

A Re-Evaluation of Allometric Relationships for Circulating Concentrations of Glucose in Mammals

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Abstract

Purpose: The present study examined the putative relationship between circulating concentrations of glucose and \log_{10} body weight in a large sample size (270) of wild species but with domesticated animals excluded from the analyses. **Methods:** A data-set of plasma/serum concentration of glucose and body weight in mammalian species was developed from the literature. Allometric relationships were examined. **Results:** In contrast to previous reports, no overall relationship for circulating concentrations of glucose was observed across 270 species of mammals (for \log_{10} glucose concentration adjusted $R^2 = -0.003$; for glucose concentration adjusted $R^2 = -0.003$). In contrast, a strong allometric relationship was observed for circulating concentrations of glucose in *Primates* (for \log_{10} glucose concentration adjusted $R^2 = 0.511$; for glucose concentration adjusted $R^2 = 0.480$). **Conclusion:** The absence of an allometric relationship for circulating concentrations of glucose was unexpected. A strong allometric relationship was seen in *Primates*.

Keywords

Glucose, Allometric, Mammals, Primates

1. Introduction

Glucose in the blood is the principal energy source for brain functioning and but glucose can be used as the energy source for multiple other tissues. A relationship between metabolic rate and circulating concentration of glucose has been reported [1] with higher blood concentration of glucose with increasing metabolic rates in across vertebrates. Moreover, there is a negative relationship between blood concentrations of glucose and body weight (log) in mammals (blood: [2]; serum: [3]). In birds, an allometric relationship for circulating concentra-

tions of glucose was reported in one study (blood: [4]) but not in another (plasma/serum: [5]). This leads us to question whether an allometric relation for circulating concentrations of glucose, in fact, exists in mammals. The presence of such a relationship would be consistent with the relationship between basal metabolic rate being proportional to either the body weight to the power two thirds (2/3) (reviewed: [6]) or three quarters (3/4) [7] [8].

What is not clear is whether the supposed relationship between circulating concentrations of glucose and log body weight is real reflecting a true allometric relationship (and reduced needs for energy in larger animals) or represents an artifact of species included in previous analyses and the inclusion of domesticated animals in the analyses. Domesticated animals have been selected for growth and larger body size and consequently lower circulating concentrations of glucose [9]. There are also marked phylogenetic differences in circulating concentrations of glucose within the Class *Mammalia* [10]. The present study re-examines the relationship between circulating concentrations of glucose and body weight in mammals with a large sample size (270) of wild species but with domesticated animals excluded from the analyses.

2. Materials and Methods

2.1. Databases

A database was assembled for serum/plasma concentrations of glucose in wild species of mammals using the published or calculated mean for the species based on rigorous and systematic series of searches of the literature [10] together with body weights principally from the Animal Diversity Web. This is presented in **Table 1**.

Table 1. Database of plasma/serum concentrations of glucose (from [11]) and log body weight).

		Species	
		Glucose (mM)	Log B.Wt.
Platypus	<i>Ornithorhynchus anatinus</i>	4.3	3.217
Short-beaked Echida	<i>Tachyglossus aculeatus</i>	4.2	3.653
Western Quoll	<i>Dasyurus geoffroii</i>	6.2	3.041
American Woolly Opossum	<i>Caluromys derbianus</i>	5	2.489
Grayshort-tailed Opossum	<i>Monodelphis domestica</i>	5.3	2.088
Common Opossum	<i>Didelphis marsupialis</i>	5.1	3.185
Virginia Opossum	<i>Didelphis virginiana</i>	4.8	3.597
Common Wallaroo	<i>Macropus robustus</i>	4.8	4.477
Red Kangaroo	<i>Macropus rufus</i>	4.7	4.954
Tammar Wallaby	<i>Macropus eugenii</i>	5.2	3.878
Brush-tailed Rock-Wallaby	<i>Petrogale penicillata</i>	6.2	3.872
Quokka	<i>Setonix brachyurus</i>	4.3	3.538
Tasmanian Pademelon	<i>Thylogale billardierii</i>	4.5	3.86
Common Brush-tail Possum	<i>Trichosurus vulpecula</i>	7.62	3.455
Mountain Brushtail Possum	<i>Trichosurus cunninghami</i>	6.8	3.544
Gilbert's Potoroo	<i>Potorous gilbertii</i>	9.1	3.296
Sugar Glider	<i>Petaurus breviceps</i>	4.2	2.041
Northern Hairy-nosed Wombat	<i>Lasiorhinus krefftii</i>	8	4.512
Southern Hairy-nosed Wombat	<i>Lasiorhinus latifrons</i>	6.2	4.407
Lesser Hedgehog tenrec	<i>Echinops telfairi</i>	4.4	2.301
Rock Hyrax	<i>Procavia capensis</i>	3.7	3.58
African Elephant	<i>Loxadonta africana</i>	4.6	6.638
Asian Elephant	<i>Elephas maximus</i>	5.55	6.602
West Indian Manatee	<i>Trichechus manatus</i>	4.55	5.681
Aardvark	<i>Orycteropus afer</i>	5.1	4.785

Continued

Nine-banded armadillo	<i>Dasybus novemcinctus</i>	3.4	3.752
Three-Banded armadillo	<i>Tolypeutes matacus</i>	4.8	3.176
Gilbert's Potoroo	<i>Potorous gilbertii</i>	9.1	3.296
Sugar Glider	<i>Petaurus breviceps</i>	4.2	2.041
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Three-Banded armadillo	<i>Tolypeutes matacus</i>	4.8	3.176
Brown-throated Three-toed Sloth	<i>Bradypus variegatus</i>	5.5	3.6375
Hoffmann's Two-Toed Sloths	<i>Choloepus hoffmanni</i>	3	3.778
Southern Two -toed Sloth	<i>Choloepus didactylus</i>	1.2	3.778
Giant Anteater	<i>Myrmecophaga tridactyla</i>	4.6	4.548
European Hedgehog	<i>Erinaceus europaeus</i>	6	3
Four-toed Hedgehog	<i>Atelerix albiventris</i>	5.1	2.778
South African Hedgehog	<i>Atelerix frontalis</i>	7.4	2.547
Japanese Shrew Mole	<i>Urotrichus talpoide</i>	8.7	1.083
Least Shrew	<i>Cryptotis parva</i>	7.1	0.653
Old World Mole	<i>Talpa europaea</i>	9.1	2
Pallas's Mastiff Bat	<i>Molossus molossus</i>	5.8	1.079
Great Fruit-eating Bat	<i>Artibeus lituratus</i>	6.9	1.813
Common Vampire Bat	<i>Desmodus rotundus</i>	4.9	1.477
Malaysian Flying-fox	<i>Pteropus vampyrus</i>	6.65	3.929
Rodriguez Island Flying-fox	<i>Pteropus rodricensis</i>	6.5	2.512
Egyptian Fruit-bat	<i>Rousettus aegyptiacus</i>	6	2.097
Wahlberg's Epauletted Fruit-bat	<i>Epomophorus wahlbergi</i>	5.2	1.903
Small Flying-fox	<i>Pteropus hypomelanus</i>	6.9	2.717
Red Panda	<i>Ailurus fulgens</i>	6.4	3.695
Striped Skunk	<i>Mephitis mephitis</i>	13.3	3.544
Raccoon	<i>Procyon lotor</i>	3.6	3.7853
Kinkajou	<i>Potos flavus</i>	5.5	3.5185
Ringtail	<i>Bassariscus astutus</i>	6.3	3.0338
South American Coati	<i>Nasua nasua</i>	5.6	3.6532
White-nosed Coati	<i>Nasua narica</i>	5.4	3.6021
Eurasian otter	<i>Lutra lutra</i>	5.6	3.8293
North American river otter	<i>Lontra Canadensis</i>	5.9	3.9778
Sea Otter	<i>Enhydra lutris</i>	6.9	4.4698
Giant Otter	<i>Pteronura brasiliensis</i>	5.6	4.3802
American Marten	<i>Martes Canadensis</i>	13	3.677

Continued

American Mink	<i>Mustela vison</i>	6.9	3.061
European Badger	<i>Meles meles</i>	6.1	4.066
European Polecat	<i>Mustela putorius</i>	9.3	2.9811
Walrus	<i>Odobenus rosmarus</i>	5.4	6.0212
Australian Sea Lion	<i>Neophoca cinerea</i>	4.3	5.3064
California Seal Lion	<i>Zalophus californianus</i>	7.5	5.2844
Northern Fur Seal	<i>Callorhinus ursinus</i>	5.8	5.23
Harbor Seal	<i>Phoca vitulina</i>	10.5	5.061
Harp Seal	<i>Phoca groenlandica</i>	9.8	5.105
Hooded Seal	<i>Cystophora cristata</i>	7.1	5.362
Northern Elephant Seal	<i>Mirounga angustirostris</i>	5.8	6.161
American Black Bear	<i>Ursus americanus</i>	4	5.35
Brown Bear	<i>Ursus arctos</i>	6.65	5.531
Malayan Sun Bear	<i>Helarctos malayanus</i>	5.2	4.663
Giant Panda	<i>Ailuropoda melanoleuca</i>	5.1	5.011
Sloth Bear	<i>Melursus Ursinus</i>	5.1	4.989
Spectacled Bear	<i>Tremarctos Ornatus</i>	5.7	5.114
Polar Bear	<i>Ursus aritimus</i>	6.2	5.677
Binturong	<i>Arctictis binturong</i>	7.1	4.161
Canada Lynx	<i>Lynx canadensis</i>	7.6	4.037
Eurasian Lynx	<i>Lynx lynx</i>	7.4	4.431
European Wildcat	<i>Felis silvestris</i>	9.3	3.628
Sand Cat	<i>Felis margarita</i>	8.2	3.38
Bobcat	<i>Felis rufus</i>	7.2	3.978
Cougar	<i>Felis concolor</i>	8.35	4.872
Iriomote Cat	<i>Felis iriomotensis</i>	9.1	3.568
Jaguar	<i>Panthera onca</i>	4.6	5.009
Tiger	<i>Panthera tigris</i>	7.1	5.41
Cheetah	<i>Acinonyx jubatus</i>	6.5	4.667
Egyptian Mongoose	<i>Herpestes ichneumon</i>	9.7	3.458
Slender-tailed Meerkat	<i>Suricata suricatta</i>	6.8	2.86
Dwarf mongoose	<i>Helogale parvula</i>	7.6	2.439
Aardwolf	<i>Proteles cristata</i>	6	4.041
Spotted Hyena	<i>Crocuta crocuta</i>	7.2	4.796
Striped Hyena	<i>Hyaena hyaena</i>	6.1	4.544
Hunting Dog	<i>Lycaon pictus</i>	6.8	4.431
Grey Wolf	<i>Canis lupus</i>	5.6	4.712
Coyote	<i>Canis latrans</i>	8.2	4.14
Golden Jackal	<i>Canis aureus</i>	6.6	3.954
Maned Wolf	<i>Chrysocyon brachyurus</i>	5.9	2.86
Crab-eating Fox	<i>Cerdocyon thous</i>	13.7	2.439
Ranch Gray Fox	<i>Urocyon cinereoargenteus</i>	7.6	4.041
Raccoon Dog	<i>Nyctereutes procyonoides</i>	3.3	3.845
Kit Fox	<i>Vulpes macrotis</i>	7.2	3.342

Continued

Swift Fox	<i>Vulpes velox</i>	5.6	3.398
Red Fox	<i>Vulpes fulva</i>	7.6	4.045
Fossa	<i>Cryptoprocta ferox</i>	7.8	4.796
African Wild Ass	<i>Equus africanus</i>	4.1	4.544
Grevy's Zebra	<i>Equus grevyi</i>	6	4.431
Mountain Zebra	<i>Equus zebra</i>	6.9	4.712
Ongar	<i>Equus hemionus</i>	9	4.14
Przewalski horse	<i>Equus przewalski</i>	7.2	3.954
Plains Zebra	<i>Equus quagga</i>	8.8	5.439
Black Rhinoceros	<i>Diceros bicornis</i>	4.9	6.041
Indian Rhinoceros	<i>Rhinoceros unicornis</i>	4.6	6.243
Sumatran Rhinoceros	<i>Dicerorhinus sumatrensis</i>	4.2	6.146
White Rhinoceros	<i>Ceratotherium simum</i>	4.7	6.401
Baird's Tapir	<i>Tapirus bairdii</i>	4.8	5.352
Brazilian Tapir	<i>Tapirus terrestris</i>	4.3	5.301
Malayan Tapir	<i>Tapirus indicus</i>	5.6	5.597
Mountain Tapir	<i>Tapirus pinchaque</i>	6.4	5.201
Barking Deer	<i>Muntiacus muntjak</i>	5.2	4.407
Eld's Deer	<i>Panolia eldii</i>	6.62	5
Elk	<i>Cervus canadensis</i>	8.7	5.45
Red Deer	<i>Cervus elaphus</i>	9.71	5.204
Fallow Deer	<i>Dama dama</i>	7.02	4.74
Chital deer	<i>Axis axis</i>	7.4	4.72
Moose	<i>Alces alces</i>	7.8	5.716
White-tailed Deer	<i>Odocoileus virginianus</i>	10.1	4.987
Père David's Deer	<i>Elaphus davidianus</i>	11.2	5.271
Pudú	<i>Pudu pudu</i>	5.7	5
Caribou	<i>Rangifer tarandus</i>	8.3	5.271
Roe Deer	<i>Capreolus capreolus</i>	10	4.414
Rusa Deer	<i>Cervus timorensis</i>	4.5	5.061
Sambar Deer	<i>Cervus unicolor</i>	8.5	5.234
Pronghorn	<i>Antilocapra americana</i>	13.2	4.767
Impala	<i>Aepyceros melampus</i>	7.55	4.72
Cuvier's Gazelle	<i>Gazella cuvieri</i>	4.5	4.544
Dama Gazelle	<i>Gazella dama</i>	6.4	4.74
Dorcas Gazelle	<i>Gazella dorcas</i>	7	4.243
Goitered Gazelle	<i>Gazella subgutturosa</i>	5	4.481
Grant's Gazelle	<i>Gazella granti</i>	10.2	4.746
Springbok	<i>Antidorcas marsupialis</i>	8.4	4.597
Brindled Wildebeest	<i>Connochaetes taurinus</i>	7.35	5.288
Black Wildebeest	<i>Connochaetes gnou</i>	9.3	5.161
Bontebok	<i>Damaliscus dorcas</i>	6.5	4.829
Bongo	<i>Tragelaphus eurycerus</i>	6.2	5.488
Common Eland	<i>Taurotragus oryx</i>	10.3	5.813

Continued

Nilgai	<i>Boselaphus tragocamelus</i>	7.9	5.25
Greater Kudu	<i>Tragelaphus strepsiceros</i>	9.2	5.337
Water Buffalo	<i>Bubalus bubalis</i>	3.2	5.628
American Bison	<i>Bison bison</i>	8.4	5.787
European Bison	<i>Bison bonasus</i>	6.8	5.954
Bushbuck	<i>Tragelaphus scriptus</i>	5.1	4.721
Lesser Kudu	<i>Ammelaphus imberbis</i>	10	4.916
Barbary Sheep	<i>Ammotragus lervia</i>	10.3	5.021
Spanish Ibex	<i>Capra pyrenaica</i>	10.3	4.76
Southern Chamois	<i>Rupicapra pyrenaica</i>	6.8	4.568
Rocky Mountain Bighorn Sheep	<i>Ovis Canadensis</i>	8.7	4.954
Stone Sheep	<i>Ovis dalli</i>	11.7	4.9
Mouflon	<i>Ovis orientalis</i>	8.9	4.628
Maxwell's Duiker	<i>Philantomba maxwellii</i>	7.1	3.778
Adax Antelope	<i>Addax nasomaclatus</i>	5.2	4.996
Gemsbok Oryx	<i>Oryx gazella</i>	10.7	5.322
Scimitar-horned Oryx	<i>Oryx dammah</i>	14	5.301
Roan Antelope	<i>Hippotragus equinus</i>	11.3	5.419
Sable Antelope	<i>Hippotragus niger</i>	8.7	5.36
Waterbuck	<i>Kobus ellipsiprymnus</i>	10.45	5.362
Lechwe	<i>Kobus leche</i>	10.3	4.977
Mountain Reedbuck	<i>Redunca fulvorufula</i>	9.6	4.477
Mrs Gray's Waterbuck	<i>Kobus megaceros</i>	7.2	4.954
Guanaco	<i>Lama guanicoe</i>	7.6	5.061
Giraffe	<i>Giraffa camelopardalis</i>	9	6.192
Okapi	<i>Okapia johnstoni</i>	8	5.398
Hippopotamus	<i>Hippopotamus amphibius</i>	7.5	6.462
Pygmy Hippopotamus	<i>Choeropsis liberiensis</i>	8.6	4.337
Buru babirusa	<i>Babyrousa babyrussa</i>	6	4.854
Red River Hog	<i>Potamochoerus porcus</i>	4.5	4.944
Warthog	<i>Phacochoerus africanus</i>	4.5	5
Wild Boar	<i>Sus scrofa</i>	9.3	5.228
Collared Peccary	<i>Tayassu tajacu</i>	6.1	4.301
Chacoan Peccary	<i>Catagonus wagneri</i>	6.1	4.591
Bryde's Whale	<i>Balaenoptera edeni</i>	8.4	7.162
Bowhead Whale	<i>Balaena mysticetus</i>	5.3	7.9
Dall Porpoise	<i>Phocoenoides dalli</i>	7.7	5.243
Finless Porpoise	<i>Neophocaena phocaenoides</i>	7.85	4.845
Gray Whale	<i>Eschrichtius robustus</i>	5.4	7.161
Amazon River Dolphin	<i>Inia geoffrensis</i>	6.7	5.151
Commerson's Dolphin	<i>Cephalorhynchus commersonii</i>	5.5	4.699
Bottlenose Dolphin	<i>Tursiops truncatus</i>	6.3	5.58
Common Dolphin	<i>Delphinus delphius</i>	5.8	5.072
False Killer Whale	<i>Pseudorca crassidens</i>	6.3	6.482

Continued

Killer Whale	<i>Orcinus orca</i>	8.95	6.857
Pacific White-sided Dolphin	<i>Lagenorhynchus obliquidens</i>	6.65	5.013
Pilot Whale	<i>Globicephala macrorhynchus</i>	8.1	6.342
Spotted Dolphin	<i>Stenella attenuata</i>	7.7	4.954
Beluga whale	<i>Delphinapterus leucas</i>	6.4	6.154
Brazilian Porcupine	<i>Coendou prehensilis</i>	5.5	3.7
Black-tailed Hairy Dwarf Porcupine	<i>Coendou melanurus</i>	3.95	3.279
Coypu	<i>Myocastor coypus</i>	8.9	3.875
Greater Cane Rat	<i>Thryonomys swinderianus</i>	5.15	3.374
Dusky-footed Wood Rat	<i>Neotoma fuscipes</i>	6.4	2.366
Meadow Vole	<i>Microtus pennsylvanicus</i>	5.7	1.69
Pine Vole	<i>Microtus pinetorum</i>	5.6	1.407
Norwegian Lemming	<i>Lemmus lemmus</i>	7.3	1.875
Muskrat	<i>Ondatra zibethicus</i>	13.4	2.945
Central Rock-rat	<i>Zyomys pedunculatus</i>	3.8	1.978
House Mouse	<i>Mus musculus domesticus</i>	5.05	1.322
Libyan Jird	<i>Meriones libycus</i>	6.4	1.929
Persian Jird	<i>Meriones persicus</i>	6.7	2.061
Short-tailed Bandicoot Rat	<i>Nesokia indica</i>	6.7	2.456
Indian Gerbil	<i>Tatera indica</i>	5.9	2
Norway Rat	<i>Rattus norvegicus</i>	6.3	2.505
Sand Rat	<i>Psammomys obesus</i>	4.3	1.574
Kangaroo Rat	<i>Dipodomys merriami</i>	14.3	1.653
Gray squirrel	<i>Sciurus carolinensis</i>	7.7	2.736
Thirteen-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>	9	2.097
White-Tailed Prairie Dog	<i>Cynomys leucurus</i>	8	3.075
Guinea Pig	<i>Cavia porcellus</i>	6.7	2.954
Long-tailed Chinchilla	<i>Chinchilla lanigera</i>	7	2.813
Tuco-tuco	<i>Ctenomys talarum</i>	5.2	2.146
Bank Vole	<i>Myodes glareolus</i>	3.95	1.267
Deer mice	<i>Peromyscus maniculatus</i>	5.6	1.23
Golden or Syrian Hamster	<i>Mesocricetus auratus</i>	5.8	2.051
Northern red-backed Vole	<i>Myodes rutilus</i>	4.4	1.477
Fat-tailed Jird	<i>Pachyuromys duprasi</i>	12.2	1.562
Gerbil	<i>Meriones unguiculatus</i>	4.3	1.966
Libyan jird	<i>Meriones libycus</i>	6.4	1.906
Short-tailed Bandicoot Rat	<i>Nesokia indica</i>	6.7	2.458
Spiny mice	<i>Acomys cahirinus</i>	8.8	1.699
Blind Subterranean Mole Rat	<i>Spalax judaei</i>	8.61	2.511
Black-tailed Jackrabbit	<i>Lepus californicus</i>	8.7	3.312
European Brown Hare	<i>Lepus europaeus</i>	12.9	3.677
Eastern Cottontail Rabbit	<i>Sylvilagus floridanus</i>	12.9	3.066
Riparian Brush Rabbit	<i>Sylvilagus bachmani</i>	6.3	2.845
Black Lemur	<i>Eulemur macaco</i>	4.9	3.254

Continued

Black-and-white ruffed Lemur	<i>Varecia variegata</i>	6.7	3.544
Eastern Lesser Bamboo Lemur	<i>Hapalemur griseus</i>	6.4	2.85
White-Fronted Brown Lemur	<i>Eulemur fulvus</i>	3	3.447
Red ruffed Lemur	<i>Varecia rubra</i>	5.5	3.641
Ring-tailed Lemur	<i>Lemur catta</i>	7.5	3.362
Verreaux's Sifaka	<i>Propithecus verreauxi Strepsirhini</i>	6.6	3.58
Bushbaby	<i>Galago crassicaudatus Strepsirhini</i>	5.4	3.176
Slender Loris	<i>Loris tardigradus</i>	7.5	2.279
Three-striped Night Monkey	<i>Aotus trivirgatus</i>	9.1	3.086
Cotton-Top Tamarin	<i>Saguinus oedipus</i>	14.7	2.505
Common Marmoset	<i>Callithrix jacchus</i>	10.6	2.491
White-Footed Tamarin	<i>Saguinus leucopus</i>	9.4	2.699
Goeldi's Monkey	<i>Callimico goeldii</i>	8.9	2.563
Tufted Capuchin	<i>Cebus apella</i>	7.2	3.491
Common Squirrel Monkey	<i>Saimiri sciureus</i>	5.53	2.82
De Brazza's Monkey	<i>Cercopithecus neglectus</i>	4.3	3.76
Hamadryas Baboon	<i>Papio hamadryas</i>	4.3	4.365
Lion-tailed Macaque	<i>Macaca silenus</i>	5.8	3.771
Bonobo	<i>Pan paniscus</i>	4.1	4.592
Chimpanzee	<i>Pan troglodytes</i>	4.6	4.61
Gorilla	<i>Gorilla gorilla</i>	3.81	5.13
Orangutan	<i>Pongo pygmaeus</i>	4.3	4.94
Rhesus Monkey	<i>Macaca mulatta</i>	3.83	3.813
Stump-tailed Macaque	<i>Macaca arctoides</i>	4.3	3.947
Three-striped Night Monkey	<i>Aotus trivirgatus</i>	9.1	3.097
Brown Woolly Monkey	<i>Lagothrix lagotricha</i>	5.9	3.845
Owl Monkey	<i>Aotus nancymae</i>	6.5	3.097
Red howler Monkey	<i>Alouatta seniculus</i>	5.7	3.785
Black-capped or Bolivian squirrel monkey	<i>Saimiri boliviensis</i>	7.8	2.888
Central American squirrel or Colombian monkey	<i>Saimiri oerstedii</i>	6.4	2.888
Tonkean Macaque	<i>Macaca tonkeana</i>	3.4	4.099
Sooty Mangabey	<i>Cercocebus atys</i>	4.8	3.895
Northern Plains Gray Langur	<i>Semnopithecus entellus</i>	5.9	4.14
Chacma or Cape baboon	<i>Papio ursinus</i>	5.4	4.362
Celebes black Macaque	<i>Macaca nigra</i>	4	4.061
Crab-eating or Cynomolgus Macaque	<i>Macaca fascicularis</i>	5.89	3.699
Grivet or African Green monkey	<i>Chlorocebus aethiops</i>	5.87	3.602

2.2. Statistics

Allometric relationships (comparing both serum/plasma concentrations of glucose and \log_{10} serum/plasma concentrations of glucose with \log_{10} body weight) across the Class Mammalia were analyzed by linear regression (Microsoft Excel). The data were also analysed separately for major groups of mammals including Marsupial mammals, Eutherian mammals, for taxa within the Eutherian mammals, namely *Glires*, *Euarchonta*, *Laurasiatheria*, *Afrotheria* and *Xenarthra* (following the relationships advanced in [11]-[13]) together with Orders and sub-orders within the *Laurasiatheria* and *Euarchonta* where there is sufficient data for analysis.

3. Results

There was not a relationship between circulating concentrations of glucose and \log_{10} body weight in wild mammals (circulating concentrations of glucose: adjusted $R^2 = -0.003$; \log_{10} circulating concentrations of glucose: adjusted $R^2 = -0.003$) (Table 2 and Table 3) (Figure 1). Similarly, there was no allometric relationships when data for marsupial or eutherian mammals were analyzed separately (Table 2 and Table 3) or with major taxa within the *Eutheria*.

However, there was a strong relationship between circulating concentrations of glucose and \log_{10} body weight in some taxa; specifically across species within the Order *Primates* (circulating concentrations of glucose: adjusted $R^2 = 0.480$; $p < 0.001$; \log_{10} circulating concentrations of glucose: adjusted $R^2 = 0.511$ $p < 0.001$) (Table 2 and Table 3). Moreover there were moderate allometric relationships in the Orders *Perissodactyla* and *Carnivora* (Adjusted $R^2 = 0.085$; $p < 0.05$) (Table 2 and Table 3). Within the Order *Primates*, there was an even stronger allometric relationship in the Sub-order *Haplorhini* (New World and Old World monkeys together with Apes) (circulating concentrations of glucose: adjusted $R^2 = 0.597$; $p < 0.001$; \log_{10} circulating concentrations of glucose: adjusted $R^2 = 0.657$; $p < 0.001$) (Figure 2) but no allometric relationship in in the Sub-order *Strepsirhini*. Within the Order *Carnivora*, the moderate allometric relationship was no longer significant when the data were examined within Sub-orders (circulating concentrations of glucose: Sub-order *Caniformia*-adjusted $R^2 = 0.059$, $p = 0.064$; *Feliformia*-adjusted $R^2 = 0.098$, $p = 0.128$). Despite there being data on circulating concentrations of glucose in a large sample size (76 species) within the Order *Cetartiodactyla*, there was no allometric relationship observed. Moreover, if the data for Cetacean species was analyzed separately, again no allometric relationship was observed (circulating concentrations of glucose: *Cetacea*-adjusted $R^2 = -0.077$, $p = 0.948$; *Artiodactylia*-adjusted $R^2 = 0.0007$, $p = 0.312$).

4. Discussion

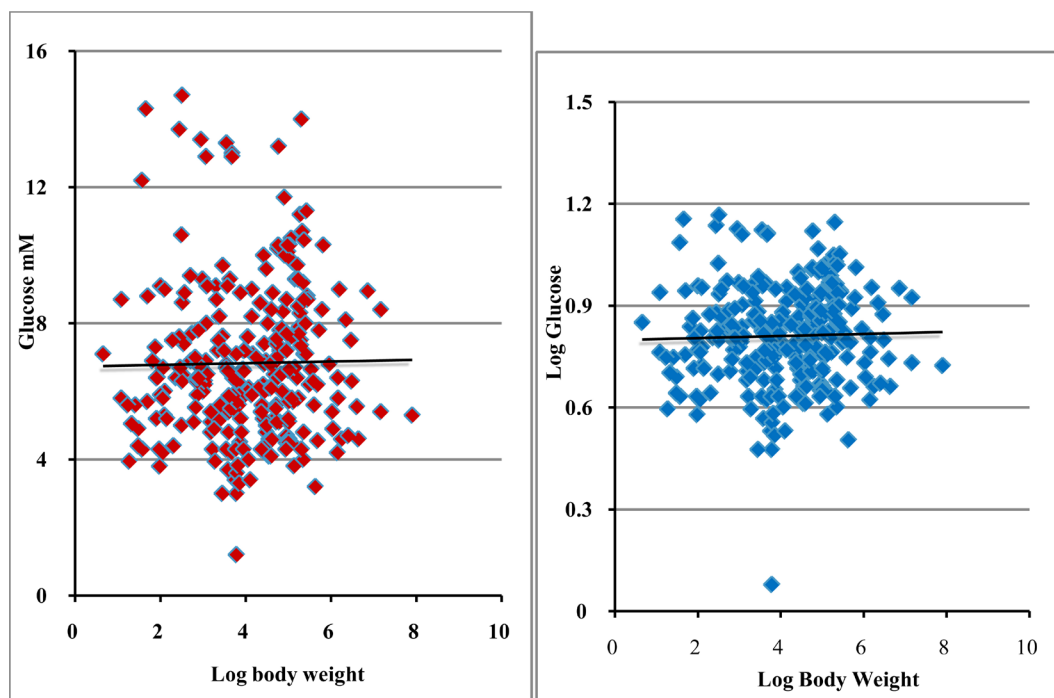
There was no relationship between circulating concentrations of glucose and log body weight in wild species of

Table 2. Relationship between serum/plasma concentrations of glucose and log body weight in mammalian species.

Taxa	Adjusted $R^2 = (n=)$	$p =$	Slope
Class <i>Mammalia</i>	-0.003 (270)	0.815	
Infra-class Marsupialia	-0.047 (18)	0.629	
Infra-class Eutheria (Placentalia)	-0.004 (250)	0.936	
Within Infra-class Eutheria (Placentalia)			
Super-order Afrotheria	0.183 (5)	0.219	
Super-order Euarchonta	0.480 (38)	8.62E-07	-2.33
Super-order Glires	0.049 (38)	0.096	
Super-order Laurasiatheria	-0.006 (163)	0.878	
Super-order Xenarthra	-0.245 (6)	0.906	
Within Laurasiatheria			
Order Carnivora	0.081 (59)	0.016	-0.74
Order Cetartiodactyla	-0.013 (76)	0.871	
Order Chiroptera	0.209 (8)	0.209	
Order Perissodactyla	0.235 (14)	0.045	-1.12
Within Super-order Glires			
Order Rodentia	-0.018 (34)	0.532	
Within Super-order Euarchonta			
Primates	0.480 (38)	8.62E-07	-2.33
Within Primates			
Sub-order Strepsirhini	0.0075 (9)	0.337	
Sub-order Haplorhini	0.597 (29)	5.56E-07	-2.69

Table 3. Relationship between \log_{10} serum/plasma concentrations of glucose and \log_{10} body weight across mammals and in mammalian taxa.

Taxa	Adjusted $R^2 = (n=)$	p =	Slope
Class <i>Mammalia</i>	-0.003 (269)	0.686	
Infra-class Marsupialia	-0.044 (17)	0.560	
Infra-class Eutheria (Placentalia)	-0.004 (251)	0.684	
Within Infra-class Eutheria (Placentalia)			
Super-order Afrotheria	0.179 (6)	0.222	
Super-order Euarchonta	0.511 (38)	2.82E-07	-0.153
Super-order Glires	0.068 (38)	0.062	
Super-order Laurasiatheria	-0.006 (163)	0.786	
Super-order Xenarthra	-0.249 (6)	0.948	
Within Laurasiatheria			
Order Carnivora	0.068 (59)	0.0256	-0.040
Order Cetartiodactyla	-0.013 (76)	0.910	
Order Chiroptera	0.204 (8)	0.146	
Order Perissodactyla	0.242 (14)	0.0425	-0.079
Within Super-order Glires			
Order Rodentia	-0.005 (34)	0.368	
Within Super-order Euarchonta			
Primates	0.511 (38)	2.82E-07	-0.153
Within Primates			
Sub-order Strepsirhini	0.022 (9)	0.392	
Sub-order Haplorhini	0.657 (29)	5.95E-08	-0.172

**Figure 1.** Relationship between plasma/serum concentration and body weight across mammalian species. Left: plasma/serum concentration (mM) and \log_{10} body weight across mammalian species; Right: \log_{10} plasma/serum concentration and \log_{10} body weight across mammalian species (mM).

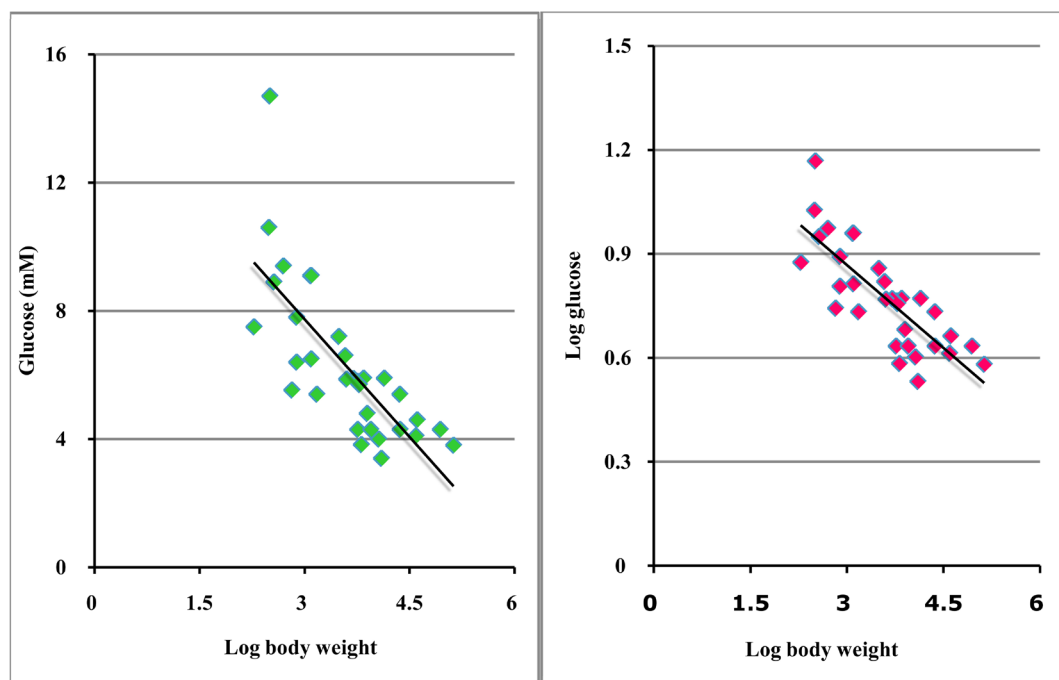


Figure 2. Allometric relationship for plasma/serum concentrations of glucose in Primate species (left glucose, right log glucose concentration).

the Class *Mammalia* or Infra-classes *Eutheria* or (*Placentalia*) (Table 2 and Table 3; Figure 1). This is in contrast to previous studies in mammals [2] [3]. The basis for the differences is not clear. The present study employed a much large number of species and deliberately omitted domesticated species. There were similarly no allometric relationships observed across species for many mammalian taxa including marsupials, eutherian mammals, Super-orders *Afrotheria* (e.g. aardvarks, elephants, sea cows), *Glires* (rodents, rabbits and hares), *Laurasiatheria* (e.g. carnivores, large herbivores and whales) and *Xenoarthra* (anteaters, armadillos, sloths) and in Laurasiatherian orders such as *Chiroptera* (bats) and *Cetartiodactyla* (even toed ungulates such as deer together with whales and dolphins).

There was a very strong allometric relationship between circulating concentrations of glucose and log body weight in species of the Class *Primates* (apes, monkeys and lemurs) (Table 2 and Table 3, Figure 2) and, particularly, in the Sub-order *Haplorhini* (New World and Old World monkeys together with the Apes). Body weight accounted for much of the variation in circulating concentrations of glucose in species in the Sub-order *Haplorhini* (>60%) (Figure 2). Moreover, there was an allometric relationship with circulating concentrations in species in the Orders *Perissodactyla* (odd toed ungulates such as horses, rhinoceroses and tapirs) and *Carnivora* (Table 1). It is suggested that in these taxa that the relationship between circulating concentrations of glucose and body weight is consistent to the reductions in energy requirements per unit weight with increasing body weight. Despite the strong relationship between here was insufficient data on basal metabolic rate or brain weight in primates (or within the *Haplorhini*) [14] for an analysis with sufficient power for significance. Alternatively, circulating concentrations of glucose may play a critical role in determining optimal body weight.

The overall conclusions are that there is no allometric relationship between circulating concentrations of glucose (or \log_{10} circulating concentrations of glucose) and \log_{10} body weight across species of wild mammals. However, there was a strong allometric relationship in primates, particularly in the *Haplorhini* (monkeys and apes).

5. Conclusion

No relationship was observed between circulating concentrations of glucose and \log_{10} body weight in a large sample size (270) of wild species but with domesticated animals excluded from the analyses. The absence of an allometric relationship for circulating concentrations of glucose was unexpected. A strong allometric relation-

ship was seen in Primates.

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