

Why Are There Not More Agamid Lizards in Zoo Collections?

OF THE TWO GROUPS OF THE SQUAMATA, THE LIZARDS ARE OF COURSE THE OLDER. THEY HAVE THE CONVENTIONAL BODY PLAN OF A TYPICAL LAND VERTEBRATE: FOUR LEGS, FIVE TOES TO A FOOT, AND THE SPRAWLING GAIT OF THE EARLIEST REPTILES. MOST OF THE ADAPTATIONS THAT HAVE ALLOWED THEM TO SPREAD AND PROSPER ARE RELATIVELY UNSPECTACULAR CHANGES IN THE OLD FOUR-LEGGED LOOK – EXCEPTIONS BEING THE VARIOUS GROUPS IN WHICH THE LEGS HAVE BEEN LOST COMPLETELY. AS VERTEBRATES, LIZARDS ARE A FAIRLY REPRESENTATIVE GROUP AND IT HAS BEEN SUGGESTED THAT THE LIZARDS WOULD BE MORE SUITABLE AS A TYPE WITH WHICH TO INTRODUCE FRESHMAN BIOLOGY STUDENTS TO VERTEBRATE ANATOMY THAN THE UNIVERSALLY USED FROG. PERHAPS IT SOUNDS CYNICAL TO SAY SO, BUT I THINK THE ANSWER THERE IS THAT THE FROG BEING TAILLESS, FITS DISSECTION PANS MORE GRACEFULLY.

—ARCHIE CARR, *LIFE NATURE LIBRARY: THE REPTILES*, 1963

Some of the most beautiful and specialized lizards on the planet comprise the family Agamidae (see Scott Moody's phylogenetic and historical biogeographical relationships of the family, 1980). A sizeable number are strikingly ornate, with arresting colors and patterns. Many have an array of ornaments—crests, spines, frills, fins, dewlaps, nasal appendages, spinose “beards” and other accoutrements. A few display remarkable anti-predator behaviors that deploy these unusual structures to intimidate enemies. Agamids are found from the western Pacific through Australia and Asia to Africa and Europe. The family is large, comprising 57 genera and 483 species (Uetz et al. 2017). As a group, they are generally diurnal; most use well-developed hind limbs with five clawed digits to escape predators. They feed on a variety of insects, reptiles, nestling birds, small mammals, and plant materials.

Agamids are mostly terrestrial and have keen vision. Some use remarkably effective camouflage to avoid detection. They wave arms, do pushups, bob heads, extend dewlaps and crests, bite, compress or inflate bodies, vocalize, run bipedally, glide, lash tails, and engage in other fascinating behaviors, some of which are directed toward conspecifics.

The female Rainbow Lizard (*Agama agama*) lays eggs in a hole dug with snout and claws. The hole is constructed in sandy, wet, damp soil that is exposed to sunlight most of the day and covered by vegetation. Eggs are usually laid in clutches ranging from five to seven ellipsoidal eggs. This taxon is a thermoregulated embryo species resulting in all males at 29°C and all females at 26°C (Crews et al. 1983). The eggs hatch within eight to ten weeks. A complete treatment of life and anatomy of this lizard has been published by Vernon Harris (1963, 1964).

What other group of reptiles has such colorful standard

names? Jacky Lizard, Frilled Lizard, Bicycle Dragon, Thorny Devil, Sailfin Lizard, Lashtail, Forest Dragon, Great Anglehead Lizard, Lyrehead Lizard, Secret Toadhead Agama, Lionhead Agama, Crested Flying Dragon, Eyebrow Lizard, Picklenape, Bloodsucker, and a host of others equally intriguing.

Hence, it is surprising that so few living agamids are displayed in zoo collections, especially since they do not hide constantly like many snakes, and many species adapt well to captivity. Many of the above behaviors would be visible to the zoo visitor. Here is an account of a complex array of unique behaviors observed by one of us (JBM) at the Dallas Zoo: “An elaborate combination of specialized motor patterns were observed in the agamid lizard, *Goniocephalus dilophus*, when confronted by an intruder: 1) when most threatened, bipedal bounding or hopping flight with forelimbs rotated in a circumductory plane [movement of a limb in a circular direction], mouth closed; 2) when less threatened, lateral presentation with open mouth, tongue rolled forward, gular sac expanded, side hopping [sideways hopping movement in which this lizard hops first to one side and then the other]; and 3) when least threatened, frontal orientation, short rushes toward the intruder with mouth open, biting attempted. Expansion of the hyoid apparatus allowed for greater visibility of the yellowish dentary region. The soft gum tissue and tissue exterior to the masseter muscle deepened to a bright reddish hue, due probably to vascularization. A guttural hissing sound produced by lung evacuation through the glottis accompanied the display” (Murphy et al. 1978, Fig. 12). With relatively little effort, interesting graphics and displays could be designed to show off these remarkable creatures. To whet a zoo worker's appetite, some of the most spectacular ones are depicted here.



FIG. 1. Muricated Lizard, sometimes called Jacky Lizard (*Amphibolurus muricatus*, described as *Lacerta muricata*). Reproduced from *Journal of a voyage to new South Wales, with sixty-five plates of non-descript animals, birds, lizards, serpents, curious cones of trees and other natural productions* by John White, 1790.

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FIG. 2. Frilled Lizard (*Chlamydosaurus kingii*). Reproduced from *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles* by A. M. C. Duméril, G. Bibron and A. H. A. Duméril, 1839. This species is found in Australia and New Guinea. A specimen at the Dallas Zoo flared its frill, hopped bipedally and vocalized with grunting sounds. The French naturalists, Constant Duméril, Gabriel Bibron, and the senior author's son, Auguste Duméril, produced this classic herpetological work, based on the collections of the Muséum d'Histoire Naturelle in Paris (9 volumes in 10 plus an atlas of colored plates, 1834–1854). All of the saurian plates were illustrated by artist Jean Gabriel Prêtre (1780–1845), produced between 1836 and 1839. These books have been reprinted by SSAR of nearly 7,000 printed pages and 250 plates in six volumes with an introduction by Roger Bour, including extensive new biographies of all three authors.

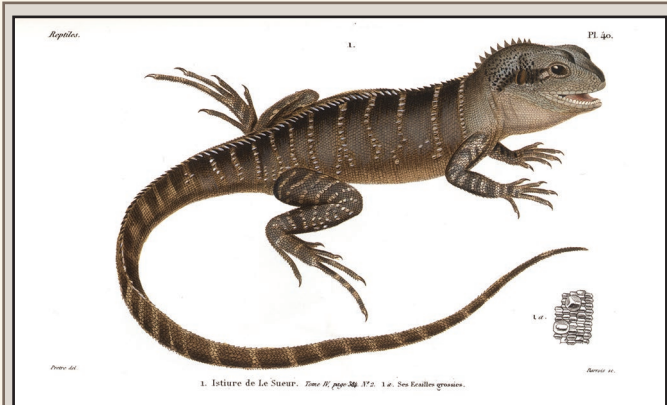


FIG. 3. Eastern Water Dragon (*Physignathus lesueurii*). Reproduced from *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles* by A. M. C. Duméril, G. Bibron, and A. H. A. Duméril, 1839. This species is found in Australia. A large captive population lives in a spacious semi-aquatic display at the U.S. National Aquarium in Baltimore, Maryland.

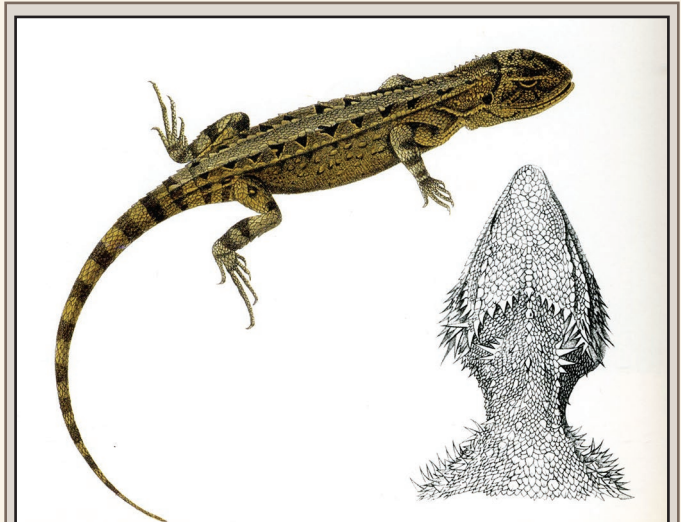


FIG. 4. Bearded Dragon (*Pogona barbata*). Reproduced from *Le règne animal...* by Baron Georges Cuvier, 1836–1839. An interactive display at the Smithsonian's National Zoo in Washington, D.C., used this species to demonstrate shuttling thermoregulation. See Avery (1994) for a discussion of effects of temperature on captive reptiles and amphibians.



FIG. 5. Jerdon's Forest Lizard (*Calotes jerdoni*; top) from India, Burma, and Bhutan, and Khasi Hills Forest Lizard (*Calotes maria*) from India. Reproduced from Albert Günther (1870) *Descriptions of a new Indian lizard of the genus Calotes*.

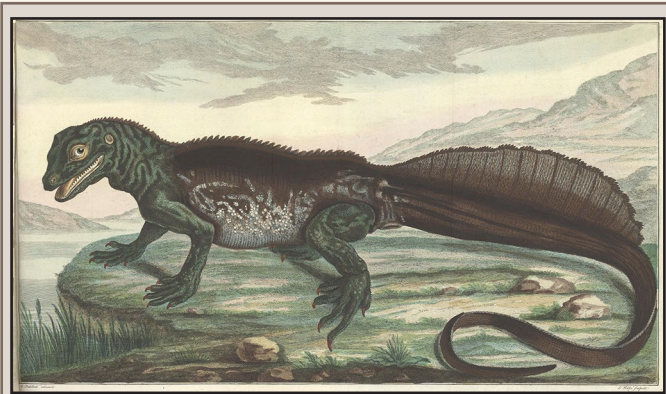


FIG. 6. Sailfin Lizard (*Hydrosaurus amboinensis*). Reproduced from *Johannis Alberti Schlosser medicinae doctoris ... Epistola ad virum expertissimum, peritissimumque Ferdinandum Dejean ... De lacerta Amboinensi...* J. A. Schlosser, 1768. This impressive large and semi-aquatic species is found in Indonesia and New Guinea. A captive group of Philippine Sailfin Dragons (*Hydrosaurus pustulatus*) maintained at the Dallas Zoo would often swim in a pool of water. This species is hardy and breeds readily in captivity. Recently-hatched lizards were used as a stimulus to study tail-luring in Death Adders (*Acanthophis antarcticus*). These lizards were separated from the snakes with a glass panel and were susceptible to the lure, lunging at snake tails. See Carpenter et al. (1978), Chiszar et al. (1990).



FIG. 7. Great Anglehead Lizard (*Dilophyrus Grandis*, now *Gonocephalus grandis*). Reproduced from *Catalogue of reptiles inhabiting the Malayan Peninsula* by T. E. Cantor, 1847. This species is found in Indonesia, Malaysia, Thailand and Viet Nam. We have never seen one alive in a zoo.



FIG. 8. Okinawa Tree Lizard (*Japalura polygonata*). Reproduced from George Boulenger (1887) *On a collection of reptiles and amphibians made by Mr. H. Pryor in Loo Choo Islands*. This species is native to Taiwan and Japan. "In the five centuries of published works in the field of herpetology, only two can be said to cover comprehensively and scientifically *all* of the species of amphibians and reptiles of the world. One, in English, was by George A. Boulenger and based on the collections of the British Museum in London (9 volumes, 1882–1896). These books were reprinted in 1961–1966, clothbound, and despite their age, remain among the most frequently consulted references in herpetology today." (Murphy 2017).

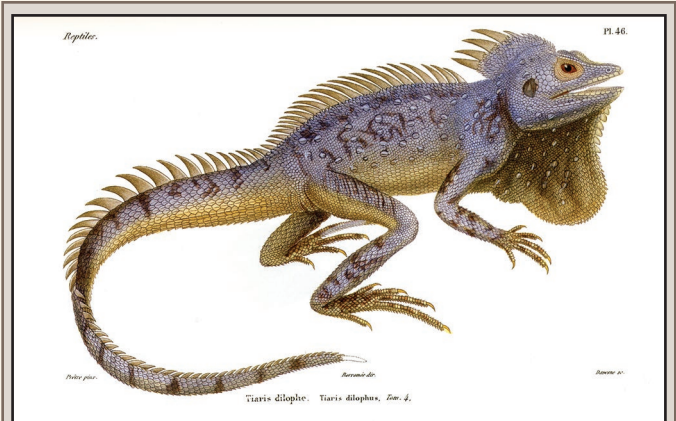


FIG. 9. Indonesian Forest Dragon (*Hypsilurus dilophus* now *Gonocephalus dilophus*). Reproduced from *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles* by A. M. C. Duméril, G. Bibron and A. H. A. Duméril, 1839. This species occurs in Indonesia. See text for a description of behaviors.

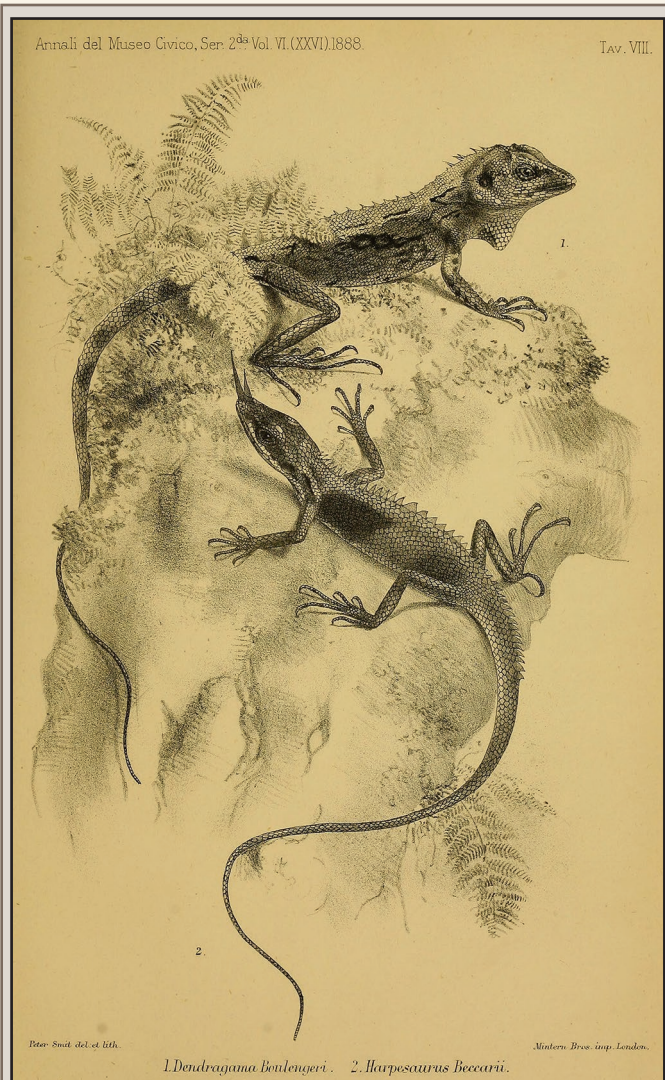


FIG. 10. Boulenger's Tree Lizard (*Dendragama boulengeri*) and Sumatra Nose-horned Lizard (*Harpesaurus beccarii*). Reproduced from *Note Erpetologiche - Alcuni nuovi Sauri raccolti in Sumatra dal Dr. O. Beccari. Ann. Mus. civ. stor. nat. Genova 2* by Giacomo Doria, 1888. Both species are endemic to Indonesia.



FIG. 11. Green Water Dragon (*Physignathus munitz*, now *Physignathus cocincinus*). Reproduced from *The Reptiles of British India* by Albert C. L. G. Günther, 1864. Many zoos display this lizard species, which has been reproduced in captivity.



FIG. 12. Ornate Mastigure (*Uromastix ornatus*, now *Uromastix ornata*). Reproduced from *Zoology of Egypt. Vol. I. Reptilia and Batrachia* by John Anderson, 1898. This species is native to Israel, Egypt, Yemen, and Saudi Arabia. Most species of this genus have been maintained alive in zoo collections. They thrive as long as temperatures are high enough.

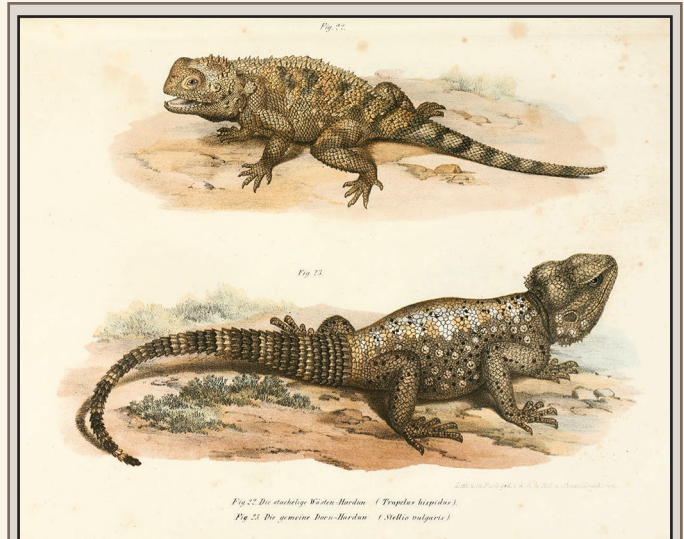
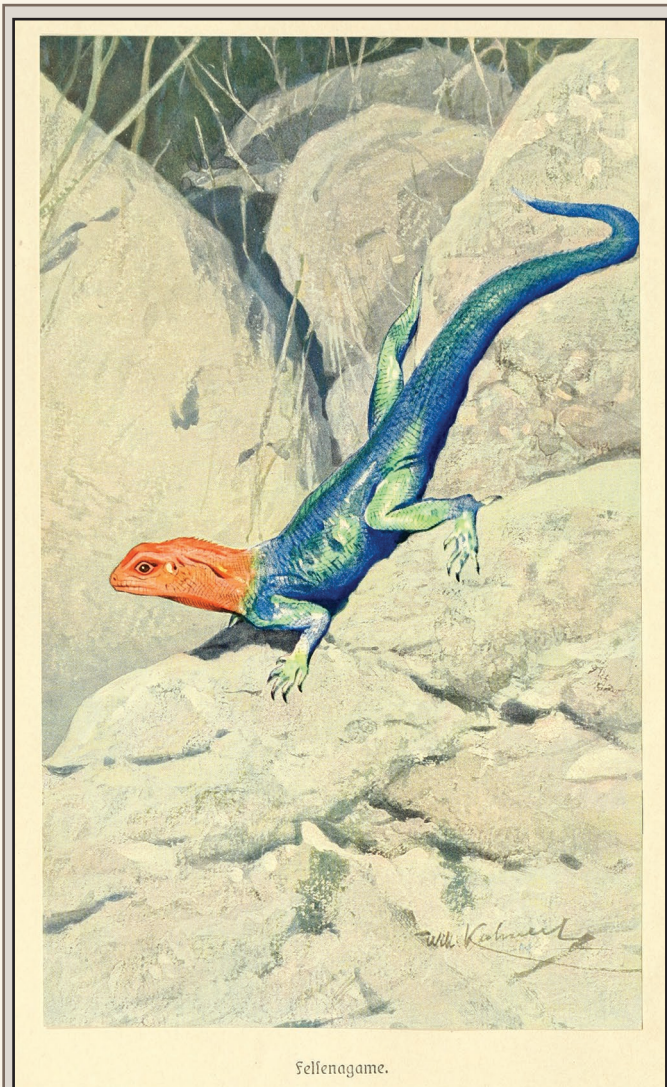


FIG. 13. Harduns (*Trapelus hispidus*, *Stellio vulgaris*) from Africa, Egypt and Syria. Reproduced from *Bilder-Atlas zur wissenschaftlich-populären Naturgeschichte des Wirbelthiere* by L. J. F. J. Fitzinger, 1867.



Fellenagame.

FIG. 14. Common or Red-head Agama (*Agama agama*). Reproduced from *Brehms Tierleben. Allgemeine Kunde des Tierreichs. Volume 2* by Alfred E. Brehm, 1911. A captive population of this species, along with *Cordylus*, *Platysaurus*, *Chamaesaura* and *Pseudocordylus*, lived in a large display of mixed African lizards at the Dallas Zoo. Brehm coined the term “Vivarium,” directed the Hamburg zoo from 1863 onward, and founded the Aquarium Unter den Linden (Berlin’s main street) in 1869. His ten-volume comprehensive treatment of animals set the standard for such compilations. The reptile section (vol. 4) was revised by Franz Werner in 1912–1913. This invasive species and Indochinese Tree Agama (*Calotes mystaceus*) have been established in Florida, USA.

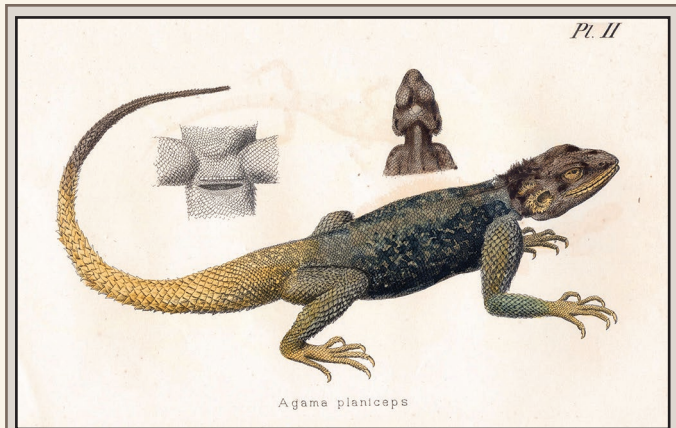


FIG. 15. Namib Rock Agama (*Agama planiceps*). Reproduced from the title page of *Herpétologie d'Angola et du Congo* by J. V. Barbosa du Bocage, 1895; these drawings were made by Enrique Casanova.



FIG. 16. “The external appearance of this Lizard is the most ferocious of any that I know, the horn of the head and the numerous spines on the body giving it a most formidable aspect” John Edward Gray (1841). Four agamids are pictured in this chromolithograph from *Kunstformen der Natur* [Art Forms in Nature] by Ernst Haeckel in 1904. This Thorny Devil (*Moloch horridus*) in bottom right corner is difficult to keep in captivity as it is an ant specialist. This plate (79) is called “Lacertilia/Eidechsen.” In the 1960s, curator Ed Almandarz at Lincoln Park Zoo in Chicago tried all ant species in the region with no success—all were totally ignored. In Australia, Pianka and Pianka (1970) wrote that a captive only accepted one ant taxon of eight offered (*Tridomyrex rufoniger*) and discussed the “hydropscopic nature” of the skin.

Acknowledgments.—This contribution is dedicated to the memory of Charles Lewis Camp (1893–1975), who published *Classification of the Lizards* in 1923. This important work was reprinted by SSAR in 1971, with a new preface by the author and an introduction by Garth Underwood. Smithsonian librarians Polly Lasker assisted with citations and Leslie Overstreet provided a guide to reading plates.

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ADDENDUM

HOW TO READ SIGNED PLATES
PREPARED BY LESLIE OVERSTREET
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Typically, two people were involved in producing printed images: the original artist who created the image and the craftsman who transferred it to the wood block, metal (copper or steel) plate, or lithographic stone for printing. Their names commonly appear along the bottom edge of the illustration, with the artist in the lower left corner and the craftsman (wood-cutter, engraver, or lithographer) in the lower right. Sometimes, the name of the printer or “publisher” also appears in the lower right corner. Their roles are specified by the following abbreviations:

a.f., aq., aquaf., aquaforti = etched by
cael., caelavit = engraved by
d., del., delin., delineavit = drawn by
des., desig. = drawn by
dessiné = drawn by
direx., direxit = directed by (head of workshop)
eng., engd. = engraved by
ex., exc., excu., excud., excudit, excudebat = printed by;
 published by
f., fe., fec., fecit, fa., fac., faciebat = made by
gez., gezeichnet = drawn by
grav., gravé = engraved by
imp., impr., impressit = printed by (*imp. lith.* = printed on a lithographic press)
inc., inci., incid., incidit, incidebat = engraved by
inv., invent., inventor = designed by (the original artist)
lith., litho., lithog. = lithographed by
p., pictor, pin., pingebat, pinsit, pinx., pinxit = painted by (original work)
ph.sc., photosculpsit = engraved by light
s., sc., scul., sculp., sculpsit, sculpebat, sculptor = engraved by