

CHRONICLE OF ZOOLOGICAL CLASSIFICATION OF MAMMALS

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Introduction. The interest of humans in grouping animals has been an issue since before Christian times. Grouping animals based on their relationship to humans is probably the most primitive sign of classification (e.g., edible or inedible, dangerous or docile, wild or domestic, and so on). Officially, the International Code of Zoological Nomenclature, Article 3, establishes the beginning of zoological nomenclature to be January 1, 1758, marked by the tenth edition of Linnaeus's "Systema Naturae." This edition utilizes the application of binomial nomenclature in zoological taxonomy and is considered as Carl von Linne's greatest contribution to this field. Prior to this time, other individuals had proposed methods of animal classification, but most classification schemes proposed before the 17th century were confused and unsatisfactory. The classification criterion varies between authors, although most of the groupings were based on anatomical and morphological characteristics of the animals in question. The number of existing species at the time of proposed classification systems also varies, e.g., Zoological Record volumes 115-134, published in 1981 through 1998, respectively, report a new taxa count of 6,363 mammalian names, 3,972 of which are at the species level, and 1,356 at the genera level. Furthermore, classifications have taken fossils into account in mammalian groupings, and as they are discovered, included them at different points in time.

Objective. The primary goal of this paper is to review influential classification attempts, discuss the different criteria used, and indicate the changes and modifications made from past classification schemes to modern times. Particular emphasis will be placed on demonstrating how the present method of zoological classification is of limited value to the zoo nutritionist and in assessing the nutritional needs of captive animals. Upon review of past and present classification, three major differential factors are prominent, and partially responsible for the variations between classification. These factors should be kept in mind during the discussion section, and are as follows: [1] discovery of new species or extinction of others that influence which animals are classified by different authors, [2] concepts or theories contemporary to the author that may affect his/her perception (e.g., non-evolution theory vs. Darwin's natural selection theory), and [3] broad range of seemingly unrelated variables used to group mammals (e.g., possessing a pouch, egg layers, length of proboscis, structure of hoof, dentation, flight, scaly surface, prehensile digits, and other).

Review and Discussion. One of the earliest attempts of classification was conducted by Greek philosopher Aristotle (384-322 BC), who grouped living organisms as plants (i.e., plants and fungi) and animals. Aristotle directed his focus on feet and teeth characteristics, and in his later publications, started relating his observations and referring to similarities across different species for function and behavior. For approximately the next 1,500 years little work was conducted on classification. There are some indications that Wotton, 1552 (Gregory, 1910), proposed to divide viviparous by their foot structure, resulting in three groups: many-toed, doubled hoofed, and single hoofed and he also

suggested distinguishing whales from the fish class. But after Aristotle, the succeeding major contribution was attributed to Rev. John Ray (1627-1705), an English naturalist, who applied the principal of plant classification known as “Excluded Middle”. This principle (everything is either “A” or “not A”), is a strict application of a single set of characters, typical in all artificial systems. This classification system proposed a first division of animals in general by existence of blood or lack thereof. The animals identified as “bloodless” are what we now call invertebrates. The subsequent criteria were respiratory system, followed by heart and reproduction method, respectively (Table 1). Concerning mammals, identified by Ray as the viviparous quadrupeds group, the suggested ordinal classification was based on characteristics of extremities (i.e., hoofed or clawed, divided or undivided, number of digits); the number of front teeth was also used as criterion.

Following Ray’s advances, Carl von Linne (Carolus Linnaeus) is considered one of the major contributors to zoological classification. His 10th Edition of “Systema Naturae” (1758) is considered the starting point of zoological nomenclature, by the introduction of binomial nomenclature, i.e., the scientific name given to species. The term “Mammalia” is attributed to Linnaeus, in which he included hairy quadrupeds and the Cetacea group. His classification lists orders in a linear series, and the utilized grouping criteria were as follow: [1] teeth number, specifically what he called “front teeth,” [2] feet structure (e.g., hoofed, cloven = order pecora; claws on the feet acute = order ferae), [3] what he called “sustenance,” which could be interpreted as diet or feeding behavior (e.g., sustenance by pulling up plants and chewing the cud = order pecora; sustenance by rapine, upon carcasses ravenously snatched = order ferae; sustenance by gnawing bark, roots, vegetables, etc. = order glires). The 12th edition of “Systema Naturae,” 1766, classified mammals in seven orders and consisted of the following families. Order Primates: *Homo*, *Simia*, *Lemur*, *Vespertilio*; order Bruta: *Elephas*, *Trichechus*, *Bradypus*, *Myrmecophaga*, *Manis*, *Dasybus*; order Ferae: *Phoca*, *Canis*, *Felis*, *Viverra*, *Mustela*, *Ursus*, *Didelphis*, *Talpa*, *Sorex*, *Erinaceus*; order Glires: *Hystrix*, *Lepus*, *Castor*, *Mus*, *Sciurus*, *Noctilio*; order Pecora: *Camelus*, *Moschus*, *Cervus*, *Capra*, *Ovis*, *Bos*; order Belluae: *Equus*, *Hippopotamus*, *Sus*, *Rhinoceros*; and order Cete: *Monodon*, *Balaena*, *Physeter*, *Delphinus* (McKenna and Bell, 1997). To be able to compare modern classification to Linnaeus 12th edition of Systema Naturae, Table 2 and the following descriptions and comments can be useful.

In the order Primate: *Vespertilio* is the family under which Linnaeus grouped all bats, now classified under Chiroptera. The other families proposed by Linne are primates as we know them now.

In order Bruta: *elephas* are now classified under order Proboscidea and represent the Asian elephant. *Trichechus* are manatees, now classified as Sirenia. *Bradypus* is the three-toed sloth, which was classified as Edentata and is presently classified under the order Xenarthra (McKenna and Bell, 1997 and Novak, 1999). *Myrmecophaga* is an ant eater, now also classified under order Xenarthra.

In Linnaeus order Ferae: *Phoca* represents harbor seal, ringed seal, harp seal and ribbon seal. McKenna and Bell (1997) grouped these animals under the Carnivora order. In Novak (1999) they are classified under Pinnipedia. *Sorex* is now classified under Insectivora (Novak, 1999) and consists of long-tailed shrews. *Talpa* is the common old

world mole, now classified under Insectivora (Novak, 1999) and under lipothyha in McKenna and Bell (1997).

In the order Cete: *monodon* are narwhal, *balaena* are right and bowhead whales, *physeter* are sperm whales, *delphinus* are common dolphinsdolphins. It is important to note that this order is not much different than the one we know now as Cetacea, with the obvious inclusion of new species, not identified in 1766.

For order Glires: *castor* are beavers, now classified under rodents. *Noctilio* are bats, now classified under Chiroptera. *Hystrix* are old world porcupine, currently classified under the order Rodentia.

In the order Belluae: *Sus* consists of pigs, hogs and boars and is now classified under Artiodactyla. Linnaeus included hippopotamus in this order, which now are also Artiodactyla. He included *Equus* (horses) and rhinoceros under this order, both of which are now classified under the order Perissodactyla.

There have been other contributors to zoological classification like Jean-Baptiste de Lamarck (1744-1829), George Cuvier (1769-1832), Henri Marie Ducrotay De Blainville (1777-1850), Richard Owen (1804-1892), Louis Agassiz (1807-1873), Thomas Henry Huxley (1825-1895), Theodore Gill (1837-1914) and other. Excellent comprehensive historical review on classification work of these authors and others have been published by Gregory (1910) and Simpson (1945) and hence not covered herein.

Each order has a long history and has gone through many modifications since its origin. The following are some examples of the origin and history of two orders, Chiroptera and Sirenia. Chiroptera (bat families): this name was proposed by Blumenbach in 1779 (authorship), but it was Gray, 1821 who proposed this group of animals as a class, under the name of Chiroptera. It is interesting to note, that the non-linnean suggested classification by Aristotle (330 BC) referred to this group as Dermaptera. Sirenia (Dugong, sea cow and manatees): Illiger, 1811, is attributed authorship and proposed this group as a family under the order Natantia, but it was Gill, 1872, that used it as an order. Haeckel, 1866, called this group Phycoceta, and listed it as a suborder of Cetacea. Hay, 1923, proposed it as a suborder under the name of Trichechiformes.

Even in the past few years there are deviations of where mammalian species are classified. In McKenna and Bell (1997), Dermoptera (single live family is cynocephalus = gliding lemurs, flying lemurs, colugos, cobegos, kaguan, kubuk) is published as an suborder of the order Primates. In Novak (1999) it is listed as an separate order.

For a in depth look on changes within the taxonomical classification, we have selected several mammalian orders (*Monotremata*, *Marsupialia*, *Primate*, *Carnivora*, *Perissodactyla*, and *Artiodactyla*) and tabulated their change throughout time. For this purpose we used five Editions of "Walker's Mammals of the World" (1964, 1975, 1983, 1991, and 1999) (Table 3). Marsupial is the order which has undergone the most changes, especially between the 1991 and the 1999 editions. *Monotremata* and *Perissodactyla* have remained unchanged since 1964. *Carnivora* and *Artiodactyla* each had a family added between 1991 and 1999. The order *Primates* was modified in 1983, 1991 and 1999 publications. The criteria for these modifications vary. For example, the formation of the family *Herpestidae*, under the order *Carnivora*, was based on animal size, body length, limb length, type of claw, type of anal scent glands, and other.

The current development and use of molecular technology will represent even another criterion for classification, focusing on the genetic origin of species, and alterations in the classification as we know it are expected.

Conclusion. The above review is intended to demonstrate how the classification of mammals has evolved and how complex and detailed it has become, while remaining still incomplete. Despite the inclusion of several criteria, i.e. body size, dental formula, anatomical structures and several other, we have yet to find a grouping in which nutrition or diet is the primary factor. A possible cause of not having used nutritional parameters in prior classifications could be due to the variability of diets. Not only by species, but also by geographical location and evolutionary trends observed in feeding behavior due to environment.

As a nutritionist, the past and present mammalian classification systems do not provide information on feeding or aid in the determination of feeding regimes. It would be presumptuous of us to believe we have discovered all existing species on this planet, nor are we suggesting that modifications or changes within the existing species will not occur. We do believe there is enough data and observations on animals that have been classified to extract nutritional information and parameters in order to develop an alternative grouping of mammals in terms of nutrition. This would provide helpful information to feed these animals in captivity.

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Table 1. Table “Animalium Tabula generalis” published by Rev. John Ray in “Synopsis Methodica Animalium Quadrupedum et Serpentina Generis”, 1686 (Gregory, 1910). Translated and interpreted by authors of this paper.

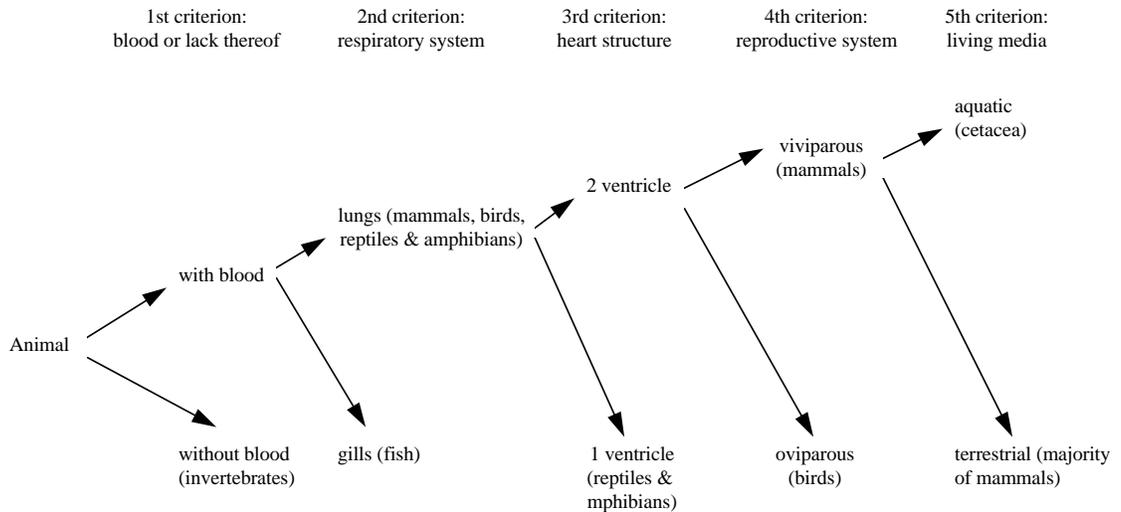


Table 2. Linnaeus “Systema Naturae”, 1766, 12th Edition (McKenna and Bell, 1997) Description of some species and current classification of the animals in question. (Novak, 1999).

Linnaeus orders	Linnaeus family	Animal description	Current order
Primates	Homo	Humans	Primates
Primates	Lemur	Lemurs	Primates
Primates	Vespertilio	Bats	Chiroptera
Bruta	Elephas	Asian Elephant	Proboscidea
Bruta	Trichechus	Manatee	Sirenia
Bruta	Bradypus	Three-toed sloth	Xenarthra
Bruta	Myrmecophaga	Ant eater	Xenarthra
Bruta	Dasypus	Long-nosed Armadillo	Xenarthra
Ferae	Talpa	Common old world mole	Insectivora
Ferae	Sorex	Long-tailed shrew	Insectivora
Ferae	Phoca	Harbor, harp, ribbon, ringed seal	Pinnipedia
Ferae	Canis	Wolves, fox, and allies	Carnivora
Ferae	Ursus	Bears	Carnivora
Ferae	Didelphis	Large american opossum	Didelphimorphia
Glires	Hystrix	Old world porcupine	Rodents
Glires	Noctilio	Bat	Chiroptera
Glires	Castor	Beavers	Rodents
Pecora	Camelus	Camels	Artiodactyla
Pecora	Moschus	Musk deer	Moschidae
Pecora	Capra	Goats	Artiodactyla
Belluae	Eqvus	Horses	Perissodactyla
Belluae	Hippopotamus	Hippopotamus	Artiodactyla
Belluae	Sus	Pigs and Hogs	Artiodactyla
Cete	Monodon	Narwhal	Cetacea
Cete	Balaena	Right whale, bowhead	Cetacea

Table 3. Comparison of several zoological orders, published in five editions of “Walker’s Mammals of the World”

Order	1964 Family	1975 (3rd Edition) Family	1983 (4th Edition) Family	1991 (5th Edition) Family	1999 (6th Edition) Family
monotremata	tachyglossidae	tachyglossidae	tachyglossidae	tachyglossidae	tachyglossidae
	ornithorynchidae	ornithorynchidae	ornithorynchidae	ornithorynchidae	ornithorynchidae
marsupialia	didelphidae	didelphidae	didelphidae	didelphidae	classified under new order
			microbiotheriidae	microbiotheriidae	classified under new order
	dasyuridae	dasyuridae	dasyuridae	dasyuridae	classified under new order
			thylacinae	thylacinae	classified under new order
	myrmecobiidae	myrmecobiidae	myrmecobiidae	myrmecobiidae	classified under new order
	notoryctidae	notoryctidae	notoryctidae	notoryctidae	classified under new order
	peramelidae	peramelidae	peramelidae	peramelidae	classified under new order
			thylacomyidae	thylacomyidae	classified under new order
	caenolestidae	caenolestidae	caenolestidae	caenolestidae	classified under new order
	phalangeridae	phalangeridae	phalangeridae	phalangeridae	classified under new order
			phascolarctidae	phascolarctidae	classified under new order
			petauridae	petauridae	classified under new order
			burramyidae	burramyidae	classified under new order
			tarsipedidae	tarsipedidae	classified under new order
	phascolomyidae	phascolomyidae	vombatidae	vombatidae	classified under new order
	macropodidae	macropodidae	macropodidae	macropodidae	classified under new order
primate	tupaiae	tupaiae	tupaiae	new order (all) = scandentia	scandentia
	lemuridae	lemuridae	lemuridae	lemuridae	lemuridae
			lepilemuridae	megaladapidae (+ extinct genus)	megaladapidae
			cheirogaleidae	cheirogaleidae	cheirogaleidae
	indridae	indridae	indridae	indridae	indridae
					palaeopropithecidae (all extinct)
					archaeolemuridae (all extinct)
	daubentoiidae	daubentoiidae	daubentoiidae	daubentoiidae	daubentoiidae
	lorsidae	lorsidae	lorsidae	lorsidae	lorsidae
	tarsiidae	tarsiidae	tarsiidae	tarsiidae	tarsiidae
	cebiidae	cebiidae	cebiidae	cebiidae	cebiidae
	callitricidae	callitricidae	callitricidae	callitricidae	callitricidae
	cercopitheciidae	cercopitheciidae	cercopitheciidae	cercopitheciidae	cercopitheciidae
	pongidae	pongidae	pongidae	pongidae	pongidae
			hylobatidae	hylobatidae	hylobatidae
	hominidae	hominidae	hominidae	hominidae	hominidae

Table 3. Comparison of several zoological orders, published in five editions of “Walker’s Mammals of the World”

Order	1964 Family	1975 (3rd Edition) Family	1983 (4th Edition) Family	1991 (5th Edition) Family	1999 (6th Edition) Family
carnivores	canidae	canidae	canidae	canidae	canidae
	ursidae	ursidae	ursidae	ursidae	ursidae
	procyonidae	procyonidae	procyonidae	procyonidae	procyonidae
	mustelidae	mustelidae	mustelidae	mustelidae	mustelidae
	viverridae	viverridae	viverridae	viverridae	viverridae
					herpestidae
	hyaenidae	hyaenidae	hyaenidae	hyaenidae	hyaenidae
	felidae	felidae	felidae	felidae	felidae
perissodactyla	equidae	equidae	equidae	equidae	equidae
	tapiridae	tapiridae	tapiridae	tapiridae	tapiridae
	rhinocerotidae	rhinocerotidae	rhinocerotidae	rhinocerotidae	rhinocerotidae
artiodactyla	suidae	suidae	suidae	suidae	suidae
	tayassuidae	tayassuidae	tayassuidae	tayassuidae	tayassuidae
	hippotamidae	hippotamidae	hippotamidae	hippotamidae	hippotamidae
	camelidae	camelidae	camelidae	camelidae	camelidae
	tragulidae	tragulidae	tragulidae	tragulidae	tragulidae
	cervidae	cervidae	cervidae	cervidae	cervidae
					moschidae
	giraffidae	giraffidae	giraffidae	giraffidae	giraffidae
	antilocapridae	antilocapridae	antilocapridae	antilocapridae	antilocapridae
	bovidae	bovidae	bovidae	bovidae	bovidae