

## A History of the Ecological Sciences, Part 11: Emergence of Vertebrate Zoology During the 1500s

The study of animals during the early Scientific Revolution was stimulated by publication of the zoological writings of Aristotle and Pliny during the late 1400s and early 1500s (Sarton 1955:53–63, 78–86, Perfetti 2000). Brunfels initiated publication of large botanical books (herbals) in the 1530s, inspired by Dioscorides' *Materia medica*. A comparable tradition in zoology began in the 1550s, apparently inspired by publication of Andreas Vesalius' *De fabrica humanis* (1543), which introduced to other physicians the possibility of publishing large books on animals. The species-by-species organization that botany adopted from Dioscorides was also adopted in zoology, and then zoology was quicker than botany to develop monographs on particular groups of animals: mammals, birds, fishes, and insects. In the first half of the 1500s, before Vesalius set the new standard, works published in zoology were modest in scope and size, and one is discussed here to indicate the achievements of that period.

William Turner (1508–1568), from Northumberland, had an early interest in natural history, but he was also swept up by the Protestant Reformation after it reached England. He entered Pembroke Hall at Cambridge University, was ordained a deacon in 1536, and was licensed to preach at his college in 1537. However, preaching apparently got him in trouble, and he spent some time in prison before his exile in 1540. He studied medicine in Italy (1540–1541) at Ferrara and Bologna, obtained a medical doctorate, then traveled in Switzerland and Germany from 1541 to 1544 (Raven 1947: 48–79, Webster 1976). He established ties with other naturalists before returning to England by June 1549 during the reign of Protestant King Edward VI, but fled abroad again during the reign of Catholic Queen Mary (1553–1558) before returning home permanently. Turner devoted more time and publications to plants than animals, but his *Avium praecipuarum quarum apud Plinium et Aristotelem mentio* (1544) is notable for being the first book published on the natural history of birds from a scientific rather than a utilitarian perspective. Although it is organized according to the names and observations of Aristotle and Pliny, he added his own observations. One of Turner's longest accounts is on the Great Gray Shrike (*Lanius excubitor*), which includes these observations (Turner 1903:119–121):

*It has short wings, and flies as if by bounds upwards and downwards. It lives on beetles, butterflies, and biggish insects, and not only these, but also birds after the manner of a Hawk. For it kills Reguli and Finches and (as once I saw) Thrushes; and bird-catchers even report that it from time to time slays certain woodland Pies, and can put Crows to flight. It does not seize the birds it kills with its claws, after a swift flight, as Hawks do, but attacks them stealthily and soon (as I have often had experience) aims at the throat and with its beak squeezes and breaks the skull. Then it devours the crushed and*



**Fig. 1.** Conrad Gessner. From an advertisement for Hans Fischer et al., *Conrad Gessner, 1516–1565, Universalgelehrter, naturforscher, Arzt* (1966a).

*bruised bones, and when anhungered crams into its gullet lumps of flesh as big as the gape's narrowness can take. Again, beyond the habit of the rest of birds, when prey happens to be more plentiful, it lays by some for future scarcity. For it impales and hangs the bigger flies and insects on the thorns and spines of shrubs. . . .*

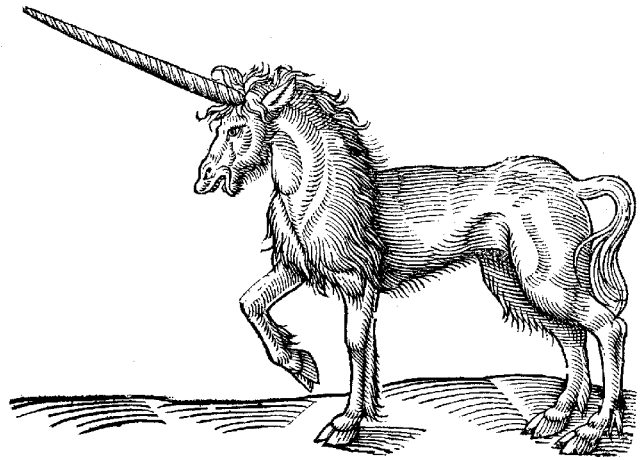
Turner sent additional observations on birds and fish to Conrad Gessner (Fig. 1), who published them in his *Historia animalium*; Turner's bird notes quoted by Gessner are reprinted in Latin in Evans' *Turner on Birds* (Turner 1903:x–xiv), and one of his fish notes from Gessner is quoted in English by Raven (1947:113–114).

Andreas Vesalius (1514–1564), born in Brussels, studied medicine at the universities of Louvain and Paris and taught anatomy at the University of Padua. Galenos (c.130–c.200) was the unquestioned authority on anatomy and physiology, but Vesalius realized that he had only dissected various mammals, never a human cadaver. Vesalius thus conceived the daring idea of publishing an encyclopedia of human anatomy that pointed out all the discrepancies between Galen's knowledge based on animals and Vesalius' knowledge based on human anatomy. He obtained the assistance of a talented artist who drew full-page illustrations of what Vesalius dissected, and his *De fabrica humanis* (1543) was (along with Copernicus' book on astronomy) one of the founding works in the Scientific Revolution. Vesalius' book had far-reaching influence on other aspects of zoology.

The immediate influence was on four physicians who published books in the 1550s. Three wrote books on fish (Belon, Rondelet, and Salviani) and the fourth, Gessner, wrote an encyclopedia of animals that included a volume on fish. Belon is, however, best remembered for a drawing that compares human and bird skeletons in his natural history of birds (1555; reprinted in Bodenheimer [1958:234–236] and Delaunay [1962:186–187]). Otherwise, his bird book was eclipsed by Gessner's longer bird volume that appeared in the same year (Stresemann 1975:18).

Conrad Gessner (Latin Gesnerus, 1516–1555) was a Swiss scholar who mastered a very wide range of knowledge, including languages (Fischer 1966*a,b*, Wellisch 1984). After studies in Switzerland and Paris, he studied medicine in 1540 at Montpellier, where he met Belon and Rondelet. He received a doctorate in medicine from the University of Basel in 1541 and then returned to his native Zurich to practice and publish a seemingly endless number of writings (his botanical works are discussed in Egerton 2003:130–137). His encyclopedic *Historia animalium*, in five large folio volumes (1551–1587; German translation in four volumes, 1557–1589), drew upon virtually all the Greek, Roman, and medieval authors, and also upon his own observations and those of his contemporaries from all over Europe (Ley 1968:26–152, 269–272). It is well illustrated (the first animal treatise that was), but the quality of the illustrations varies widely from fabulous and crude to accurate and artistic. He made some drawings himself and others were either sent to him or taken from other books. His first volume, on what we call mammals, was still considered authoritative in 1607 when Edward Topsell (1572–1625) published an illustrated translation in English. Like Gessner, Topsell arranged his translation in alphabetical order. In 1608, Topsell published a thinner second volume that contains translations from Gessner's volumes 2, 4, and 5, along with essays in English by Dr. John Bonham on insects, spiders, and earthworms. (A third volume on insects was unrelated to Gessner.) These volumes were reprinted in 1658 in a slightly smaller format that omitted some illustrations, and reprinted in facsimile (Topsell 1967). It is the latter edition that is used here. The mammal volume of 1551 has over 1100 pages, which are reduced to 586 folio pages in Topsell 1658.

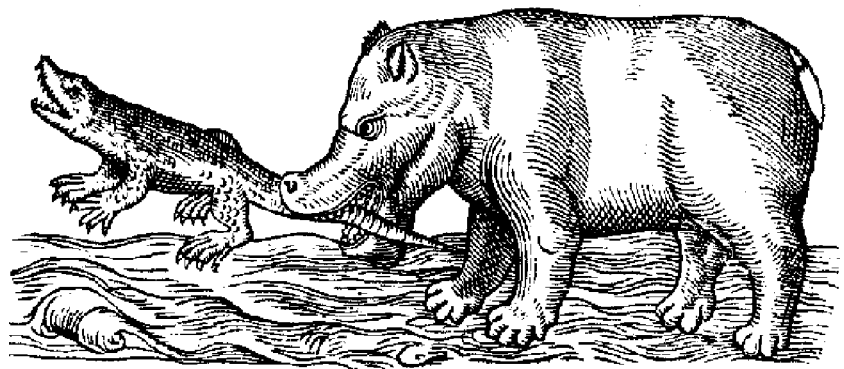
Like Pliny and Albertus Magnus, Gessner attempted to weed out folklore, with only partial success (Gmelig-Nijboer 1977:97–121). His interest in the cultural associations of different kinds of animals was often as strong as his interest in their natural history (Ashworth 1996:17–29). The mammal volume in English has eight pages devoted to the unicorn. The illustration is of a horse with a narwhal tusk on its head (Fig. 2). Gessner expressed some skepticism but was inclined to accept the possibility of the unicorn because the Hebrew word Reem was translated in the Greek Old Testament as “unicorn” (Topsell 1967:I, 552). It re-



**Fig. 2.** Unicorn. Original from Gessner 1551 (Topsell 1967:551).

tained that translation in the King James' Version (1611), but is translated as ox in the Revised Standard Version. On Martin Frobisher's second voyage in search of the north-west passage (1577), his ship discovered a dead narwhal with tusk intact floating in the North Atlantic; nevertheless, people were still discussing unicorns a century later (Shepard 1930:255–256).

Gessner's long account of apes includes information from Vesalius on anatomical differences between apes or monkeys and humans that were unknown to Galenos (Topsell 1967:I, 3). Gessner's attempt to distinguish different species of apes and monkeys was not very successful. He has an illustration and discussion of baboons on pages 8–9, and on pages 342–343 there is another illustration and discussion of what appears to be a baboon species, labeled “The second kinde of Hyaena, called Papiro or Dabub.” What he writes about “apes” should be read as generic observations on primates. They live mostly in caves and hollows in rocks and in trees and eat apples and nuts. They eat lice and pick them out of heads and garments. They drink wine until drunk. They deliver mostly twins. Sir Thomas More reported that one living in England defended a rabbit from a weasel. Monkeys are very afraid of crocodiles (Fig. 3).

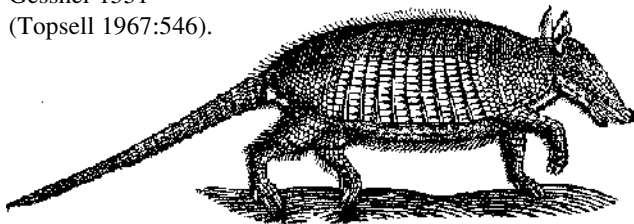


**Fig. 3.** Hippopotamus and crocodile. Original from Gessner 1551 (Topsell 1967:257).

Baboons love the milk of sheep and goats. They know how to take kernels out of almonds and walnuts, and by their swiftness they overtake venison which they tear to pieces and roast in the sun.

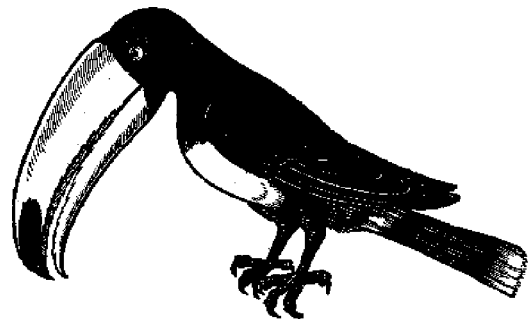
The mammal volume includes rather long accounts on dogs, horses, and sheep, and only slightly briefer treatment of other kinds of livestock. The account on horses has undoubtedly the longest discussion of their diseases ever published until then (Topsell 1967:265–339), including discussions of worms and liver flukes (Topsell 1967:303–304, 474). Gessner was quite interested in exotic animals, and described and illustrated eight mammal species from the Americas (Gmelig-Nijboer 1977:68–71): an opossum (called simivulpa), described as carrying the young in a pouch (the drawing was possibly made from a verbal description); a lama from Peru that was brought to Middelburg, Zeeland in 1558, with drawing and description coming from Theodor de Neus; a sloth, depicted walking on the ground (with no awareness that it hangs from tree limbs); a nine-banded armadillo (Fig. 4), well illustrated by Adrianus Marsilius, who also sent Gessner its carapace, tail, and claws; an anteater, with the illustration having almost no resemblance to the animal (the

**Fig. 4.** Armadillo.  
Original from  
Gessner 1551  
(Topsell 1967:546).



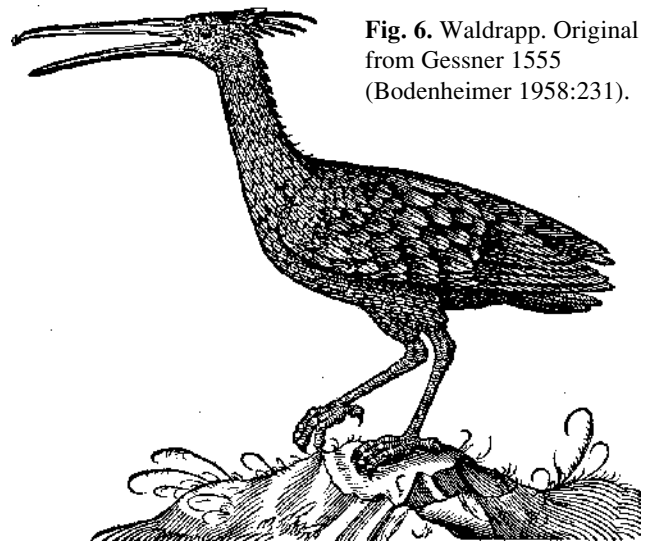
verbal description does not mention the long snout, nor that it walks on the knuckles of the forepaws); and the sagouin monkey from Brazil, the description and drawing of which he received from Antwerp apothecary Peter Goudenberg, who saw it alive. The other two species were a rodent and lizard not precisely identified (Topsell 1967:15, 16, 79, 511, 546–547).

Gessner's third volume, on birds (1555), has 806 pages on 180 species (see Figs. 5 and 6). The account and illustration of *Corvo sylvatico* ("Waldrapp," or Wood Raven; Fig. 5) was a puzzle to modern ornithologists because it fitted no species known from Bavaria, Lorraine, and northern Italy. In the 1890s, they finally realized that it was a species of ibis, *Comatibis eremita* (L.), known in modern times only from the Middle East. It is unknown why its European population disappeared, and Gessner's account (translated into English in Rothschild et al. 1897:371–372) is our evidence that it once did inhabit central Europe. Gessner's first-hand observations on the Wryneck, taken from the abbreviated German edition, is quoted in English by Stresemann (1975:20–21).



**Fig. 5.** Original from Gessner 1555 (Delaunay 1962:25).

The three naturalists who wrote fish books during the 1550s all went beyond Gessner, who supplemented his literary sources with first-hand and second-hand observations. They studied fish, and although knowledgeable about classical authors, they placed less emphasis on them, and so laid the foundation for the science of ichthyology (Gudger 1934:21). Two of the naturalists were French: Guillaume Rondelet (1507–1566) and Pierre Belon (1517–1564). The third naturalist was an Italian, Ippolito Salviani (1514–1572). All three studied the fish of the Mediterranean Sea and its tributaries. Belon was a notable early explorer–naturalist (Delaunay 1926, Petit and Théodoridès 1962: 266–271) who traveled in the Middle East, 1546–1550 and described in his travel books the animals that he saw (Fig. 7). He also described his aquatic discoveries in three works: *L'histoire naturelle des estranges poissons marins* (1551), *De aquatilibus libri duo* (1553), and *La nature et diversité des poissons* (1555). In *De aquatilibus libri duo* he "provided drawings of 110 species, including 22 cartilaginous species and 17 freshwater species, the rest being marine species; and he discussed about 20 species for which he gives no drawings" (Cuvier 1995:42). His illustration of salmon showed for the first time the hooked lower jaw



**Fig. 6.** Waldrapp. Original from Gessner 1555 (Bodenheimer 1958:231).

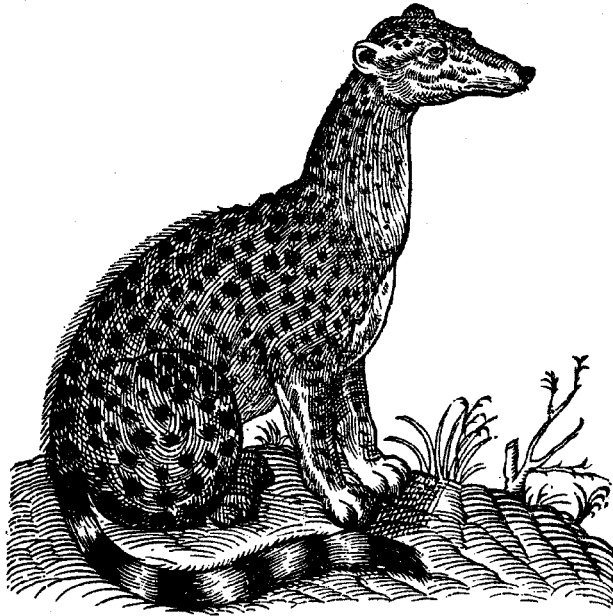


Fig. 7. Gennette. Original from Belon 1557 (Delaunay 1962:103).

of adult males (Gudger 1934:27). He decided to classify all flying vertebrates as birds and all aquatic vertebrates as fish. Still, he dissected and compared three cetaceans, *Delphinus*, *Phocaena*, and *Tursiops*, and noted the milk glands (Cole 1944:60–62); see Fig. 8.

Rondelet (Fig. 9) was a popular professor of medicine at the University of Montpellier, and also was chancellor of the university during the last decade of his life (Oppenheimer 1936). He published his extensive studies in two Latin volumes, *Libri de piscibus marinis* (1554) and *Universae aquatilium historiae pars altera* (1555), which later appeared in a briefer French edition (1558). He brought his expertise in human anatomy to the study of fish and described their morphology and internal anatomy (Cole 1944:62–72). The 1554 volume described 244 species, 47 of which were freshwater fish, and his illustrations are quite accurate (Gudger 1934:29, Petit and

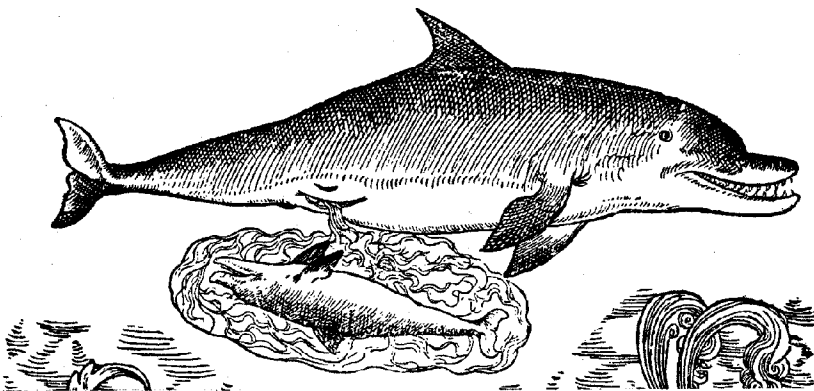


Fig. 8. Dolphin giving birth. Original from Belon 1551 (Singer 1959:92).

Théodoridès 1962:271–274, Cuvier 1995:43). The 1555 volume describes a few marine fish, 60 freshwater fish, and a variety of other marine life.

Salviani was educated in Rome, taught medicine at its university, and was physician to three popes. His *Aquatilium animalium historiae*, issued in parts, 1554–1558, featured beautiful figures engraved in brass instead of wood, but their merits are more artistic than scientific (Castellani 1975). Salviani described 99 species and illustrated 93; 18 of these were new discoveries; he also included an octopus and two squids (Gudger 1934:31–32, Petit and Théodoridès 1962:274–275).



Fig. 9. Rondelet. From Gudger 1934: Plate 2.

When Gessner got around to publishing Volume 4 of his *Historia animalium* on fish and aquatic animals (1558), he wisely drew heavily upon the works of Belon, Rondelet (see Fig. 10), and Salviani, although he did not stop there. With 1297 pages and over 900 woodcut illustrations, it was his longest volume, and it drew upon contemporaries not consulted by these three authors (Cuvier 1995:45–46). Gessner's work was truly exhaustive for the time, and it is therefore very surprising that another physician decided to outdo it.

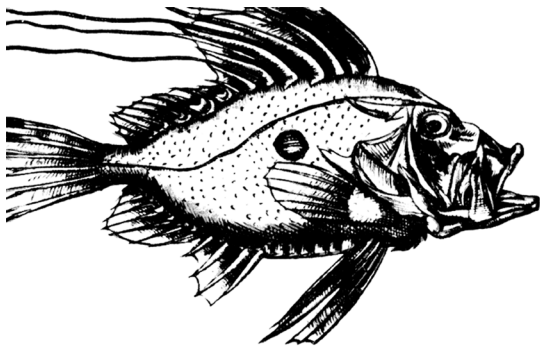


Fig. 10. *Zeus faber*. Original from Rondelet 1553 (Théodoridès 1962: facing page 272).

Ulisse Aldrovandi (1522–1605) was from a well-connected and prosperous Bologna family, and after attending Padua and Pisa universities, he received a medical degree from the University of Bologna, where he taught for 40 years (Castellani 1970, Olmi 1976) (see Fig. 11). He never practiced medicine, however, because his strong interest in natural history, partly inspired by Rondelet, whom he met in Rome, consumed all his time and energies. He urged the city of Bologna to establish a botanic garden and became



Fig. 11. Aldrovandi (Ley 1968:153).

its lifelong director. He developed the most important museum in Europe (he called it the eighth wonder of the world), which he left to the city with the proviso that it continue publishing his works, only four volumes of which he himself published. The city faithfully complied with this request for 60 years, publishing nine more volumes. Humility was not one of Aldrovandi's faults. Beneath his portrait hanging in his home and reproduced in the first volume of his *Ornithologiae* (1599, reproduced in Findlen 1994:310) he inscribed: "This is not you, Aristotle, but an image of Ulysses: though the faces are dissimilar, nonetheless the genius is the same." On other occasions he proclaimed himself a new Pliny and a new Galen.

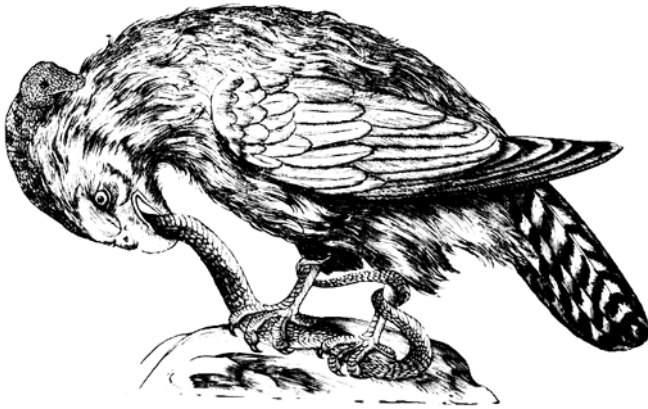
Aldrovandi's energy and persistence are universally admired; he produced 13 large, well-illustrated volumes that contained an immense amount of information, including his own observations (Tugnoli Pattaro 1981). For example, he revived the Aristotelian (and Hippocratic) project of opening incubated chicken eggs on successive days to observe the developing embryos, which he described in part of his work translated into English (Aldrovandi 1963:83–98; Adelman 1966:II, 756–757). Edward Topsell began an abridged translation of Aldrovandi's bird volumes into English, but only completed accounts of 37 species, which are arranged in alphabetical order, from Alcatraz (pelican) to Cuckoo. This fragment, excepting the already published discussion of chickens, is now published (Topsell 1972).

In his account of crows, Aldrovandi revived the ancient concept of the balance of nature (Topsell 1972:222):

*Why some lyving Creatures breede many, and other[s] fewe, this is thought to be the reason. God in nature hath so provided, that those lyving Creatures which lyve and last but a litle while, shoulde breede many, that the shortnes of their dayes might be recompenced with the number of posteritie. But Ravens, Crowes, and Hartes bringe forth fewe, and breede very slowlie because the leingth of their oune life giveth perpetuities of conservation to their kind. Therefore also such as lyve a moderate age are also moderatelie fruitfull, both amonge birds, beasts, hearbes, and plants.*

If there is anything original in this discussion, it is that the principle applies to plants as well as to animals (Egerton 1973:2001).

There are conflicting judgments on the quality of Aldrovandi's work. His reputation was immense during his lifetime, but by 1628 Fabio Colonna severely criticized both the content and publication of one of his volumes, apparently *De mollibus, crustaceis, testaceis, et zoophytis* (1606), which, of course, was one of the posthumously edited volumes (Findlen 1994:76). However, the illustrations from his bird volumes (e.g., Fig. 12) were still influential a century after their publication (Ellenius 1997). Buffon in 1749 acknowledged that there was value in his accounts, but said the valuable parts "were only a tenth of the whole, while the rest is monotonous and oppressive" (1954:15;



**Fig. 12.** Hawk and snake. Aldrovandi, *Ornithologiae* 1599–1603 (Allen 1951:405).

English translation in Aldrovandi 1963:xxix). The modern reader can sympathize with Buffon's reactions, but when Aldrovandi wrote, there was still a strong interest in cultural associations with animals, to which Aldrovandi catered (Ashworth 1996:33–35, Thorndike 1941:276–278). Cuvier's comments in 1828 were mixed, but slightly negative: "As regards fishes in particular, Aldrovandi and his editor Uterverius [published 1613] hardly did anything but abridge the work of Gessner, reduce it to their own plan, and add to the illustrations they took from it a certain number of new illustrations, among which are in fact several made after nature and that have some value, although roughly engraved in wood" (1995:46). In short, his immense amount of work carried the natural history of animals only slightly beyond Gessner (Petit and Théodoridès 1962:262–266, Ley 1968:152–161, 273), and his few references to Gessner never acknowledged him as his main source, preferring instead to emphasize his own superior organization (Stresemann 1975:22).

Only Vesalius was truly revolutionary, in that he (like Copernicus) made a part of ancient science obsolete, but the naturalists who contributed to vertebrate zoology during the 1500s corrected and expanded ancient and medieval knowledge in many significant ways, and they used the printing press effectively to disseminate their findings.

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