)—lived in a large prairie dog exhibit at Dallas Zoo for many years where they spent the winter sharing the mammal burrows. Each spring, a number of hatchlings would be found in the display.

Neotropical wood turtles (genus *Rhinoclemmys*) are at great risk from exploitation for the pet market and habitat destruction (Fig. 11; Holcomb 2012; Liu 2014). The tropical deciduous forest likely is the most endangered ecosystem on the planet. The Oaxacan Spotted Wood Turtle (*R. r. rubida*) has been bred at Behler Chelonian Center (Liu 2012). Lucia Da Silveira (1986) followed the birth and growth of the Neotropical Wood Turtle (*R. punctularia*) at the Fundaqão Rio Zoo, Rio de Janeiro, Brazil. To this day, I have encountered several wood turtle species for sale in pet shops in Washington, DC.

Honegger (1986) published on the care and long-term reproduction of the Black Marsh Turtle (*Siebenrockiella crassicollis*). I remember seeing this taxon offered for sale in many Dallas pet shops during the 1970s. We received many calls to the Zoo when these animals refused to eat prepared dried turtle food such as ant eggs. Schoppe et al. (2013) paint a grim picture for the future of the Palawan Forest Turtle (*S. leytensis*). In June 2015, nearly 4000 were confiscated in Palawan. A team of over 30 persons

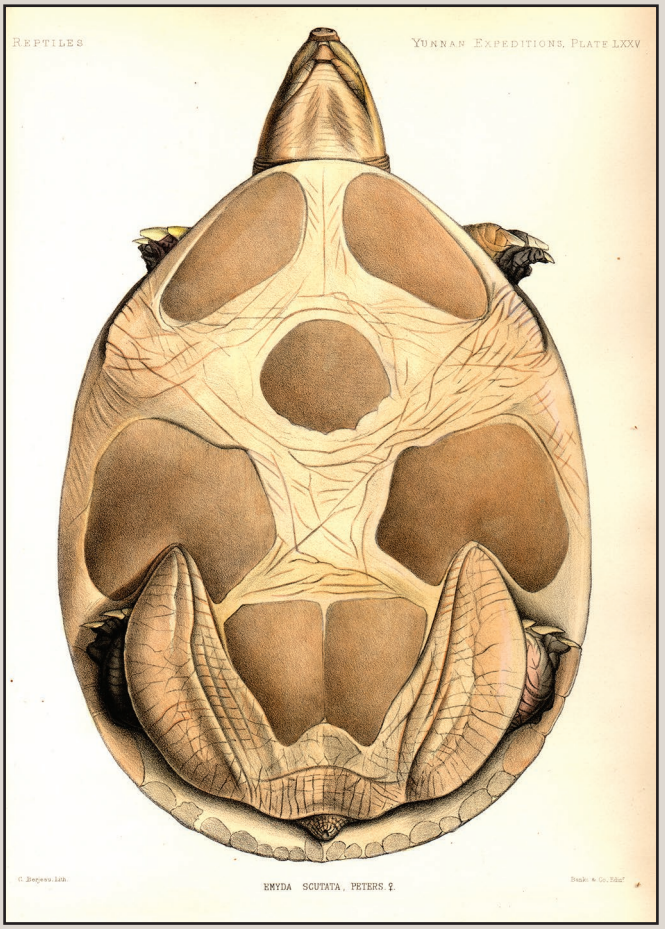

FIG. 8. Burmese Flap-shelled Turtle (*Emyda scutata* now *Lissemys scutata*) from *Anatomical and zoological researches: comprising an account of the zoological results of the two expeditions to western Yunnan in 1868 and 1875; and a monograph of the two cetacean genera, Platanista and Orcella* by John Anderson 1878. Some of the most beautiful plates ever drawn are found in this volume.

worked constantly to process the turtles for release. About 300 of the most severely diseased or injured ones are being treated until they recover and become suitable for eventual release. Falk Dathe (2001) documented care and reproduction of Amboinahinge Turtles (*Cuora amboinensis*) in the Berlin Tierpark. Repatriation of the critically endangered Golden Coin Turtles (*C. trifasciata*) has occurred using turtles bred at Behler Chelonian Center (Gibbons and Crow 2013). Timmins and Khounboline (1999) described occurrence and trade of this species in Laos. Other *Cuora* species (*C. zhoui, C. yunnanesis*) are equally at risk (Blanck 2013). According to *Turtle Survival* (2013), the Muenster Zoo in Germany hatched eight different *Cuora* species in 2012—a major success story. The Prague Zoo hatched three Asian Spiny Turtle (*Heosemys spinosa*) in 2012.

Blanco et al. (1990) propagated the batagurine turtles *Batagur baska* and *Callagur borneoensis* at Bronx Zoo. Weissenbacher et al. (2015) described conservation breeding of the Northern River Terrapin (*Batagur baska*) at Vienna Zoo, Austria, and in Bangladesh. Since 2001, three endangered Asian turtles have reproduced at Metro Toronto Zoo: Vietnamese Box Turtle (*Cuora g. galbinifrons*), Black-breasted Leaf Turtle (*Geoemyda s. spengleri*), and Malayan River Turtle (*Callagur borneoensis*). One McCord's Box Turtle (*Cuora mccordi*) hatched at Detroit

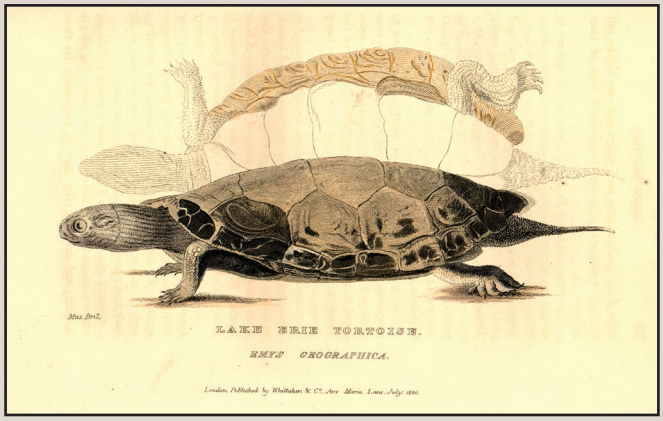

FIG. 9. Northern Map Turtle (*Emys geographica* now *Graptemys geographica*) from *The animal kingdom, arranged according to its organization, serving as a foundation for the natural history of animals, and an introduction to comparative anatomy…* by baron Georges Cuvier in 1831. Many beautiful turtles comprise this genus, making them vulnerable to over-collecting.

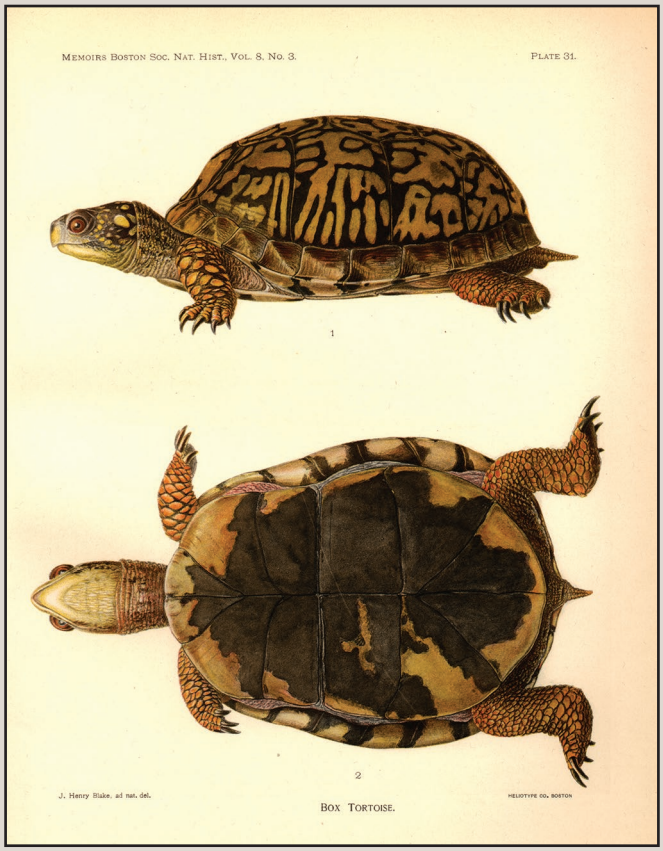

FIG. 10. Box Turtle (*Terrapene carolina*) from *The turtles of New England / / by Harold L. Babcock*, 1919. One of these turtles was so aggressive, it chased humans at breakneck speed, trying to bite fingers and toes. See text.

Zoological Institute in 2004. (See also Moll and Moll 2004.) Vyas (1997, 2001) bred the Indian Roofed Turtle (*Kachuga tecta*) in captivity at Sayaji Baug Zoo in India. Petzold (1963, 1965) bred the Vietnamese Leaf Turtle (*Geoemyda spengleri*), Indochinese Box Turtle (*Cuora galbinifrons*), and other Southeast Asian turtles in Berlin Zoological Gardens. Birchard and Marcellini (1996) described incubation time in reptilian eggs, including the Leaf Turtle. Whitaker and Vijaya (2009) studied biology of the Forest Cane Turtle (*Vijayachelys silvatica*) in South India.

Ten Fly River Turtles (*Carettochelys insculpta*) hatched at Miami Metrozoo in early September 2004 in a large outside pool (Steve Connors, pers. comm.). Visser and Zwartepoorte (2005) reproduced this turtle at Rotterdam ZooAn adult turtle living in a large tank at Smithsonian National Zoological Park regularly solicited grooming from a Sailfin Pleco catfish (probably *Pterygoplichthys gibba*), which had been placed in the enclosure to control algae. The turtle slowly swam through the tank searching for the fish. When discovering this fish, it raised its body as high as possible off the substrate, lifted and tilted its shell toward the fish, remained motionless, and allowed it to thoroughly clean the limbs, tail, plastron, carapace, head, and even the eyelids. This could last for well over an hour. Two turtles at Dallas Zoo regularly developed dermal lesions on the carapace, which disappeared when they were placed outdoors in natural sunlight. The lesions were examined but no etiologic agent could be found. Barney Tomberlin (pers. comm.) observed an adult Mangrove Monitor (*Varanus indicus*) defecate shell fragments of hatchling Fly River Turtles, identified by the soft serrated carapaces.

At National Mississippi River Museum and Aquarium in Dubuque, Iowa, a temporary exhibit was an unlikely place for the largest assemblage of chelonians in the world. The animals brought in for the exhibit called "Turtles, Secrets of the Shell" increased the total number of turtle species in the collection to 119 and brought the total number of individuals to about 250. Total cost was around $300,000 US dollars. This display opened in 2013 and closed two years later. The exhibit was extended for the second year because of popularity (Lee Jackson, pers. comm.). The chelonians were distributed to other institutions after the show was finished.

Medical and Captive Management.—Otis and Behler (1973) surveyed the incidence of Salmonellae and *Edwardsiella* in the turtles of the New York Zoological Park. Jackson and Jackson (1971) examined frequency of *Salmonella* and *Arizona* microorganisms in zoo turtles—"Abstract: A screening survey of turtles for the presence of cloacal *Salmonella* and *Arizona* microorganisms was made in nine major zoos and zoological gardens. Six *Salmonella* serotypes and one *Arizona* serotype were recovered from 14 species representing 5 turtle families. The apparent rate of infection was 12.1%." Ossiboff et al. (2015a) found three new herpesviruses of *Clemmys* and *Glyptemys*. Lucia Da Silveira and Andre (1986) published preliminary notes concerning lesions to the plastron of the Gibba Turtle (*Phrynops gibbus*) caused by fungi and bacteria. West (2001) performed an endoscopic hepatic biopsy in a Coahuilan Box Turtle at San Antonio Zoo. Jes (1989) treated amoebiasis in turtles; drugs were incorporated into a gelatin/food mix to treat 10 species at Cologne Zoo. Beck et al. (1995) compared plasma concentrations of gentamicin injected into the cranial and caudal limb musculature of the Eastern Box Turtle and Calle et al. (1998) initiated a mycoplasma survey of the taxon. Ossiboff et al. (2015b) described a Mycoplasma species of Emydidae turtles in the northeastern USA. Hiller (1984) covered veterinary experience gathered in the breeding of the Swamp Turtle (*Emys orbicularis*). Mautino and Page (1993) wrote about the biology and medicine of turtles and tortoises. Mayeaux (1994) described symptoms of gas-bubble trauma in two species of turtles (*Chelydra serpentina* and *Apalone spinifera).* Mebs (1965) was interested in determining causes for an illness of the eyes frequently found in water turtles. Wenker et al. (1999)

diagnosed periarticular hydroxyapatite deposition disease in two Red-bellied Short-necked Turtles. Dodd (2001) discussed diseases in North American box turtles and other turtles. Upton et al. (1995) described new species of *Eimeria* (Apicomplexa) from captive wood turtles at Dallas Zoo. Cedar Creek in this Zoo provided three additional species of *Eimeria* from resident Soft-shell Turtles (*Apalone spinifera pallidus*) (McAllister et al. 1990).

Husbandry.—Robert Snedigar, curator of herpetology at Brookfield Zoo in Chicago, wrote a book called *Our Small Native Animals* (1939). An enlarged revised edition was published 23 years later and covered the US chelonians, including recommendations for housing and care. Campbell (1972) developed methods for keeping Central American River Turtles (*Dermatemys mawi*) at Fort Worth Zoo. From Zoo Atlanta, George (1987) provided an overview of captive maintenance in the genus *Graptemys* and Herman (1990) outlined husbandry of the eastern *Clemmys* group. Stancel et al. (1998) found that calcium and phosphorus supplementation decreases growth but does not cause pyramiding in young Red-eared Sliders. Frolov et al. (1982) described their methods for the captive maintenance of soft-shell turtles at the Moscow Zoo. Diamondback Terrapins (*Malaclemys terrapin*) may be kept in freshwater as long as marine invertebrates are offered as food (Sachsse 1984). An adult lived for many years at Dallas Zoo without ever experiencing saltwater. See Brennessel (2006) for biology of this unique turtle. Brannian (1984) from Kansas City Zoo described a soft tissue laparotomy technique in turtles. Walder (1990) outlined chelonian management practices at Lowry Park Zoo. Dierenfeld et al. (1999) investigated circulating α-tocopherol and retinol concentrations in free-ranging and captive turtles and tortoises. Mike Goode started an impressive aquatic turtle program at Columbus Zoo (1988, 1994), which resulted a significant number of successful reproductive events.

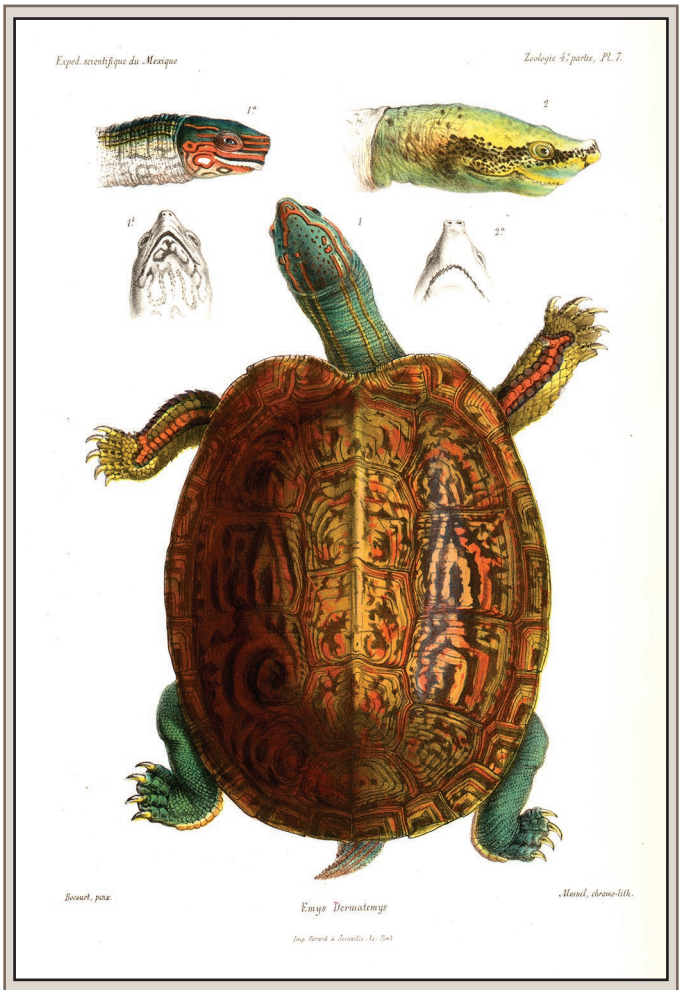

FIG. 11. Painted Wood Turtle (*Rhinoclemmys p. pulcherrima*) from *Mission scientifique au Mexique et dans l'Amérique centrale. Recherches zoologiques pour servir à l'histoire de la faune de l'Amérique centrale et du Mexique, / publiées sous la direction de Mm. H. Milne Edwards ... et Léon Vaillant.* [Atlas-ptie. 3, sect. 1, *Études sur les reptiles et les batraciens*, plate VII-*Emys pulcherrima* now *Rhinoclemmys p. pulcherrima*, *Dermatemys mawi* by Auguste Duméril et Firmin Bocourt] 1868. Both of these species are at risk.

SEA TURTLES

Hawksbill Sea Turtles (*Eretmochelys imbricata*) ply the waters off the coast of Britain and one was collected in the river Severn in the southwest of the country in 1770. This turtle was placed in a fish pond, where it survived until winter, likely the first, however brief, captive sea turtle (Coote 2001). Harwell (1982) and Caillouet et al. (1993) outlined procedures for captive rearing and medical management of Kemp's Ridley Sea Turtles (*Lepidochelys kempii*). At National Aquarium in Baltimore, Stamper and Whitaker (1994) considered the important factors prior to releasing "healthy" sea turtles and Stamper et al. (1997) described single-dose pharmacokinetics of ceftazidime in Loggerhead Sea Turtles (*Caretta caretta*). Glazebrook and Campbell (1990) surveyed diseases of oceanarium-reared and wild marine turtles in northern Australia. Bels (1987) analyzed growth and Birkenmeier (1972) reared the Leatherback Sea Turtle (*Dermochelys coriacea*) in captivity. Mowbray (1965) outlined procedures for keeping the Green Sea Turtle (*Chelonia mydas*) at Waikiki Aquarium. Owens et al. (1978) determined sex of immature *Chelonia mydas* using radioimmunoassay at San Diego Zoo. Paulraj et al. (1987) raised the Olive Ridley Sea Turtle (*Lepidochelys olivacea*) in artificial seawater. Pritchard (1979) evaluated "head starting" and other conservation techniques for marine turtles. A comprehensive overview of conservation issues has been published by Bustard (1972) and National Research Council (1990).

The most endangered sea turtle is Kemp's Ridley. The situation was so dire, a joint U.S.-Mexico Conservation Program began in 1978 at Rancho Nuevo, Mexico. Armed guards patrolled the beaches in vehicles to prevent the locals from illegally killing adult females and excavating nests. Eggs were collected from nesting females and placed in protected sites on the beach for incubation. When hatchlings emerged, they were accompanied by caretakers to the water's edge to prevent predation. Some eggs were removed from nests and moved to the National Marine Fisheries Lab in Galveston, Texas for head-starting, to be released on south Texas beaches. Patrick Burchfield and staff from Gladys Porter Zoo assisted in this program for many years, resulting in increased survivorship of juveniles and adults. For a description of this successful program, see Spotila (2004).

Sea turtles rarely breed in captivity (Kawata 2003, Fig. 12). Yoshioka and Samejima (1989) propagated the Loggerhead Sea Turtle at Nagasakibana Parking Garden, Kagoshima, Japan (Fig. 13). Remarkably, Uchida (1996) described indoor breeding of Loggerhead Sea Turtles at Port of Nagoya Public Aquarium in Japan. Nuitja and Uchida (1982) followed growth and food consumption in juveniles. Kawazu et al. (2015) examined the relationship between water temperature and eggshell formation experienced by captive Loggerhead turtles.

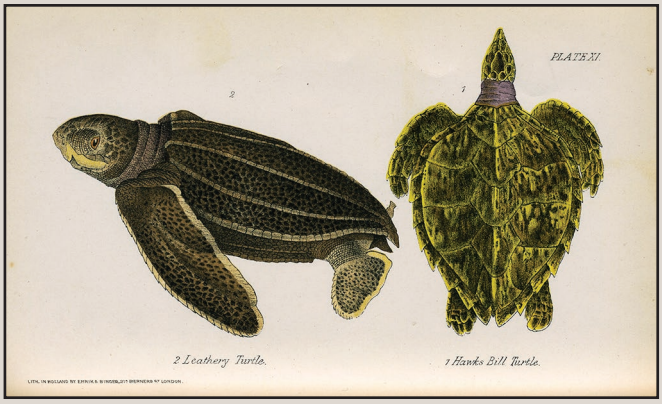

FIG. 12. Leathery and Hawksbill turtles pictured in *Our Reptiles and Batrachians* by M. C. Cooke in 1893. Sea turtles rarely breed in captivity in zoos and aquariums.

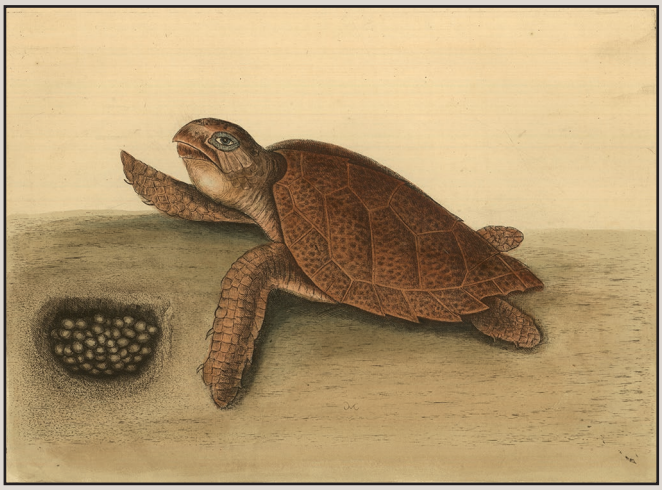

FIG. 13. Loggerhead Turtle (*Caretta caretta*) from *The natural history of Carolina, Florida and the Bahama islands: containing the figures of birds, beasts, fishes, serpents, insects, and plants: particularly the forest-trees, shrubs, and other plants, not hitherto described, or very incorrectly figured by authors. / By Mark Catesby* ...1731–1743. Notice the spines on the front flippers, which are used to hold the food item as the turtle bites off chunks during feeding.

Oka et al. (1983) from Shimonoseki Municipal Aquarium in Japan kept the Leatherback Sea Turtle (*Dermochelys coriacea*), a difficult species to maintain due to a specialized diet and pelagic habits. In 2003, SeaWorld San Diego hatched 21 Green Sea Turtles (*Chelonia mydas*). Webb et al. (2008) describe captive breeding and marketing of loggerhead turtles in Australia.

Smith and Coates (1938) from the New York Aquarium diagnosed fibro-epithelial growths in Green Sea Turtles (*Chelonia mydas*). Stamper et al. (2009) discussed morbidity in a juvenile green sea turtle due to ocean-borne plastic. Whitaker and Krum (1999) offered recommendations for medically managing sea turtles in aquaria. Neiffer et al. (1998) from Pittsburgh Zoo used PC-7 epoxy paste to repair shells in Loggerhead Sea Turtles. Miller et al. (1997) surgically removed a fish hook from a Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) at Aquarium of the Americas. Bradley et al. (1998) presented hemogram values and morphological characteristics of blood cells in Loggerhead Sea Turtles. See also LeBuff (1990) and Bolten and Witherington (2003) for complete reviews on the biology of Loggerhead Sea Turtles.

When I was a student at University of Florida in Gainesville in the early 1960s, I visited Archie Carr's lab, which held dozens of newly hatched sea turtles for research. One of the graduate student caretakers asked me if I wished to have any so I returned home with a baby Green, Loggerhead, and Hawksbill sea turtle. At that time, there was not a lot of information on care so I placed them in a large aquarium with artificial sea salt and crushed coral gravel and shells as a calcium source. The turtles thrived on a diet of squid, fish, and crustaceans and predictably began to grow. I decided to write a paper on husbandry and submitted the final product to the journal published by the International Turtle and Tortoise Society. There were no proofs sent beforehand to authors for review so I was surprised and horrified to see that the title had been changed by the editor to "A Sea Turtle at Home." Never would I have advocated that large reptiles such as these would ever be kept at home. As the turtles quickly outgrew the aquarium, they were donated to the Dallas Aquarium, as were others that had been for sale in local pet shops and were brought by owners unable to care for them. To ensure that my embarrassment would extend in to the 21st century, Jon Campbell and Bill Lamar recently sent copies of this article—my first one—to many colleagues, who responded with amused retorts. They particularly liked one phrase—"restless wanderers of the high seas!" which proved that I, being of Celtic descent, could turn a phrase even as a callow youth.

When the late curator of herpetology Mike Goode arrived at the Columbus Zoo reptile building one morning, he discovered a large styrofoam box filled with dozens of unidentified reptile eggs in front of the house. Curious as to what species oviposited these eggs, he set them up for incubation and was amazed when a bunch of baby sea turtles hatched (pers. comm.). On precisely the same day the next year, another box was waiting at the zoo and again baby sea turtles hatched. Since the mystery was unsolved, Mike had his keepers hide throughout the Zoo the third year at night to catch the culprit but again a box was waiting, turtles hatched, and no one was ever caught. All of these chelonians were sent to USFWS for headstarting and eventual release.

An excellent book was published in 2015 by Blair and Dawn Witherington called *Our Sea Turtles*. This tome is reasonably priced, comprehensive, and lavishly illustrated. Every herpetologist should have a copy on the bookshelf. One unique feature is the US map showing rehabilitation and zoo and aquarium displays with sea turtles. One interesting factoid—"A loggerhead named Tolstoy, originally acquired by Marineland in 1964, currently lives at Disney's expansive Seas aquarium at Epcot. Given that the turtle was an adult when he was first taken in, Tolstoy in most likely over 80 years, making him possibly the oldest sea turtle in any aquarium."

In summary, David Ehrenfeld (1980) emphatically stated five reasons why commercial breeding of sea turtles should not be done: 1) dependence upon natural populations by collecting eggs; 2) undermining local conservation regulations; 3) difficulty of developing and maintaining breeding stock; 4) stimulating global markets for high-priced turtle products which encourages illegal exploitation of wild populations; and 5) in farming sea turtles, a herbivore is moved from a second to a higher trophic level relying on animal protein. I share his assessment.

Acknowledgments.—This contribution is dedicated to Eric V. Goode and A. Ross Kiester of the Turtle Conservancy (publisher of *The Tortoise*) and Rick Hudson and Dwight Lawson of Turtle Survival Alliance (TSA; publisher of *Turtle Survival*), all of whom have worked

tirelessly to protect threatened chelonians. Through these publications, up-to-date information on threats is disseminated, and action plans outlined for future initiatives. It is an incredibly important element for protecting these imperiled animals. I also acknowledge the contributions of Anders G. J. Rhodin, founding editor of *Chelonian Conservation and Biology* and *Chelonian Research Monographs*. These peer-reviewed publications and ancillary workshops have been vital in sharing information about these reptiles to the scientific community. The laudable and hopefully attainable mission statement outlined in the *Turtle Conservation Fund* document by Conservation International and Chelonian Research Foundation—*A Global Action Plan for Conservation of Tortoises and Freshwater Turtles. Strategy and Funding Prospectus 2002–2007*—"To ensure that no species of tortoise or freshwater turtle becomes extinct and that sustainable populations of all species persist in the wild"— is more realistic due to the efforts of these five conservationists.

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