

ZOO VIEW

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Conservation Initiatives and Studies of Tortoises, Turtles, and Terrapins Mostly in Zoos and Aquariums. Part I—Tortoises

TORTOISES AND TURTLES ARE AT THE FOREFRONT OF THE GLOBAL BATTLE TO PREVENT AN IMMINENT MASS EXTINCTION. EVERY YEAR MORE THAN 10 MILLION TORTOISES AND TURTLES CHANGE HANDS IN ASIA; TENS OF THOUSANDS PER DAY. MOST OF THESE ARE TAKEN FROM THE WILD OR SMUGGLED OPENLY ACROSS THE BORDERS THAT DIVIDE THE NATIONS OF SOUTHEAST ASIA FROM CHINA. THEY MAY HAVE BEEN SMUGGLED FIRST FROM INDONESIA OR MALAYSIA INTO THESE BORDER COUNTRIES. THE BORDER, SO IRONCLAD WHEN IT COMES TO MILITARY ISSUES, IS JUST A POROUS MEMBRANE WHEN ILLEGALS TRADE IN WILD ANIMALS OR THEIR PARTS IS INVOLVED. THE TRADE IN LIVE TURTLES BOUND FOR THE CHINESE FOOD MARKETS IS WORTH AN ESTIMATED 700 MILLION DOLLARS ANNUALLY. THERE ARE SEVERAL VARIETIES OF TURTLES IN CHINA THAT HAVE NEVER BEEN SEEN ALIVE IN THE WILD; THEIR EXISTENCE IS KNOWN ONLY FROM A FEW OF THE LAST REMAINING INDIVIDUALS THAT WERE SPOTTED IN MARKETS. A CONSERVATIONIST WHO VISITED ONE SUCH MARKET IN THE LATE 1990'S ESTIMATED AT LEAST TEN THOUSAND TURTLES, MOST OF THEM TAKEN FROM THE WILD, FOR SALE IN THAT MARKET ALONE.

—THE LAST TORTOISE BY CRAIG B. STANFORD, 2010

SLIGHTLY OVER HALF OF ALL TURTLE SPECIES HAVE BEEN ASSESSED AS THREATENED WITH EXTINCTION BASED ON IUCN RED LIST CRITERIA (OFFICIAL AND DRAFT THREAT ASSESSMENTS BY THE IUCN TORTOISE AND FRESHWATER TURTLE SPECIALIST GROUP; WWW.IUCNREDLIST.ORG, WWW.IUCN-TFSG.ORG, ONE OF THE HIGHEST PERCENTAGES OF ANY MAJOR GROUP OF VERTEBRATES (TURTLE CONSERVATION COALITION, 2011; TURTLE TAXONOMY WORKING GROUP [TTWG] 2014). THEREFORE, TURTLES CLEARLY REPRESENT A GLOBAL BIODIVERSITY CONSERVATION PRIORITY. BECAUSE OF THEIR PARTICULAR VALUE TO HUMANS, WHETHER AS FOOD, MEDICINE, PETS, OR AS PROVIDERS OF ECOLOGICAL SERVICES, AND THEIR VERY SLOW RECOVERY FROM (OVER) EXPLOITATION, TURTLES TEND TO BE AT THE CUTTING EDGE OF BIODIVERSITY DECLINE AND AN INDICATOR OF ECOSYSTEM DEGRADATION. THE DISTRIBUTION OF TURTLE SPECIES AND SUBSPECIES, AND THE OCCURRENCE OF DEEP PHYLOGENETIC LINEAGES, IS NOT UNIFORM ACROSS THE PLANET.

—MITTERMEIER ET AL. 2015

THUS, TECHNOLOGY IS NOT A PANACEA FOR THE DISEASE OF EXTINCTION. IT IS A PALLIATIVE—A TOPICAL TREATMENT WITH WHICH TO BUY TIME, TO PRESERVE OPTIONS FOR A FEW POPULATIONS AND SPECIES JUDGED OF SPECIAL VALUE. IN THE FINAL ANALYSIS, IT IS NO MORE IMPORTANT THAN THE

SPECIES IT SUSTAINS, WHICH WOULD OTHERWISE BE LOST FOREVER, AND NO LESS.

—WILLIAM CONWAY, RETIRED DIRECTOR OF WILDLIFE CONSERVATION SOCIETY (CONWAY 1988)

In the middle of the twentieth century, wild chelonians living throughout the world were collected and distributed to pet shops, pet wholesalers, and advertised on pricelists of reptile dealers. The variety available was astonishing and the numbers imported were staggering (see Murphy and McCloud 2010a for examples). Those days are gone forever. As noted in the excerpt above from Mittermeier et al. (2015), over one-half of all tortoises and aquatic turtles are said to be danger of extinction (Fig. 1). What does this grim prediction mean for professionals working in zoos and aquariums and all of us who treasure chelonians? Can zoo workers realistically begin to stem the tide of these extinction events in the next few decades? Must they reassess their role and create better ways of setting up captive colonies of imperiled reptiles should reintroduction be an option? Rick Hudson (2002) of the Fort Worth Zoo describes just one alarming incident that tested zoo and aquarium capabilities to the breaking point: Thousands of Asian turtles destined for the food market had been confiscated in Hong Kong and were distributed to institutions and private turtle breeders. Colleagues devoted months—in addition to their normal duties at their institutions—evaluating chelonian health and dispensing treatments, finding suitable holding areas, ensuring that these reptiles adapted to captivity, and arranging transportation and proper documentation for distribution to other facilities.

In this paper, I relate the interesting history of keeping these creatures over centuries, focusing mainly on studies in zoos and aquariums. For example in 1897, a tortoise house was built at London Zoo (Fig. 2). Known as the Father of Herpetoculture, Johann von Fischer published many papers on chelonians in the 1870–80s. Indeed, there was a healthy interest in keeping them throughout the Victorian era: “Strolling on the promenade in 19th Century Paris with a live turtle was all the rage, as described by Walter Benjamin. . . : ‘Around 1840, it was briefly fashionable to take turtles for a walk in the arcades. The *flâneurs* [idlers] like to have the turtles set the pace for them. If they had had their way, progress would have been obliged to accommodate itself to this pace . . . this attitude did not prevail” (Murphy and McCloud 2010b).

It is hard to grasp the enormity of the negative forces in Asia that are contributing to the virtual extinction of so many taxa. It takes stamina to read the various chapters in *Asian Turtle Trade* (van Dijk et al. 2000) without total despair. For discussion of issues related to biology, international conservation, and captive management of tortoises and turtles, see Noël-Hume and Noël-

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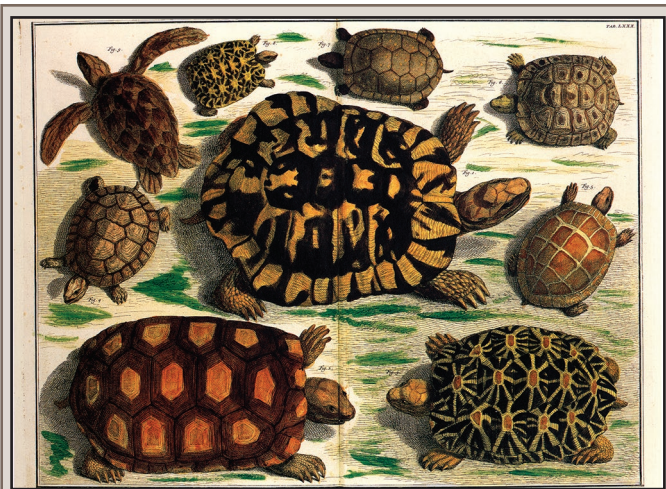


FIG. 1. Over half of the tortoises and freshwater turtles on the planet are in imminent danger of extinction. Image from Albertus Seba's *Locupletissimi rerum naturalium thesauri accurata descriptio, et iconibus artificiosissimis expressio, per universam physices historiam...* 1734–1765.

Hume (1954), Packard and Philipps (1984), Petzold (1984), Obst (1986), Swingland and Klemens (1989), Campbell and Busack (1989), Gibbons (1994), Swingland (1994), Klemens and Thorbjarnarson (1995), Gibbons et al. (2000), Klemens (2000), Orenstein (2001), Syed et al. (2007), Williams and Osentoski (2007), Wyneken et al. (2008), Jackson (2010), Chitty and Raftery (2013), Hai-Tao Shi et al. (2013), Ettlting and Schmidt (2015), and Kuchling (2015).

Changes have occurred over the past several decades as the availability of chelonians has dramatically shrunk from earlier days; zoos and aquariums are now trying desperately to set up captive management programs. There also has been a positive shift towards developing collaborations and partnerships with outside organizations such as Turtle Survival Alliance (TSA) and Turtle Conservancy's Behler Chelonian Center (named after the late curator of herpetology John Behler at Wildlife Conservation Society's Bronx Zoo). These facilities specialize in breeding critically endangered tortoises and turtles, including setting up places in range countries for these purposes. In other instances, zoos are targeted to respond rapidly to crises such as massive confiscations. It's not clear how often this can be done successfully, especially when facing situations of this magnitude. Since reintroduction is not an option in most cases, the only possible conservation strategy may be to accumulate captive colonies, even with limited resources and holding areas, with the hope that their species can be returned to the wild in the future.

TORTOISES

The small tortoises in Europe.—Herpetocultural historian Jon Coote (2001) examined the interesting story of captive turtles and tortoises in England. The following anecdotes are from his wonderful paper and from Flower (1937) and Keeling (1992). The story begins in 1601, with a large Marginated Tortoise (*Testudo marginata*). Seven Bishops of Peterborough were enamored with tortoises for over two centuries (1601 until 1821). The final tortoise, living outside in a garden all year, weighed 13.5 lbs [6.1 kg]; it ate dandelion flowers, strawberries, gooseberries, lettuce, currants, raspberries, pears, plums, apples, peaches, nectarines, endive, green peas, leeks, and oranges, but disliked

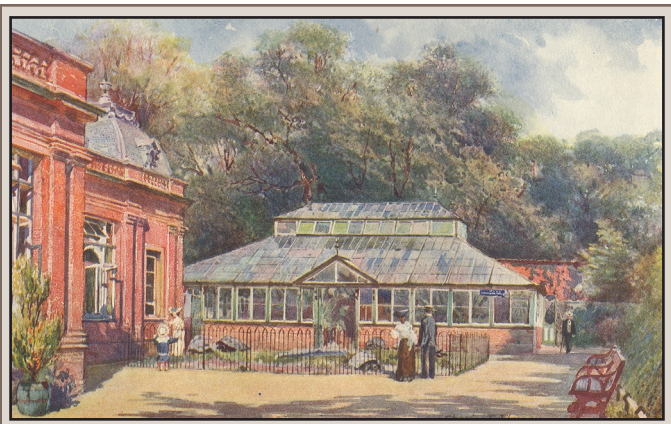


FIG. 2. Tortoise House at London Zoo ca. 1900. The structure was constructed three years earlier for a cost of approximately £465, later became a Tropical House and was demolished in 1985. Image from H. Schrerren's *The Zoological Society of London* in 1905.

cherries, asparagus, parsley, carrots, turnips, and spinach. This chelonian retired each winter. Upon emergence in the spring, this reptile dazzled the crowd with its strength; it's reported to have wandered around with a weight of 18 stone (252 lb) on its carapace.

William Laud bought a Spur-thighed Tortoise (*Testudo graeca*) in 1625, which lived with him at the Palace of Fulham. Eight years later, when Laud became the Archbishop of Canterbury, he carried the tortoise to his new dwelling—Lambeth Palace—where it survived for another 120 years. The tortoise was accidentally killed in 1753, but its shell remains in the Palace library.

Another Spur-thighed Tortoise called "Timothy" originally lived on a captured Portuguese pirate ship, thereafter rescued by Captain John Guy Courtenay Everard of Her Majesty's Ship (HMS) Queen in 1854. The tortoise was permanently deposited in 1914 at Powderham Castle, home to the Earls of Devon since 1325, after a series of voyages on various British naval vessels. A noble life style must have suited Timothy, who enjoyed a life span of at least 148 years and possibly as many as 164 years. This tortoise outlived seven or eight earls, spending its time outdoors and hibernating each winter. The tortoise dragged a sign (affixed to the rear margin of its shell with a string), which read "My name is Timothy. I am very old. Please do not pick me up." Timothy, who had become quite famous, died in April 2004; his death was covered extensively by the press (Bruce 2004). Major Stanley Smyth Flower, director of Giza Zoo in Egypt (1925) had his facts correct: "Tortoises, as is a matter of common knowledge, live to ages exceeding those, as far as our present information goes, of all other vertebrate animals."

Gilbert White discussed his pet Greek Tortoise (also named Timothy) in his book *The Natural History of Selborne* (1780): "Pitiable seems the condition of this poor embarrassed reptile: to be cased in a suit of ponderous armour, which he cannot lay aside; to be imprisoned, as it were, within his own shell, must preclude, we should suppose, all activity and disposition for enterprize. Yet there is a season of the year (usually the beginning of June) when his exertions are remarkable. He then walks on tiptoe, and is stirring by five in the morning; and, traversing the garden, examines every wicket and interstice in the fences, through which he will escape if possible; and often has eluded the care of the gardener, and wandered to some distant field. The motives that impel him to undertake these rambles seem to be of the amorous kind: his fancy then becomes intent on sexual

attachments, which transport him beyond his usual gravity, and induce him to forget for a time his ordinary solemn deportment.” See also Bruce (2004) and Klinkenborg (2006) for interesting stories of really old tortoises.

A private “Tortoise House” was built between 1820 and 1830 in the southwest corner of the grounds of Wotton House in Surrey, owned by the Evelyn family. This edifice was built by either George Evelyn or his son William John. An open upper floor supported a wooden pedimented ‘summer-house’ where visitors were served tea and could watch aquatic turtles swimming in a pool.

The author of the first book on captive management written in English, *The Vivarium* (1897), was Reverend Gregory Bateman. Various European tortoises could be bred in Great Britain and the eggs successfully hatched using chicken incubators. Tortoise eggs placed in damp moss hatched within 8–10 weeks if incubated at a temperature of at least 75°F (23.8°C) but not greater than 90°F (32.2°C). Aquatic turtle eggs take longer to incubate. Incubation temperatures were rather high for most taxa (up to 96°F [35.5°C]).

Beginning in the mid-1950s and continuing into the 1960s, hundreds of Mediterranean Spur-thighed (*Testudo graeca*), Hermann’s (*T. hermanni*), Horsfield’s (*T. horsfieldii*) and occasional Marginated (*T. marginata*) tortoises were imported into the U.S. for the pet trade. I saw hundreds piled in stacks without food or water for sale at pet wholesale businesses in Chicago and in southern Florida (Fig. 3). These piles might have Red-legged and Yellow-legged Tortoises intermixed with the European ones.

Giant tortoises.—Advances in captive and medical management through careful observations have expanded our understanding of the needs of giant tortoises although I am not sure what new knowledge was acquired as the Hon. Walter Rothschild rode his tortoise *Rotumah* around the grounds at London Zoo in the late 1890s (Fig. 4). Evans and Quaranta (1951) studied social behavior in a captive herd of giant tortoises, largely from southern Albemarle Island, at New York Zoological Park. Living at the Life Fellowship Bird Sanctuary in Florida since 1960, a male tortoise (*Geochelone nigra porteri*), appropriately named Goliath, is the heaviest captive tortoise, weighing nearly

400 kg (Pritchard 1996, fig. 23). Over 400 Galápagos tortoises have been hatched at the Life Fellowship Bird Sanctuary (Pritchard 1996). At this facility, Noegel and Moss (1989) recorded the first hatching of *G. e. guntheri* from adults acquired on the Townsend Expedition in 1928. A number of papers have treated the reproductive biology of Galápagos and Radiated Tortoises (*G. radiata*) (Burchfield 1975; Burchfield et al. 1980, 1987; Hairston and Burchfield 1989; Robeck et al. 1990; Hairston 1991; Rostal et al. 1998). In Zürich Zoo, Hatt and Honegger (1997) and Honegger and Rübel (1991) outlined experiences and observations in raising Galápagos tortoises (*G. [elephantopus] nigra*)—husbandry protocols, diseases, and the reproductive program which resulted in 29 hatchlings. Casares et al. (1995) managed giant tortoises (*G. elephantopus*, now *G. nigra* and *G. gigantea*) at this Zoo. Furrer et al. (2004) compared growth rates of juvenile *G. nigra* in Zürich and the Charles Darwin Research Station on the Galápagos Islands. After four years, the zoo tortoises weighed 10 times as much and the carapaces were almost twice as long when compared to the chelonians at the research station: nutrients were reduced and fiber increased for the zoo specimens. The San Diego Zoo has a long successful history with Galápagos Tortoises (Shaw 1961, 1962; Bacon 1980; Schafer and Kjekorian 1983; Ryder et al. 1989; Schramm et al. 1999, 2000). Throp (1969, 1975) bred the Galápagos Tortoise at Honolulu Zoo. See also MacFarland et al. (1974). Raphael (1980) described sand impaction in a Galápagos Tortoise. Wright et al. (1997) developed diets for Galápagos and Aldabran tortoises at Philadelphia Zoo. At Rotterdam Zoo, Liesegang et al. (2001) judged the influence of

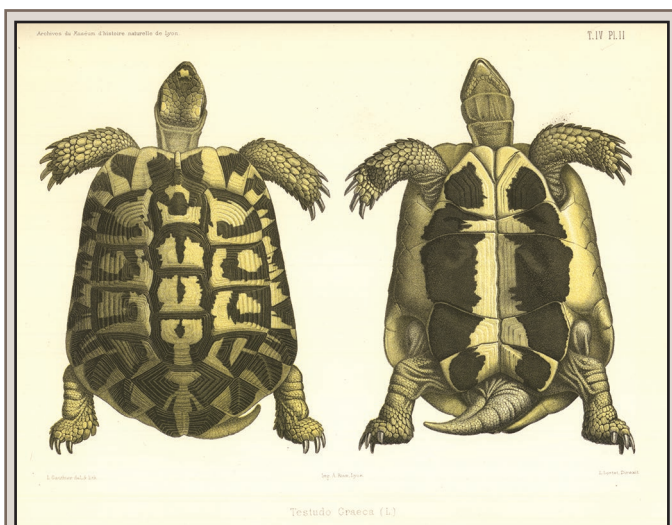


FIG. 3. The Greek Tortoise (*Testudo iberica* now *T. graeca*) was imported in overwhelming numbers for the pet trade in the United States during 1950–1960s. Images from *Observations sur les tortues terrestres et paludines du bassin de la Méditerranée* by Louis-Charles Lortet in 1886.

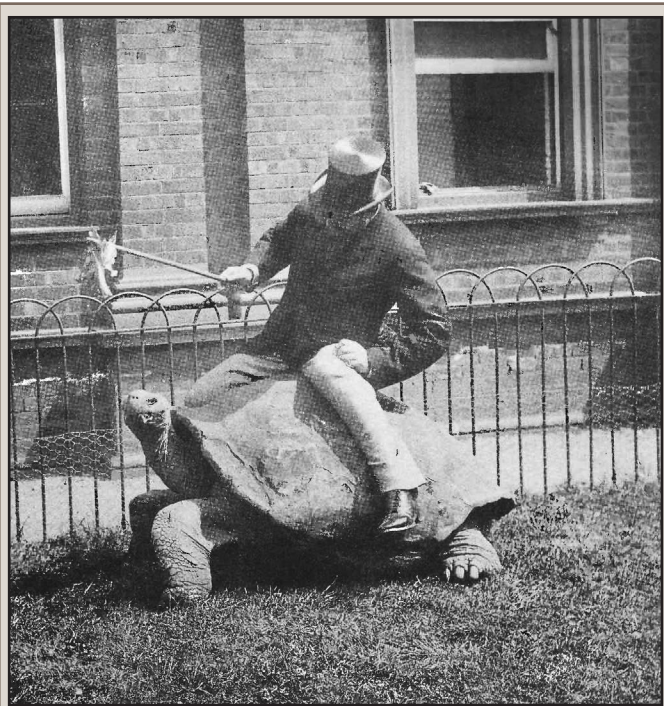


FIG. 4. The Hon. Walter (later 2nd Baron) Rothschild riding his giant tortoise *Rotumah* in front of London Zoo reptile house ca. 1898. He was certainly well dressed. Notice the food extended on a stick to entice the animal to move forward. He developed a private zoological museum called Walter Rothschild Zoological Museum in Tring, which opened to the public in 1892. The collection was transferred to the nation in 1937 and is overseen by the Natural History Museum in London. The name was changed in 2007 to Natural History Museum at Tring.

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different dietary calcium levels on the digestibility of CA, Mg, and P in captive-born juvenile Galápagos Tortoises (*G. nigra*). Hirsch (1980) pointed out how Galápagos Tortoises were exploited in the past and proposed needed conservation measures and Louis et al. (1990) explored taxonomic relationships among subspecies in zoo populations.

The history over centuries of these tortoises is interesting but sometimes saddening. Between 1831 and 1868, whalers traveled by sea to the Galápagos Islands to collect tortoises for food and oil. Charles Haskins Townsend, director of the New York Aquarium, examined 79 logbooks and discovered that 151 ships made 189 visits, leading to a conservative estimate of 13,013 tortoises removed (Townsend 1925)—“What a contribution could be made to the world’s food supply if the otherwise unimportant islands where, unknown to primitive man, the tortoises reached such an amazing development, could be cleared of the pests introduced by civilized man and the original conditions restored! This is now unfortunately impossible on the Galapagos. The only remaining hope for the race is the establishment of survivors elsewhere.”

In 1928, Townsend collected over 200 tortoises from Albemarle Island, which he distributed to zoos to develop captive breeding programs (Fig. 5). Pritchard (1996) described their histories. In his book, he shows a large male on exhibit at Houston Zoo (fig. 9, p. 24) and covers successful captive reproduction—“Nevertheless, some individuals from the original 1928 collection still survive in US institutions, and in recent years there has been excellent captive reproduction, e.g., at the Gladys Porter Zoo in Brownsville, Texas, and at Life Fellowship Facility in Seffner, Florida (where 85 hatchlings were produced in 1988–89, with some females nesting five times in a season).” The next year, Townsend wrote a paper on the extinct Galápagos tortoise that inhabited Charles Island, estimated to have disappeared in 1850 (Broom 1929, Fig. 6). In 1931 and 1937, he published two papers on growth and age in the zoo tortoises generated from eight institutions in Florida, Texas, California, Louisiana, Hawaii, Arizona and Sydney, Australia. His other articles on tortoises, description of his life and scientific contributions, and a list of herpetological taxa named in his honor have been published (Grant 1947).



FIG. 5. Galapagos Tortoise being weighed at Bronx Zoo in 1946. Charles Haskins Townsend, director of the Aquarium, was so concerned about the future of these tortoises, he collected over 200 from Albemarle Island to develop assurance colonies at zoos in 1928.

A female Galápagos Tortoise (*Geochelone nigra porteri*) named Harriet lived at the Queensland Reptile Park, now the Australia Zoo, until its death on 23 June 2006. This tortoise was purportedly collected by Charles Darwin on 17 August 1835 on Charles Island (now Islas Santa Maria or Floreana), and taken back to England in 1836 on the H.M.S. Beagle (Coote 2001). A detailed history of this tortoise, which lived to be more than one-and-a-half centuries old, is beyond the scope of this article but see Coote (2001), Thomson et al. (1998), Powell and Caccone (2006), and Bauer and McCarthy (2010).

The most famous tortoise was “Lonesome George,” discovered on Pinta Island in 1971. The taxon *Chelonoides nigra abingdoni* was thought to have gone extinct around 1920, but this last representative was brought to the Charles Darwin Research Station in the Islands for captive breeding (see Cayot et al 1994 for history of the Station). The tortoise lived up to his name, rejecting even closely related females until his passing on 24 June 2012. George had great press coverage with a whole book written about his life (*Lonesome George, The Life and Loves of a Conservation Icon*, by Henry Nicholls, 2006). His remains are being mounted for display at the American Museum of Natural History (Sachs 2014). A photograph from the London Zoo in 1914 depicts another specimen from Pinta (Fig. 7).

There have been attempts to reconstruct lineages in captive Galápagos Islands tortoises worldwide using DNA analyses—Claudio Ciofi (pers. comm.), Frankham et al. (2002), Burns et al. (2003), Milinkovitch et al. (2004), Russello et al. (2007), Poulakakis et al. (2008), Ciofi et al. (2009), Russello et al. (2010), Benavides et al. (2012), and Edwards et al. (2013).

Two zoos have returned their rarest tortoises to the Islands—an adult female Duncan Island Tortoise in Bronx Zoo in 1972 (collected by Townsend in 1928) and an adult male Hood Island Tortoise, which lived at San Diego Zoo for over 40 years, in 1977 (Pritchard 1996).

Pritchard (1996) provides a sobering overview of the pressures faced by these tortoises—“But the spread of mankind over the face of the globe, more than any other factor, has plunged the giants into ignominious retreat. The opportunistic, ingenious new predator, literally as omnivorous as a pig and much more dangerous, proved too much for tortoises beyond a certain size.”

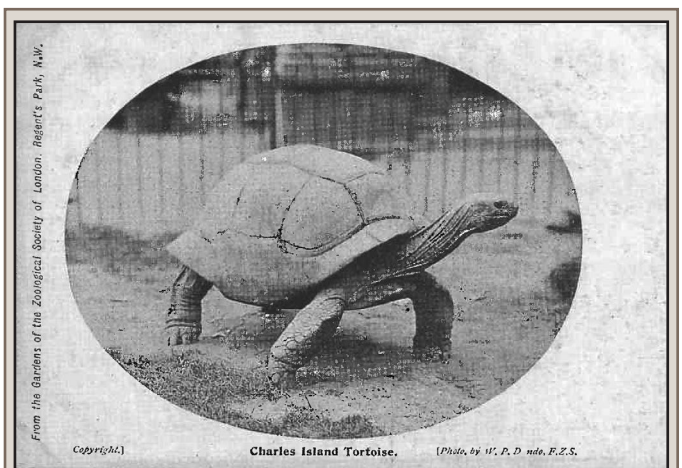


FIG. 6. Charles Island (now Floreana) Tortoise (*Geochelone (Elephantopus) elephantopus*). Official Zoological Society of London postcard from series in 1904. Photo by W. P. Dando. This reptile was believed to become extinct in the wild about 1875.

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FIG. 7. Abingdon (Pinta) Island Tortoise (*Geochelone (Elephantopus) abingdoni*), photographed by F. W. Bond on 20 January 1914 at London Zoo. This male was purchased on 12 January 1914. This species is now extinct after the death of Lonesome George on 24 June 2012.

Indian Ocean giant tortoises (*Testudo gigantea* = *Geochelone gigantea*) are often kept in zoos but the provenance of most of these chelonians is unknown, hampering the creation of meaningful captive breeding populations (Fig. 8). Taxonomy of the giant tortoises from the Seychelles, Aldabra, and Madagascar has long been confused due to the uncertain origin of many specimens bred in captivity, lack of reliable collecting data, and loss of specimen labels and tags affixed to museum specimens (Gerlach and Canning 1998). After the species was first described as *Testudo gigantea* by August Friedrich Schweigger in 1812, there have been major and contentious disagreements among herpetologists for centuries in determining the suitable scientific name for this taxon (Frazier 2006). Should the specific epithet be *gigantea*, *elephantina*, or *dussumieri*? The International Commission for Zoological Nomenclature (ICZN) received over 80 comments and over 100 published pages were produced, focusing on the quarrel over the name (BZN 66[1] Case 3463). Most disputes handled by ICZN are routine and unemotional, but this slow-moving tortoise generated a nasty firestorm of recriminations and insults hurled by some of the protagonists against the other side such as a minefield “complete with brave soldiers and cowardly ones.” After the dust settled, *gigantea*, initially proposed by Jack Frazier at Smithsonian National Zoological Park, became the official name.

A group of Aldabran tortoises was kept during summer months in a large outdoor enclosure at Philadelphia Zoo. They were fed using a large fiberglass pan, which attracted pigeons as well. When some of the food spilled on the ground, one tortoise named Mopey Dopey regularly positioned itself over the pile, lifted its body as high as possible and dropped on a pigeon attracted to the food and crushed and ate it (John Groves, pers. comm.). Frazier and Peters (1981) recorded the call of the Aldabran tortoise. During courtship, a male at Smithsonian National Zoo produces a low guttural call during mounting, which can be heard several buildings away from the reptile house. This sound is sure to quickly bring visitors to the source; when they arrive, watching these behemoths breed especially delights adolescents. Keen (1995) studied seven Aldabran tortoises at Paignton Zoo. Collins (1984) elaborated on breeding and management of the tortoise

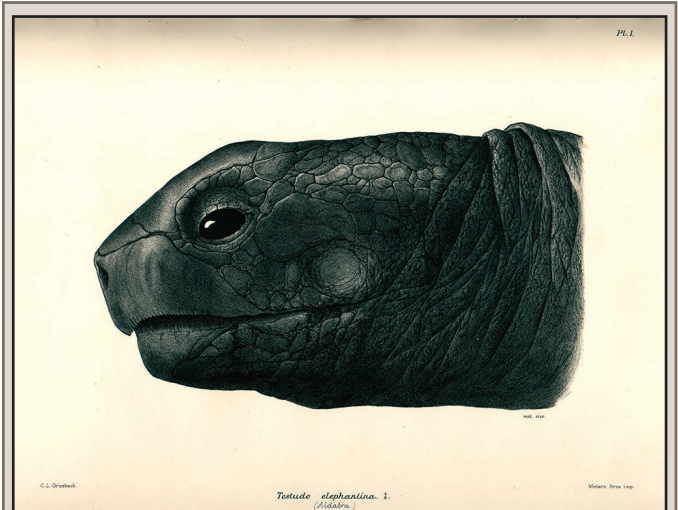


FIG. 8. Aldabra Tortoise (now *Testudo gigantea*) from *The gigantic land-tortoises (living and extinct) in the collection of the British Museum.* / by Albert C.L.G. Günther ... 1877. See text for an unusual way of catching birds for food.

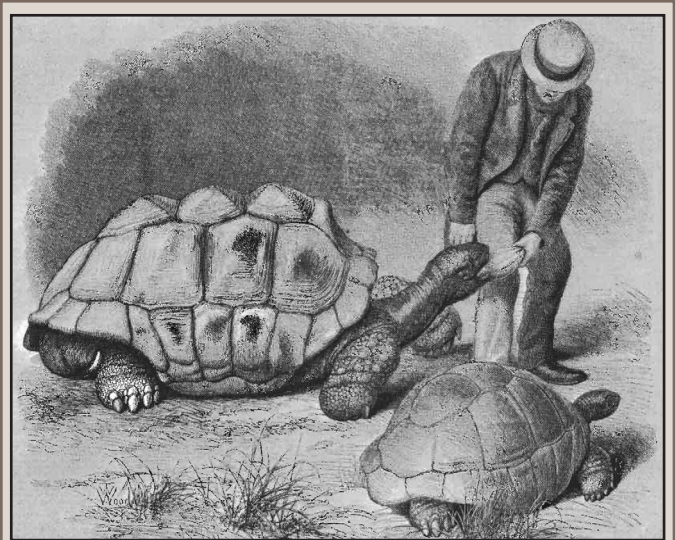


FIG. 9. Giant Tortoises at Regent's Park. *The Field*, 4 September 1875.

at Jacksonville Zoo and this chelonian reproduced at Taronga Zoo in Australia (Peters 1982; Peters and Finnie 1979). Steps needed to ensure Aldabran tortoise breeding were identified by Laszlo (1984). Operation Curieuse is a conservation program in the Republic of Seychelles (Spatt 1989).

Giant tortoises have always been popular zoo attractions (Ebersbach 2001). One of the most popular tours for donors and other interested parties at Smithsonian's National Zoo includes feeding adult Aldabran tortoises by hand—certainly a Kodak moment (Fig. 9). On one occasion a young girl was terrified and refused to enter the enclosure but other children were enraptured as they petted tortoise shells and scratched tortoise necks. Read *A Sheltered Life. The Unexpected History of the Giant Tortoise*, by Paul Chambers (2004).

Madagascar Tortoises—Here Today, Gone Tomorrow?—Although a few committed conservationists struggle against formidable odds to conserve them, the future of the tortoises in Madagascar is tenuous at best (Pedrono 2008; Raghavan

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et al. 2015). The most seriously endangered and largest of the four endemics convinced David Shukman, science editor for BBC News, to publish an alarming article (24 June 2015) on the continued illegal collection of Ploughshare Tortoises (=Angonoka) (*Astrochelys yniphora*) in Baly Bay, northwest Madagascar. The story was titled “Drastic Action to Save Endangered Tortoises by Defacing the Last Survivors,” whose numbers have dwindled to a critical level of 500 wild tortoises and several hundred captives. The shells are being permanently engraved with a large serial number and letters MG, which stands for Madagascar (see the article by Gibbons and Juvik 2012). While this defacing will almost certainly lessen the value of these chelonians by clearly showing that the reptiles were smuggled from the country and sent to the black market, armed guards are needed to protect the few remaining tortoises. However, the tortoise is also at risk from another direction—Wuhan Iron and Steel, a Chinese company, plans to open an iron ore mine in the Baly Bay area.

The Durrell Wildlife Conservation Trust (DWCT) has been involved with protecting these chelonians for many years and partnered with The Turtle Conservancy and Madagascar National Parks (MNP) in January 2012 (Fig. 10). Curl et al. (1985) investigated current status and distribution, as a component of the recovery program supported in part by DWCT. Don Reid has been directing the DWCT’s breeding and long-term monitoring project, based at the Ampijoroa Forestry Station, which has contributed immensely to understanding their biology and threatened status and has resulted in a number of significant papers (Reid et al. 1989, Burke 1990; Reid 1995; Kuchling and Razandrimamifiniarivo 1999; Smith et al. 1999; Bourou et al. 2001; Pedrono et al. 2001). Mallinson (1998) described the collaboration for tortoise conservation between the DWCT and Madagascar, which included preparation of colored educational posters for distribution. Young Ploughshare Tortoises from this captive breeding program in Madagascar have been successfully released (Pedrono and Sarovy 1998, 2000). An account covering the history, biology, conservation partnerships, and current status is available (Durrell et al. 1989; Durbin et al. 1996). Lee Durrell, Brian Groombridge, Simon Tonge, and Quentin Bloxam

wrote this disturbing note in 1989: “There are thought to be no more than 400 specimens left in the wild in areas receiving no legal protection. Existing legislation curtailing capture and trade is not enforced and there are no breeding groups in captivity outside Madagascar.”

Over two decades later, have things improved? In May 1996, the Ampijoroa Forestry Station was raided by unscrupulous collectors and two adult females and 74 juveniles were stolen for the black market. This illegal trade still exists and the prices for tortoises are astronomical. See the stunning article by Eric Goode (2012) exposing the extent of this activity. It is disgusting that uncontrolled lust for animals and profit can place this entire endangered group of tortoises at risk and negate the years of work and commitment by the DWCT staff and other conservation partners. Is there any way that this animal can survive these multiple onslaughts? I struggle against pessimism since this is yet another poignant example of human greed and indifference to the natural world, but hope that I am wrong that things will continue to spiral downward.

The late John Behler (pers. comm.) from the Wildlife Conservation Society resurveyed tortoise populations in Madagascar and discovered that hundreds, perhaps thousands, of Radiated Tortoises (*Testudo radiata*, now *Geochelone radiata*) had been killed for their livers to make pâté for the Asian food market. Dead tortoises and empty shells were scattered throughout the habitat—John found virtually no living individuals and he was convinced that this species was at severe risk throughout its entire range. Poachers were also stockpiling live tortoises in caves until enough were accumulated to smuggle to other countries. He found that viable populations of the other tortoise species there had collapsed as well, all due to human impact. The protection of these tortoises is virtually non-existent. An exhibit at Smithsonian National Zoological Park shows a picture of an enormous mound of tortoise shells in a garbage dump close to a local police station.

Elevated scutes are sometimes referred to as “pyramiding” and are thought by some authors to be caused by nutritional deficiencies. I observed several hundred confiscated wild radiated tortoises, ranging from hatchlings to large adults, at Tsimbazaza Zoo, known locally as Parc Botanique et Zoologique de Tsimbazaza in Antananarivo, Madagascar. Some shells



FIG. 10. Likely the rarest tortoise in the world, the Ploughshare Tortoise (*Geochelone yniphora*) barely hangs on in the wild. It is heavily exploited and the wild population numbers about 500 animals. The situation is so grim, these remaining tortoises are now being defaced by carving numbers into the shell to eliminate smuggling. Image from *Histoire physique, naturelle, et politique de Madagascar* by Léon Vaillant & Guillaume Grandidier in 1910.

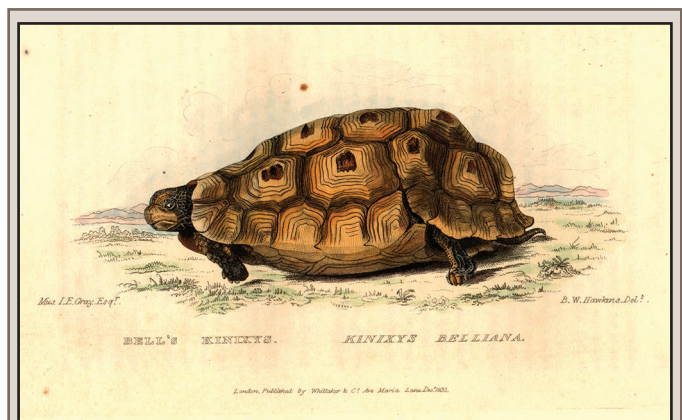


FIG. 11. Bell's Hinge-back Tortoise (*Kinixys belliana*) from *The animal kingdom, arranged according to its organization, serving as a foundation for the natural history of animals, and an introduction to comparative anatomy...* by the famous French naturalist baron Georges Cuvier in 1831.

exhibited dramatic pyramiding whereas others were completely smooth, suggesting that there is considerable variation in shell morphology, at least in this species. Peters (1969) bred the Radiated Tortoise at Taronga Zoo in Sydney, Australia, and Bloxam and Tonge (1986) elaborated upon the breeding program at Jersey Zoo.

Bloxam (1998) recorded distribution, density, and abundance of the critically endangered Madagascar Flat-tailed Tortoise (*Pyxis planicauda*). Gibson and Buley (2004) covered reproductive biology, captive husbandry, and conservation of this reptile. A Spider Tortoise (*Pyxis arachnoides*) at Smithsonian National Zoological Park laid an egg that became ruptured, repaired, and successfully hatched in 2015 (Lauren Augustine, pers. comm.). Walker et al. (2013) presented an action plan to conserve this critically endangered species.

Tortoises from Africa and Asia.—Brett Stearns at the Institute for Herpetological Research published papers on captive husbandry and propagation of tortoises, such as the Aldabra Tortoise and African Spurred Tortoise (*Geochelone sulcata*) (1985, 1987, 1989). In the Thuringia Zoo at Erfurt, Czernay and Praedicow (1988) reported on care and breeding of the spurred tortoise. Flower (1928) described the exhibition of this taxon. Visser and Zwartepoorte (1989) bred the Leopard Tortoise (*Geochelone pardalis babcocki*) at Rotterdam Zoo. Yanaga et al. (1984) artificially incubated eggs and reared the chelonian at Miyazaki Safari Park in Japan and Poglayen-Neuwall (1983) successfully bred this tortoise. Oklahoma City zoo director Dwight Lawson published papers (1993, 2000, 2001, 2006) on the African Hinge-back Tortoises (genus *Kinixys*) and Mifsud and Stapleton (2014) reviewed conservation status (Fig. 11). Pickering (1990) maintained the Pancake Tortoise (*Malacochersus tornieri*) at Tulsa Zoological Park and Wilke (1984) bred the species at Frankfurt Zoo, Dickson (1992) at Bristol Zoo, and Darlington and Davis (1990) described reproduction. Procter (1922) from London Zoo published a seminal paper on the shell morphology of this unusual tortoise. See also Stanford and Turna (2013) and Gibbons and Juvik (2013). Temperature-dependent sex determination (TSD) and ontogeny were investigated at Columbus Zoo (Ewert et al., 2004). In 2004, five tortoises hatched at the Detroit Zoological Institute. Loehr (1999) explained husbandry procedures and behavior, which led to captive breeding of the Namaqualand Speckled Padloper (*Homopus s. signatus*), also described by Morgan (1993) at the Tygerberg Zoopark, Kraaifontein, South Africa. Casares (1995) explored reproduction using ultrasound diagnostic methods and steroid analyses in the Kot Zoological Garden. Victor J. T. Loehr, Homopus Research Foundation, has been involved in many studies in captivity and on wild populations related to this genus. Over two dozen scientific articles and many notes, field reports, and popular articles have been published. Three studbooks are currently in place (*H. areolatus*, *H. signatus*, *H. femoralis*). A *Homopus* bibliography has been compiled. Goode et al. (2012) warned that the Geometric Tortoise (*Psammobates geometricus*) is quietly slipping into extinction and listed ten recommendations to improve the situation (Fig. 12).

At Wildlife Conservation Society (WCS), McDougal and Castellano (1996) elaborated on husbandry protocols that led to captive breeding of the Travancore Tortoise (*Indotestudo travancorica*). Dunn (1976) reproduced the Elongate Tortoise (*Geochelone elongata*) at Melbourne Zoo. The Sulawasi Forest Turtle (*Leucocephalon yuwonoi*) and Forsten's Tortoises (*Indotestudo forstenii*) are at serious risk from the turtle trade

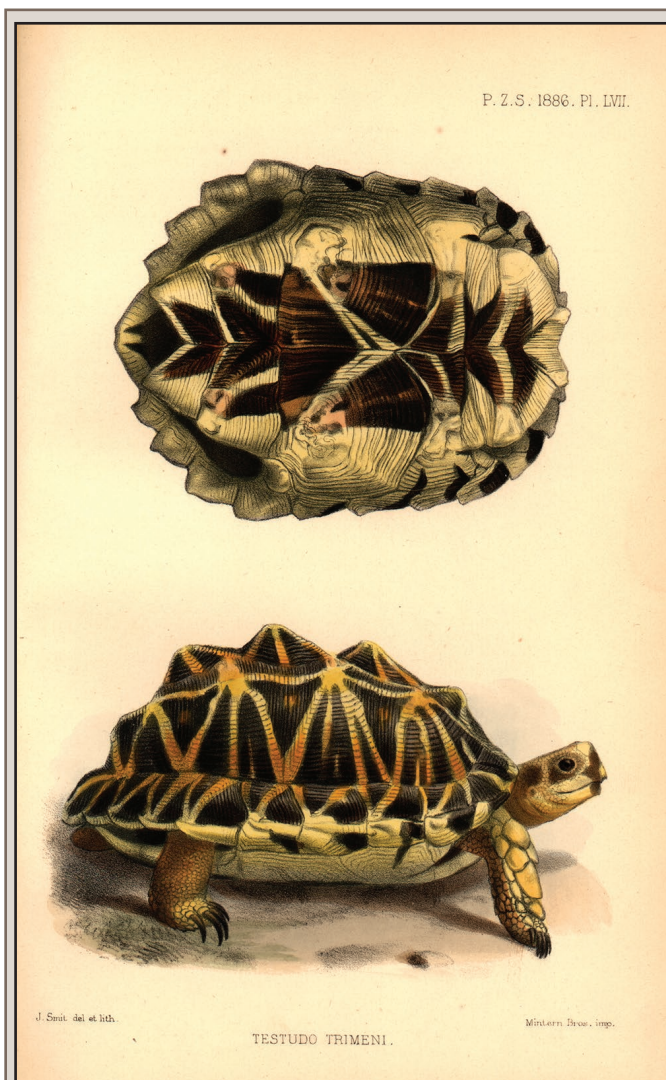


FIG. 12. Tent Tortoise (*Testudo trimeni* now *Psammobates tentorius trimeni*) from George Albert Boulenger's *On the South-African tortoises allied to Testudo geometrica* in 1886. This tortoise, like others in South Africa, is at risk.

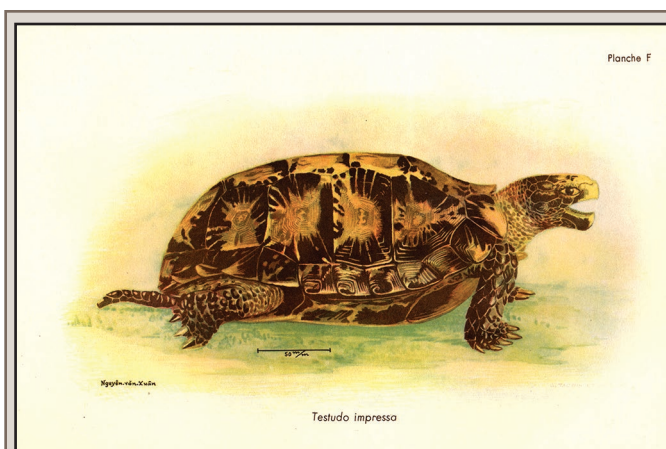


FIG. 13. The Impressed Tortoise (*Testudo impressa* now *Geochelone impressa*) is being bred in captivity as a hedge against extinction in the wild. Image from *Les Tortues de L'Indochine* by René Leon Bourret in 1941. This book was reprinted by SSAR.

in Sulawesi (Platt et al. 2001; Goode 2012). The Burmese Black Mountain Tortoise (*Manouria emys*) and Impressed Tortoise (*M. impressa*) have reproduced at Behler Chelonian Center (Stanford et al. 2012, Fig. 13) and the latter taxon at Zoo Atlanta. In 2003, two critically endangered Burmese Star Tortoises (*Geochelone platynota*) hatched at the WCS's Wildlife Survival Center. Louwman (1982) propagated the Asian Brown Tortoise (*Manouria emys*) at Wassenaar Zoo and Fort Worth Zoo hatched 16 in 2003. Matsuoka (1994) bred and followed growth of endangered Egyptian Tortoises (*Testudo kleinmanni*) at Ueno Zoo in Japan, and Dathe (1990, 2003) bred this tortoise at Berlin Tierpark (see Buskirk [1986] for status in Israel and Egypt). Zwartepoorte (2015) bred this tortoise for an *in situ* recovery project in Egypt (see also Flower 1921). Vyas and Parasharya (2000) from Sayaji Baug Zoo, Vadodara, Gujarat, India reported on distribution and status of the Star Tortoise (*Geochelone elegans*) in Gujarat State, India (Fig. 14). Kirsche (1976) contributed information pertaining to the biology of the star tortoise. (See also Noureen 2014.) Janaki Lenin sent a thoughtful and complete email in response to a query from me about the status of the Star Tortoise—see addendum.

Tortoises from the New World.—At Brookfield Zoo in Chicago, Snedigar and Rokosky (1950) described courtship and egg-laying of the Yellow-legged Tortoise (*Geochelone denticulata*). Vokins (1977) bred the Red-footed Tortoise (*Geochelone carbonaria*) at Jersey Wildlife Preservation Trust (Fig. 15). As a result of the program supported by Durrell Wildlife Conservation Trust, in

2004 the Memphis Zoo hatched the threatened Chaco Tortoise (*Geochelone chilensis*). Davis (1979) documented husbandry and breeding of the Red-footed Tortoise at Smithsonian National Zoological Park. In 1984, Pedro Trebbau, the director of the Caracas Zoo, Venezuela, published a monumental work on the chelonians of that country with Peter C. H. Pritchard.

Agassiz's Desert Tortoises (*Gopherus agassizii*) have been studied extensively at San Diego Zoo (Alberts et al. 1994; Rostal et al. 1994; Lance et al. 1995;). Thomas Van Devender from Arizona-Sonoran Desert Museum published a comprehensive book (2002) on desert tortoises (now comprising three species; see Edwards et al. 2016), which covers natural history, biology, and conservation. Does it come as any surprise when these tortoises lose the battle with “Green Energy” as explained in the article by Laufer (2013)? Ashton and Ashton (2008) have published an excellent book on natural history and management of the Gopher Tortoise (*Gopherus polyphemus*) (Fig. 16.). Kiester and Ramos (2012) outlined plans to purchase protected habitat for the Bolson Tortoise (*Gopherus flavomarginatus*) in Mexico. I saw hundreds of Texas, Desert, and Gopher Tortoises stacked waist-high (ca. 1 m) in a large pit at a traveling reptile show in Cincinnati, Ohio, for sale to the public in the early 1960s; the show lasted one week and virtually all of these tortoises had been sold (or died) by the end. A colleague at the local zoo said that the zoo received legions of phone calls from desperate owners a few weeks after the show left town—he compared the situation to steady offers to the zoo of dyed chicks after Easter. About a month later, the show came to Chicago and I decided to see if tortoises were still being sold. The same pit was again filled with hundreds of them. Many of these reptiles demonstrated severe

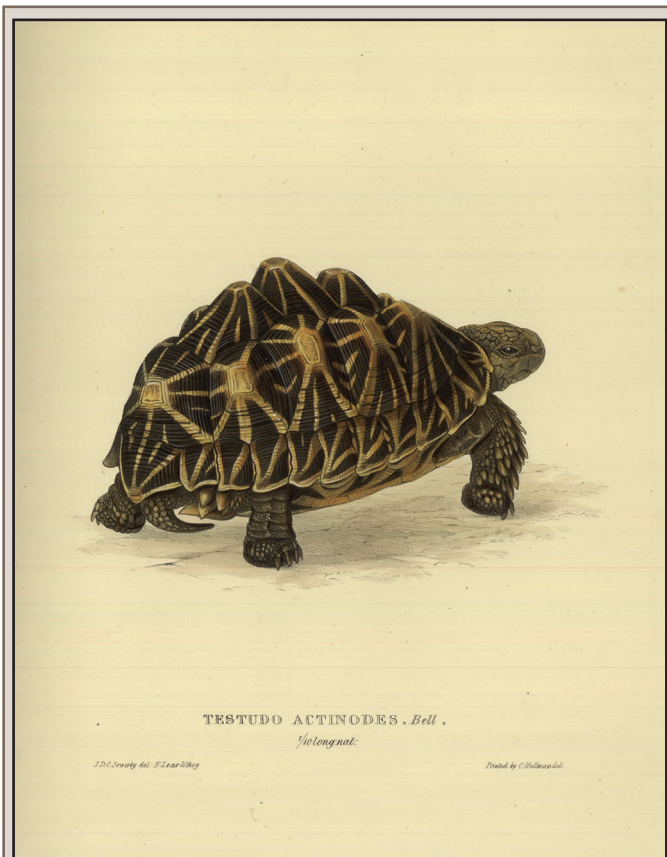


FIG. 14. Indian Star Tortoise (*Testudo actinodes* now *Geochelone elegans*) from *Tortoises, Terrapins, and Turtles Drawn from Life* by James de Carle Sowerby and Edward Lear in 1872. Thousands of these tortoises are illegally collected by poachers and smuggled to the international pet market.



FIG. 15. South American Red-footed Tortoise (*Testudo carbonaria* now *Geochelone carbonaria*) from *Tortoises, Terrapins, and Turtles Drawn from Life* by James de Carle Sowerby and Edward Lear in 1872. Many of these spectacular drawings were first published in Thomas Bell's folio work *A Monograph of the Testudinata* in 1832–1836.

respiratory infections with copious nasal discharges. See Rostal et al. (2014) for a thorough review of North American tortoises.

Medical and Management Issues in Tortoises.—At New York Zoological Park, Raphael et al. (1994) described pharmacokinetics of enrofloxacin in Indian Star Tortoises (*Geochelone elegans*), blood values in free-ranging Pancake Tortoises (1994), and clinical significance of *Cryptosporidia* in captive and free-ranging chelonians (1997). Rivera et al. (2009) identified a systemic adenovirus infection in Sulawesi tortoises (*Indotestudo forsteni*) caused by a novel siadenovirus. McAllister et al. (2014) described a new coccidian from a Galápagos Tortoise at Dallas Zoo. Garner et al. (1998) asked if seven new cases of intranuclear coccidiosis in tortoises represents an emerging disease? Jacobson et al. (1981) treated amoebiasis in Red-footed Tortoises. Hollamby et al. (2000) documented an epizootic of amoebiasis in a mixed species collection of juvenile tortoises at Lowry Park Zoo. Rideout et al. (1987) found that viviparous nematodes of the genus *Proatractis* caused mortality of captive tortoises at the Smithsonian National Zoological Park. Fournié et al. (2015) covered biogeography of parasitic nematode communities in the Galápagos Tortoise focusing on implications for conservation management. McGuire et al. (2013) identified intestinal parasites of the Gopher Tortoise from eight populations in Georgia. Ungureanu et al. (1972) discovered hemorrhagic septicemia in tortoises at Zoological Garden of Bucharest. Hauser et al. (1977) diagnosed bone metabolism disturbances in Seychelles giant tortoises. Georg et al. (1963) observed mycotic pulmonary disease of captive giant tortoises due to *Beauveria bassiana* and *Paecilomyces fumosoroseus*. Zwart et al. (1994) investigated the relationship between intestinal tracts and mineralization of skeletons by referring to normal development of carapaces in young tortoises. Oftedal and Allen (1996) discussed the importance of proper nutrition. Page et al. (1988/1989, 1991) examined pharmacokinetics of ketoconazole in Gopher Tortoises. Murphy (1973), McKeown and associates (1982, 1990, 1991), Murphy and Collins (1983), Jacobson (1994), Boyer and Boyer (1994), and McArthur et al. (2004) offered suggestions for tortoise and turtle care. Casares et al. (1994) investigated non-invasive assessments of reproductive patterns in tortoises. (See also Boycott and Bourquin 1988.)

Parental care in chelonians is certainly limited, but clearly there may be much that is unknown. In a book by Louis Somma (2003), he lists examples and there are recent citations referring to nest protection in Desert and Gopher Tortoises (Agha et al. 2013; Dziadzio and Smith 2015; Grosse et al. 2012; Zylstra et al. 2005), Asian Forest Tortoise (Eggenschwiler 2003; Emer 2007), and vocalizations in the Giant South American River Turtle (Ferrara et al. 2013, 2014).

Classical and operant conditioning has been used to facilitate veterinary care such as venipuncture and other procedures in tortoises (Weiss and Wilson 2003; Hellmuth et al. 2012).

Addendum—Status of Indian Star Tortoises (*Geochelone elegans*) according to Janaki Lenin in e-mail dated 20 July 2015. “While Indian newspapers today are full of articles about tiger and lion poaching, what passes unnoticed is an equally well-organized criminal network of smugglers trafficking in star tortoises, much sought after in the international pet trade. There are only 3 countries in the world where the species is found—India, Pakistan, and Sri Lanka. Occasionally there have been fanciful claims that confiscated animals were captive-bred (The Hindu, July 28, 2005). However, such an assertion is merely to cover the Indian government’s poor enforcement record and to downplay the impact on the wild population.

Tortoises are smuggled out of India to transit countries such as Bangladesh, Thailand and Malaysia where the smugglers are able to circumvent law enforcement. An animal dealer who was raided in Bangkok in January 2007 produced Lebanese export papers for 1000 Indian star tortoises. TRAFFIC Malaysia writes, “The only department within Peninsular Malaysia which can currently enforce CITES regulations for the Indian Star Tortoise is the *Royal Customs and Excise Department*.”

CITES strives to control the international trade in wildlife species by implementing licensing regulations. As a CITES Appendix II animal, the Indian star tortoise needs an export permit only to facilitate its legal crossing of international boundaries (besides any local legal restrictions). The export permits can be issued only ‘if the export will not be detrimental to the survival of the species.’ (CITES). According to herpetologist Romulus Whitaker, except for a couple of studies, Indian star tortoises have rarely been studied in the wild, nor their distribution and status mapped so it is virtually impossible to know how the current levels of exploitation have impacted this reptile. But regardless of these concerns there are some countries (where star tortoises

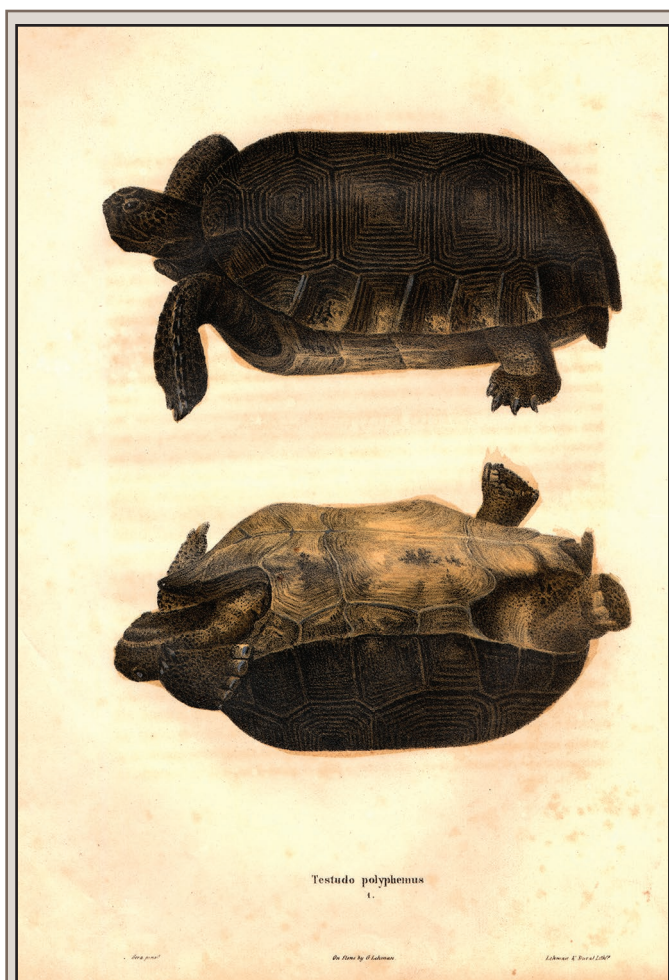


FIG. 16. All North American tortoises (genus *Gopherus*) are at risk for various reasons, including the Gopher Tortoise (*G. polyphemus*) pictured here from *North American herpetology; or, A description of the reptiles inhabiting the United States. / By John Edwards Holbrook ...1834–1840*. Unfortunately, this tortoise lives in areas desirable for human habitation and prime living spaces are being cleared for housing developments and energy production.

are not found) that are unscrupulous enough to issue the export permits.

According to the CITES trade database (www.cites.org), between 1975 and 1994, about 9200 star tortoises were exported with CITES certificates, mostly to Japan. Aware that wild-caught, smuggled Indian star tortoises were finding their way into the international trade with export permits issued by some countries, CITES issued a Notification in 1994 recommending its member countries not to accept any export or re-export permit for tortoises unless these documents were verified. There followed a five-year lull period until 2000. Lebanon entered the picture and the total number of tortoises traded under CITES began skyrocketing. Lebanon is not a signatory to CITES and since 2003 has re-exported more than 9000 Indian star tortoises claimed to be captive-bred in Kazakhstan. However, Kazakhstan has not reported exporting a single star tortoise since 2000 (the year it became party to CITES). Lebanon also exported 6000 more tortoises without disclosing the source.

Between the years 1995 and 2005, 32,000 tortoises were traded and of these Japan accepted the export permits for 20,000, contravening the CITES notification of 1994. From 2002 to 2004, Afghanistan, a country where the star tortoise is not found in the wild, exported more than 5000 of them listed as 'wild caught' to Japan. While Japan is the single largest market for scores of laundered tortoises, thousands more are smuggled to the high paying markets of Europe and the US. Between 2001 and 2004 less than 7000 star tortoises were confiscated across India while 19,000 were recorded to have been traded internationally with fraudulent papers (CITES).

Obviously India must focus on preventing wildlife crime while pushing countries such as Malaysia and Thailand to do more to prosecute smugglers. Japan must reject dubious export permits such as those issued by Lebanon. CITES needs to demonstrate that it is indeed an effective mechanism in controlling such illegal international trade. How can CITES signatory countries accept documents so blatantly fraudulent from non-party nations such as Lebanon? When the tortoise route spans the Middle East, Europe, Asia, and the United States, a united stand against smuggling is the only way to stop exploitation of the species in the wild.

Update: Since 2005, Jordan emerged as the single largest exporter of CITES-certified 'captive-bred' Indian star tortoises, even as Lebanon abandoned its role in the trade. Jordan exported more than 38,000 tortoises between 2006 and 2013, the last year for which CITES trade figures are available. Japan continues to be the main importer, taking 23,000 of the reptiles in just eight years. Taiwan comes a distant second, importing nearly 6,000 tortoises. According to the Wildlife Protection Society of India that maintains a database on wildlife crime, more than 28,500 star tortoises were confiscated at various ports and cities in India between 2005 and 2014."

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