Comparative nutrition and digestive physiology - thoughts about future possibilities

Marcus Clauss

Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Switzerland

CNS 2022

University of Zurich[UZH]

Clinic of Zoo Animals, Exotic Pets and Wildlife

Overview

Moaning and nagging

Observations on (not only comparative nutrition) science

A very restricted outlook

Thoughts on fascinating possibilities in applied and basic comparative nutrition science

Google Scholar

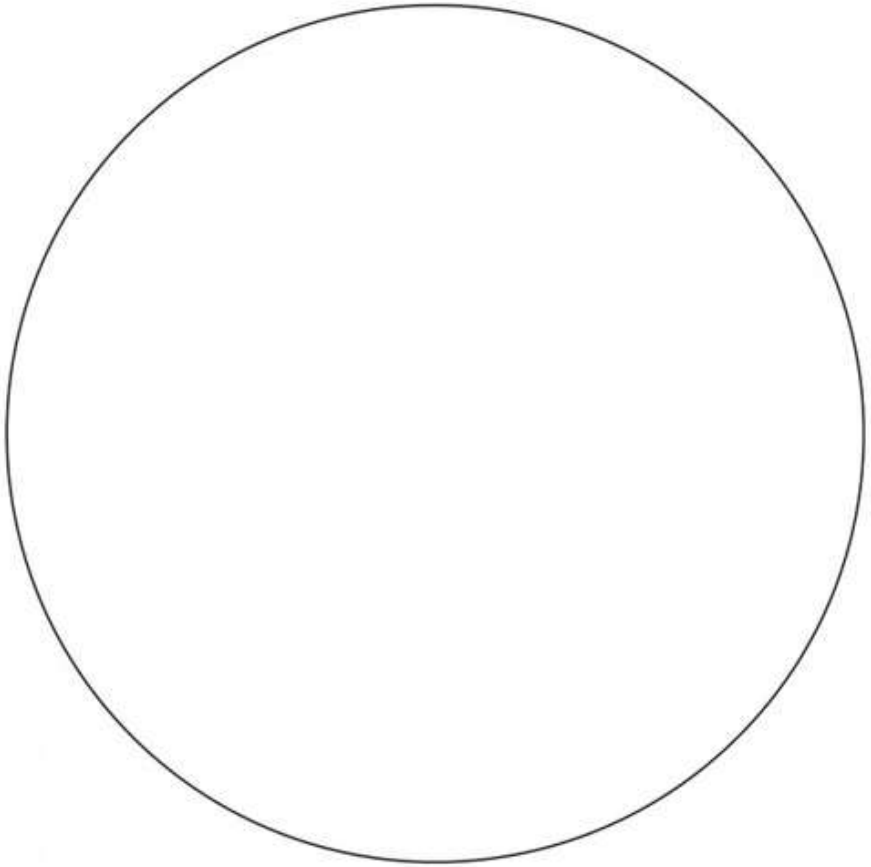
Articles Case law

Stand on the shoulders of giants

The knowledge universe:

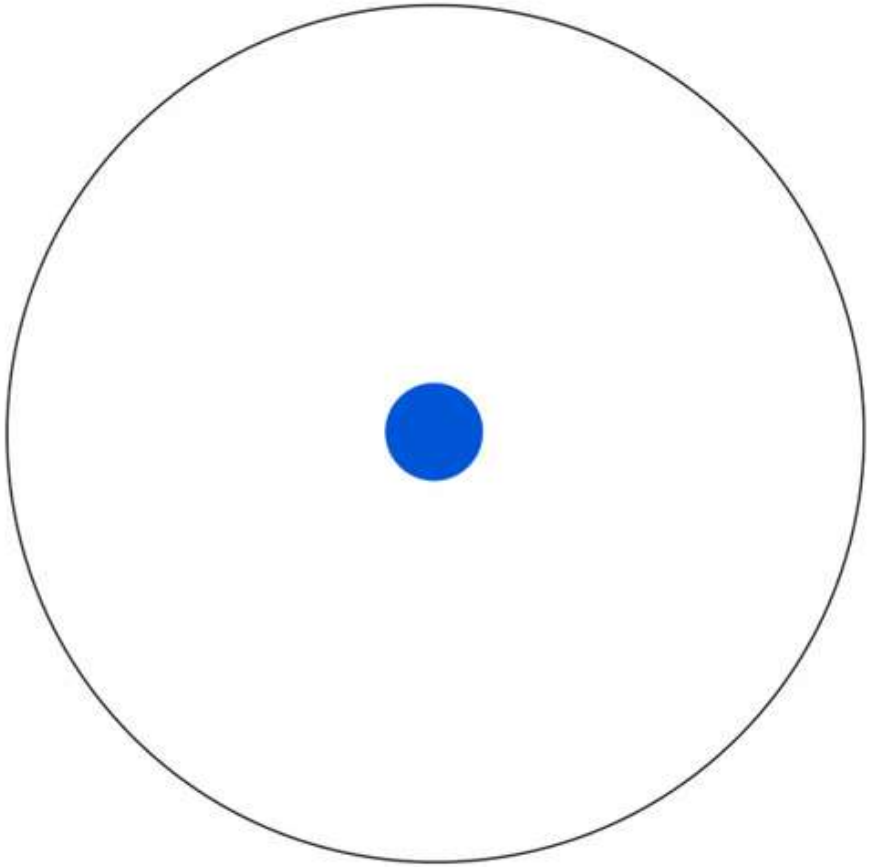
a story of constant expansion

The Knowledge Universe



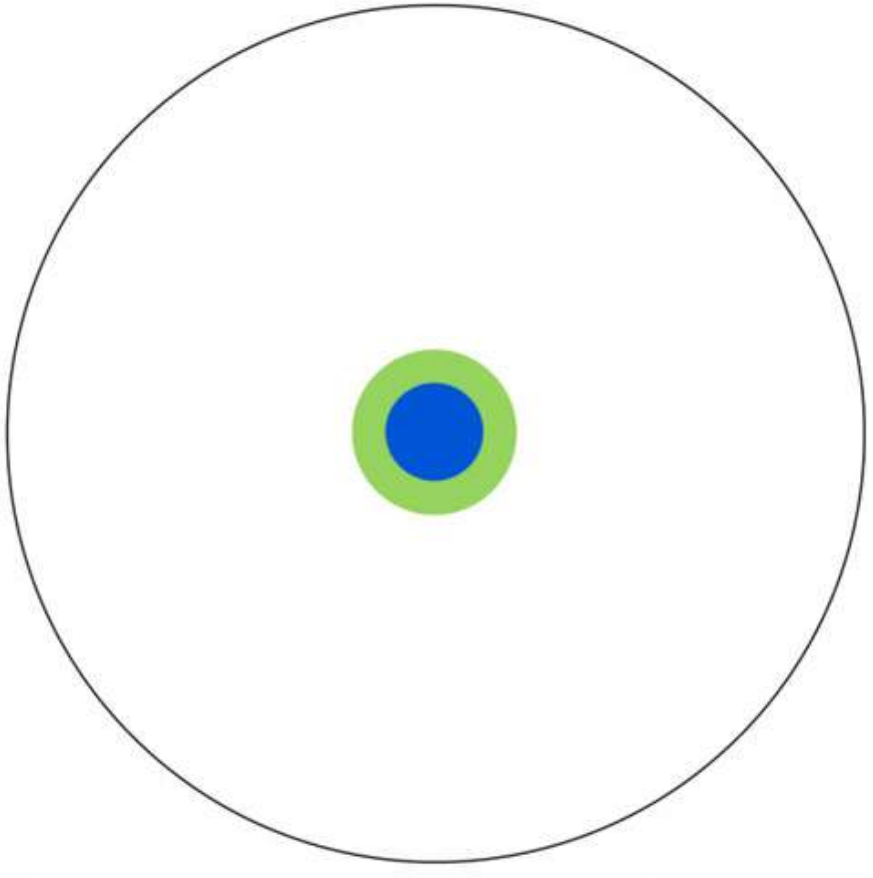
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Elementary School



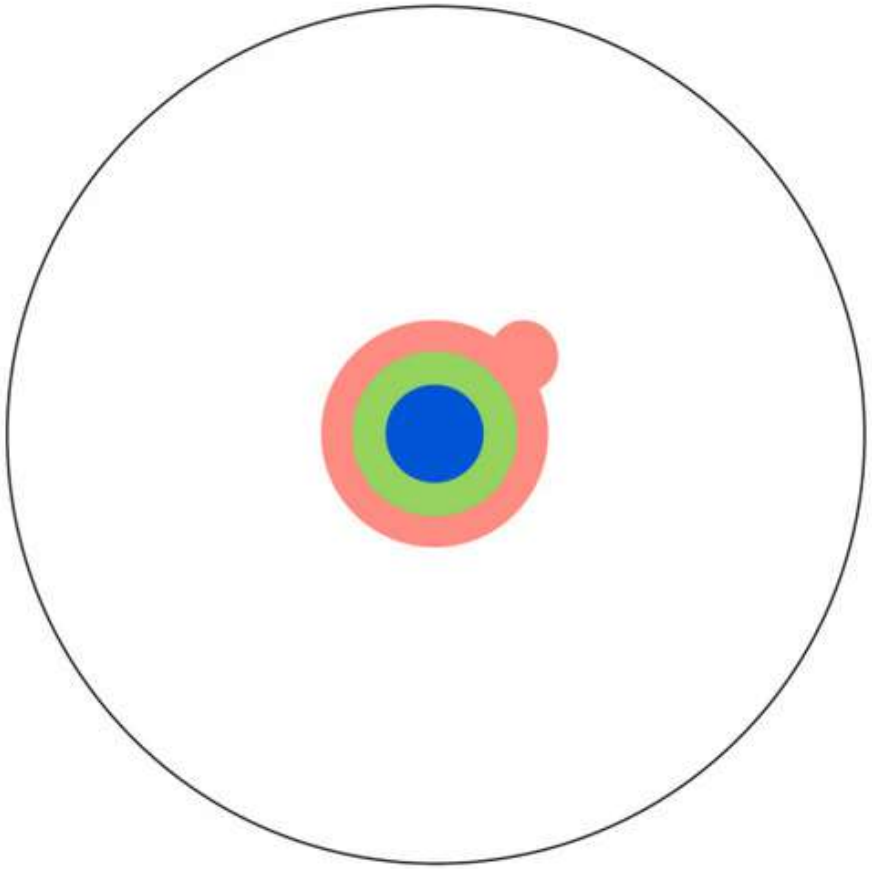
The Illustrated Guide to the Ph.D., created by Matt Might
(http://matt.might.net/articles/phd-school-in-pictures/; 2012)

High School



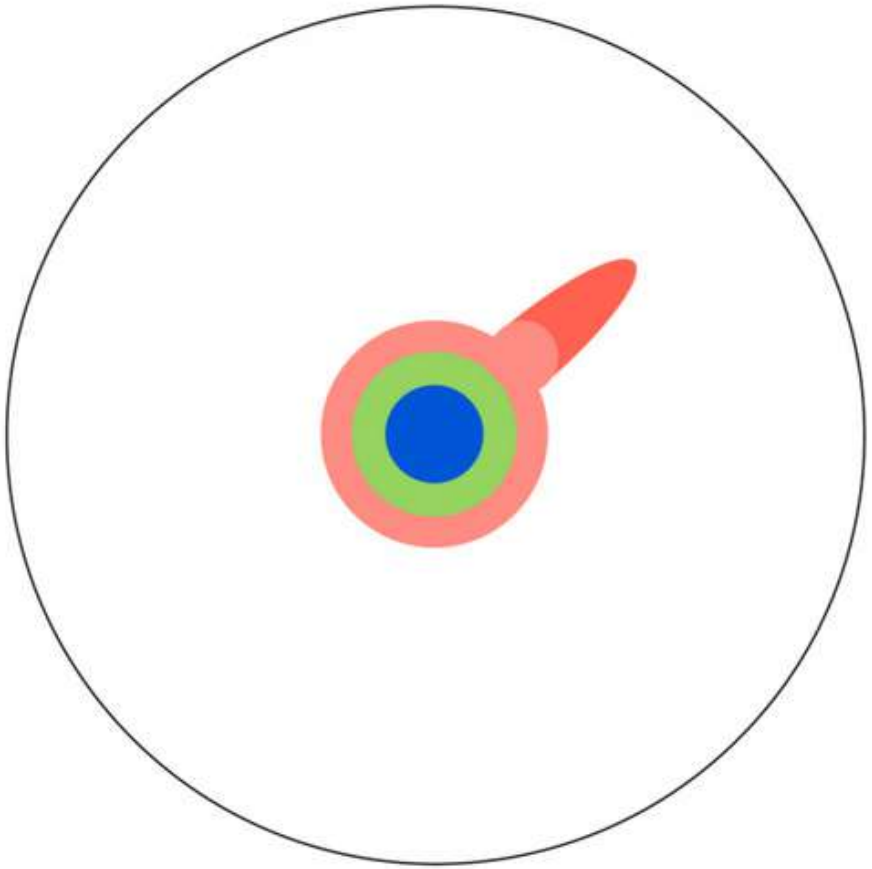
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Specialization



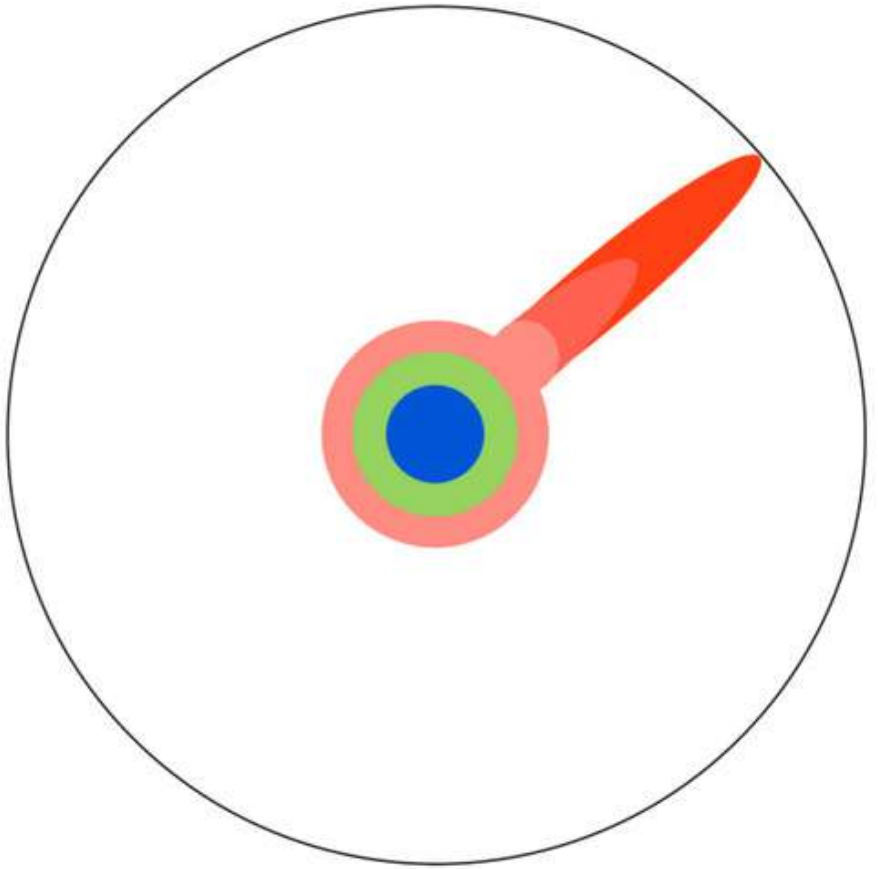
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Specialization



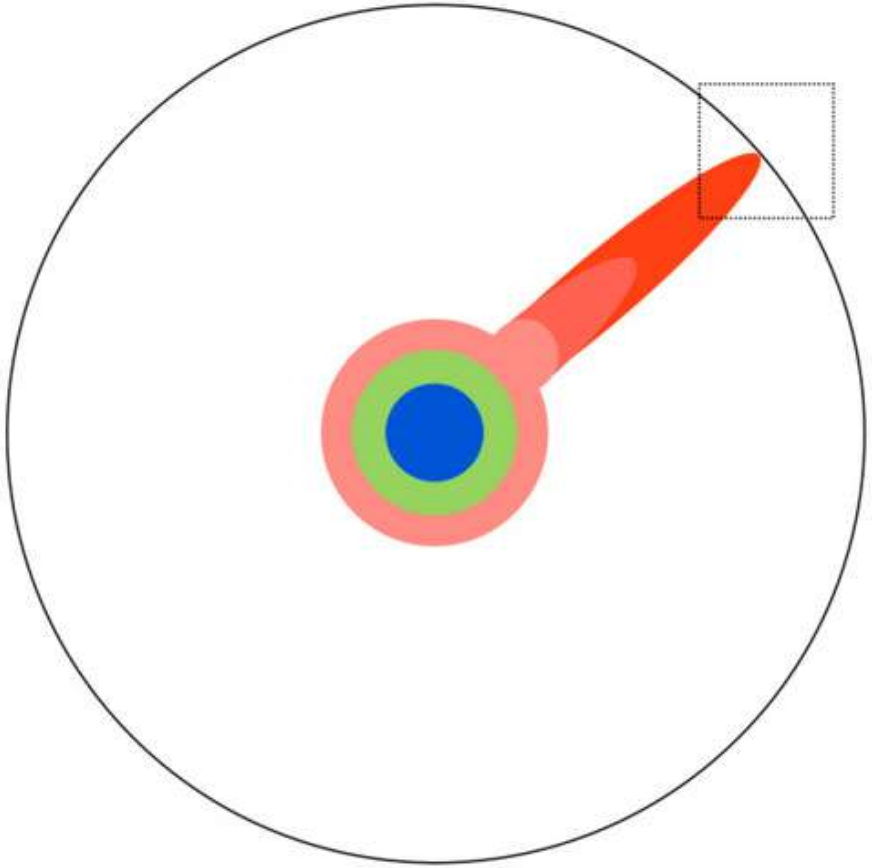
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

(Good) Literature Research



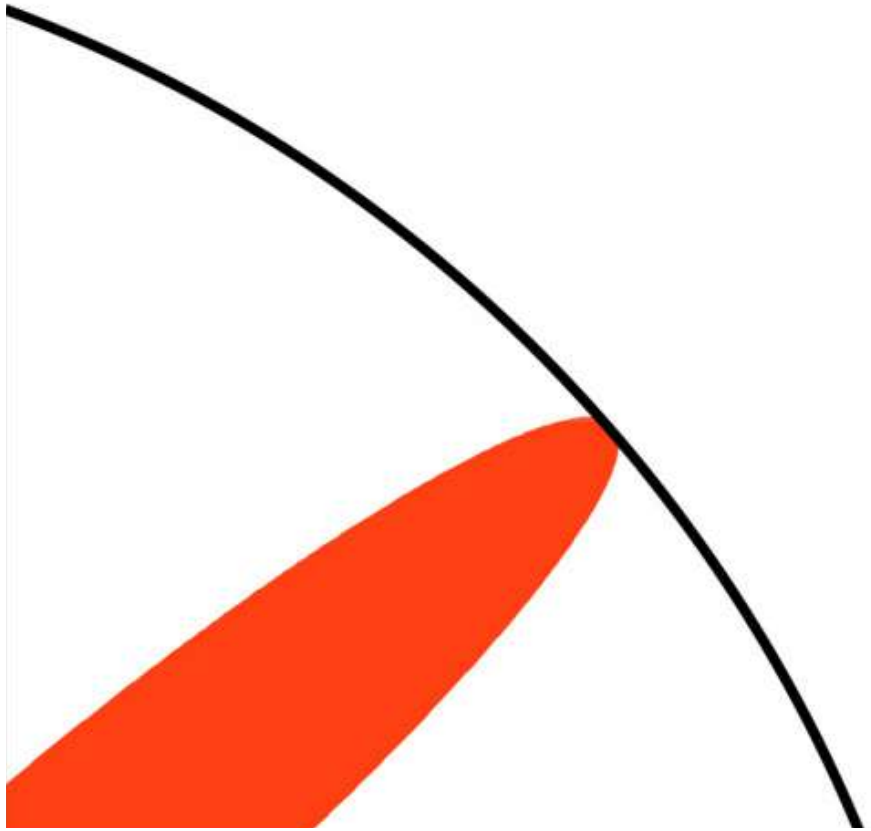
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

PhD Topic



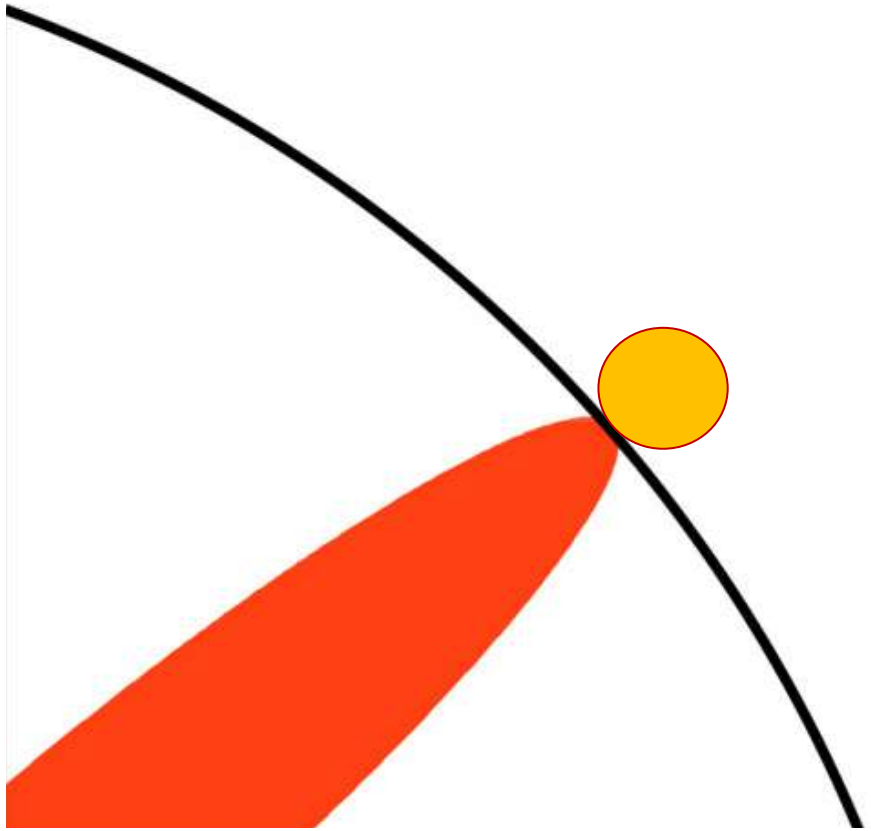
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

PhD Topic



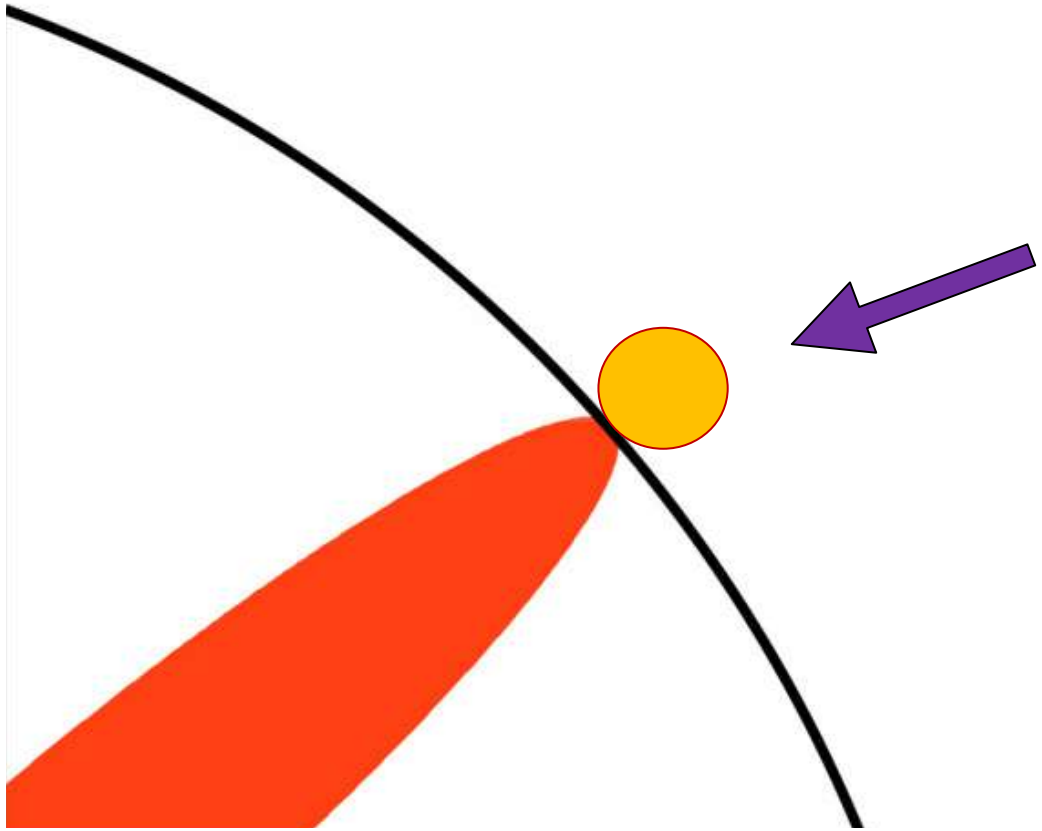
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

PhD Topic



The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

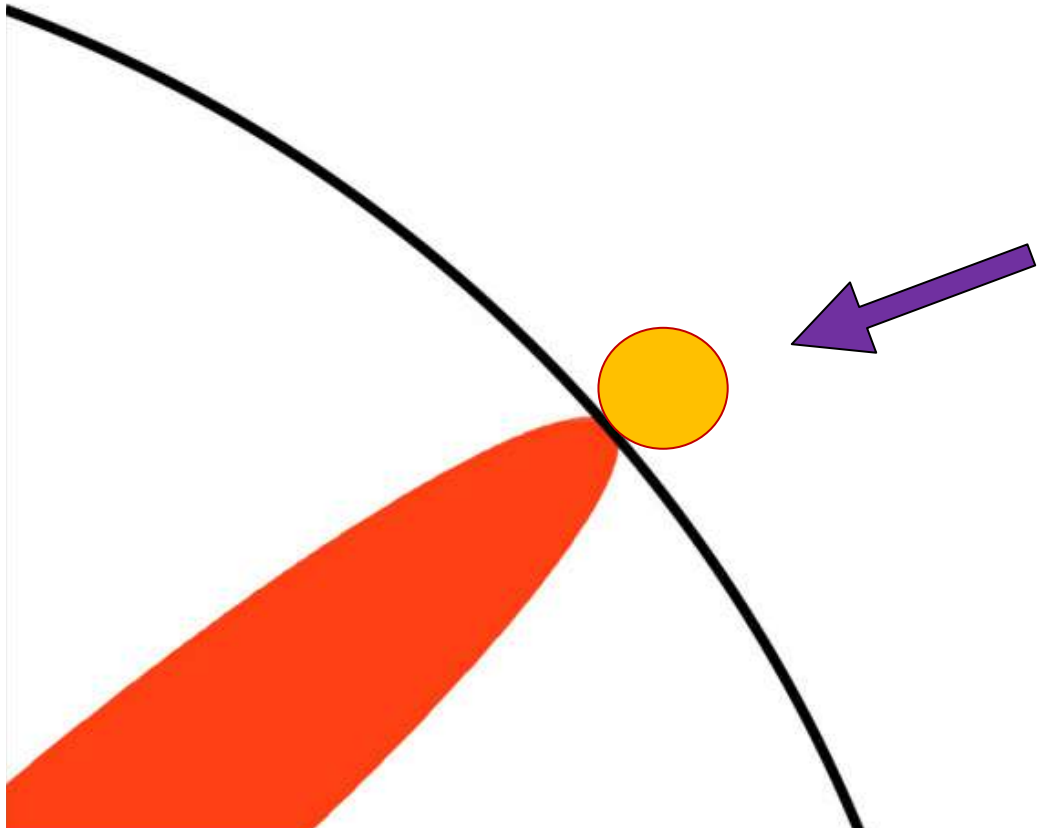
PhD Topic



what do you think waits here ?

The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

PhD Topic



what would be the most un-inspired way to describe this point?

The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Why study something ?

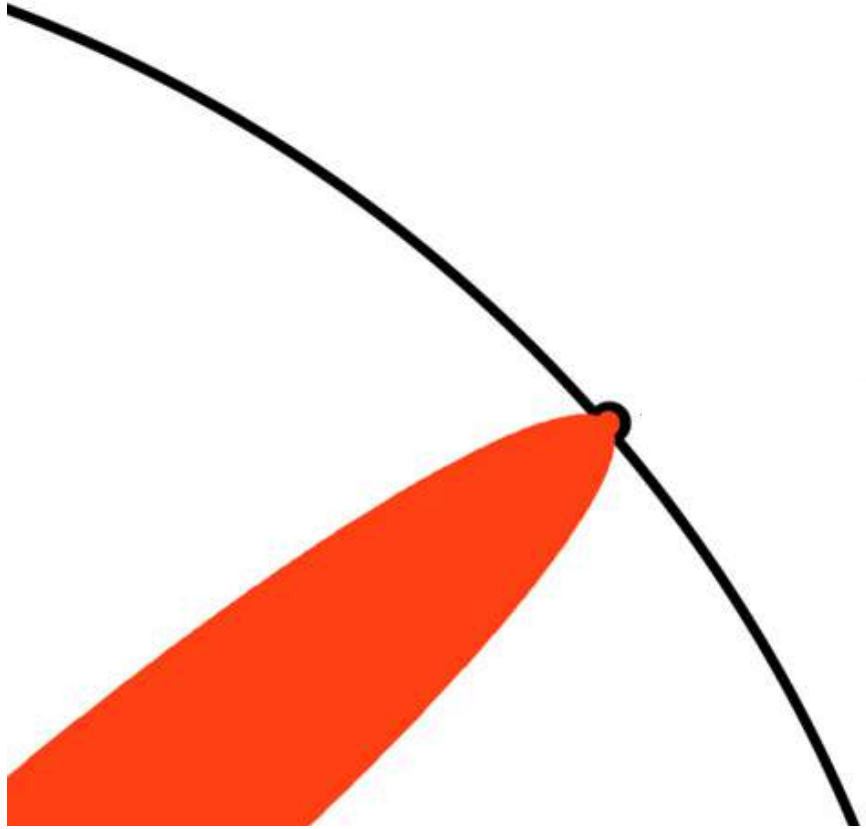
... but no information exists on x ...

... but x has not been studied so far ...

The most likely explanation for the fact that something has not been studied yet is that it is not very interesting.

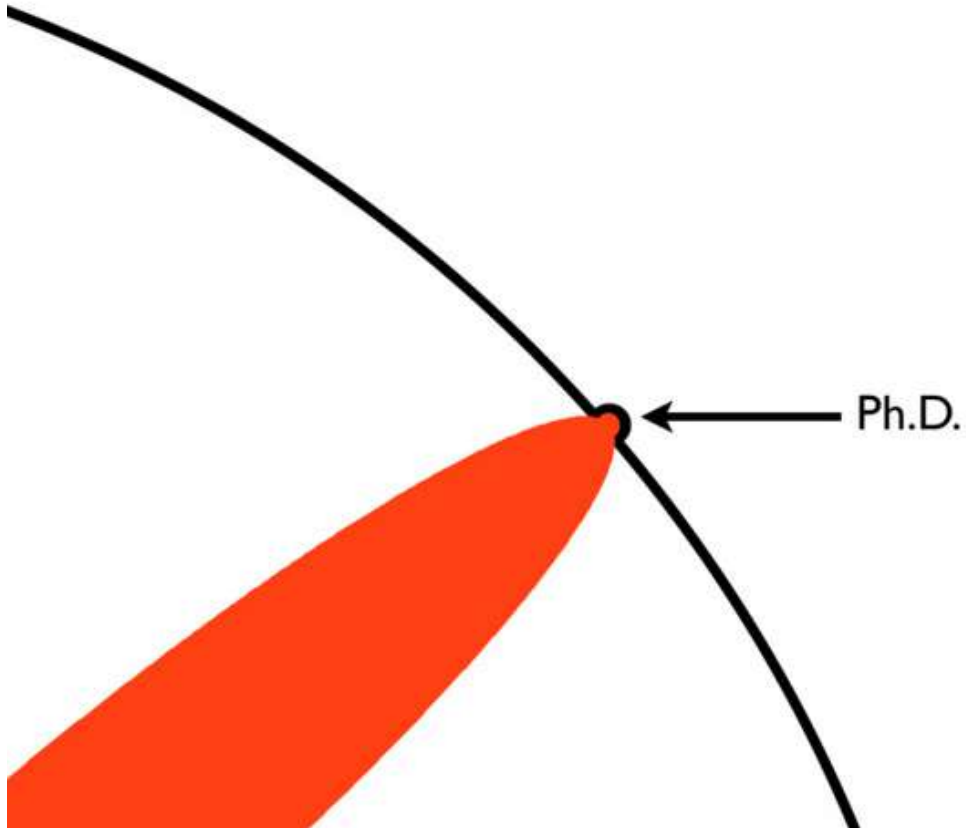
find another reason to justify your work !

New knowledge



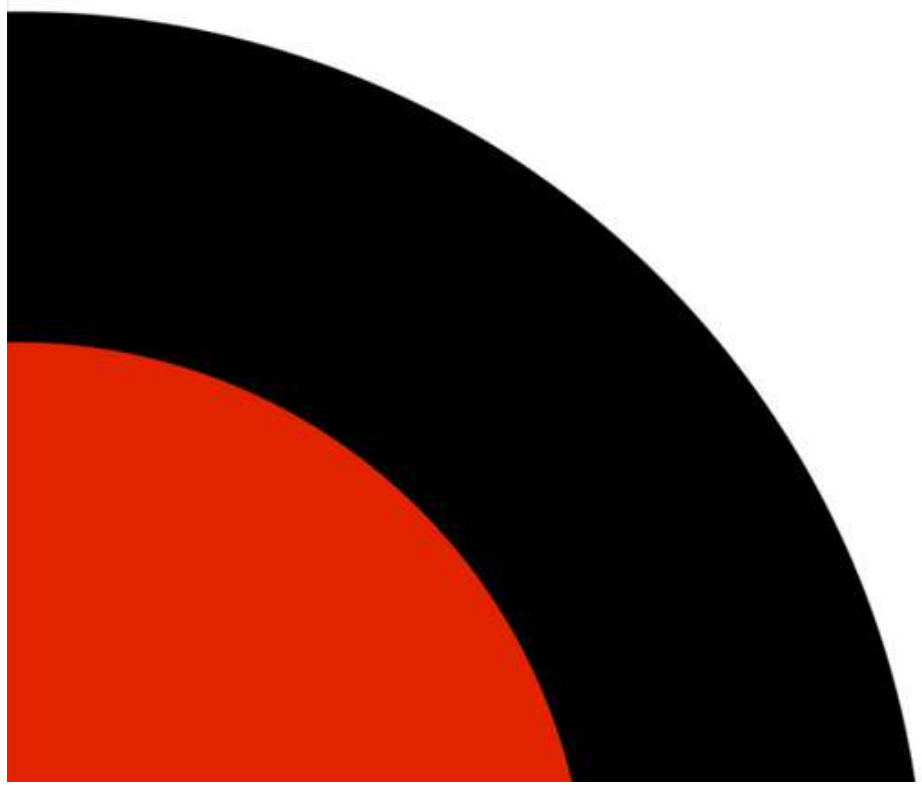
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

PhD Qualification



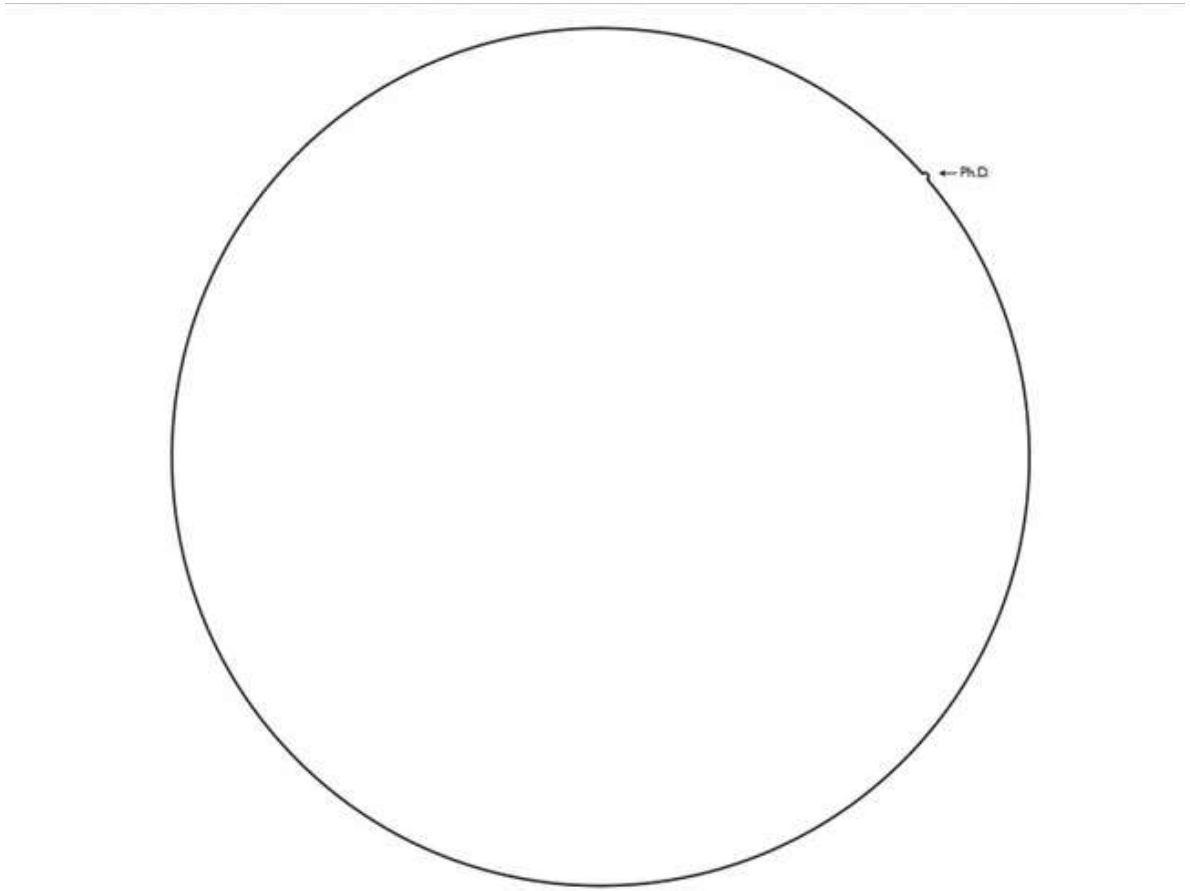
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Keep pushing !



The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

… but don‘t forget the big picture



The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

The knowledge universe:

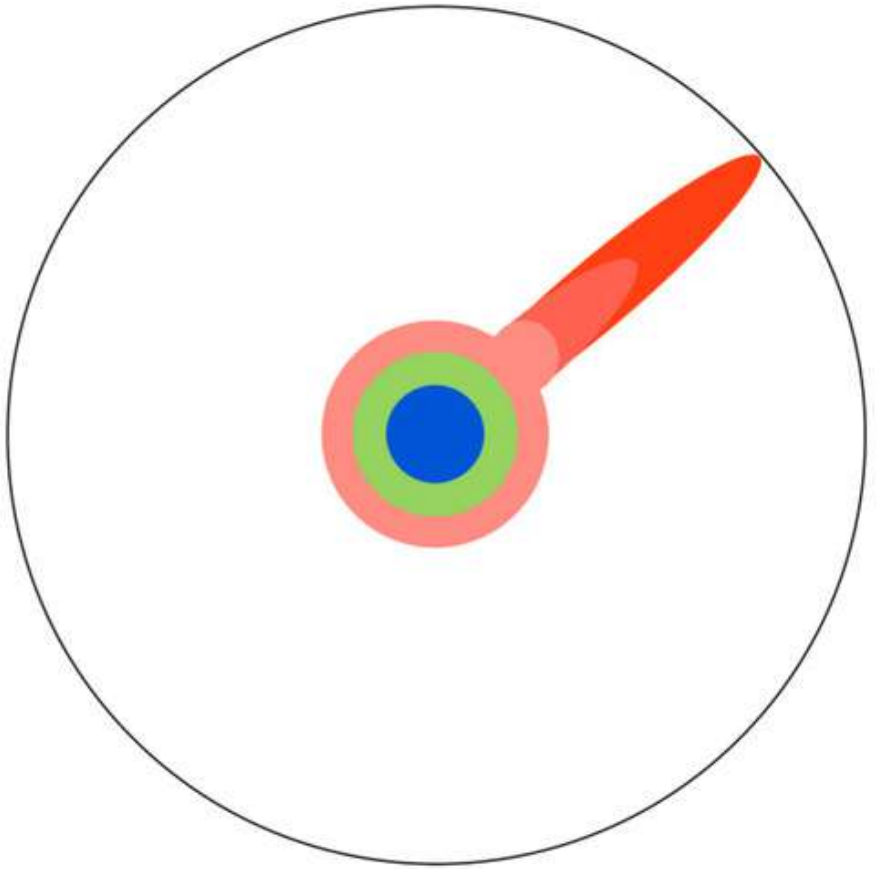
a story of constant expansion

The knowledge universe:

a story of constant expansion ?

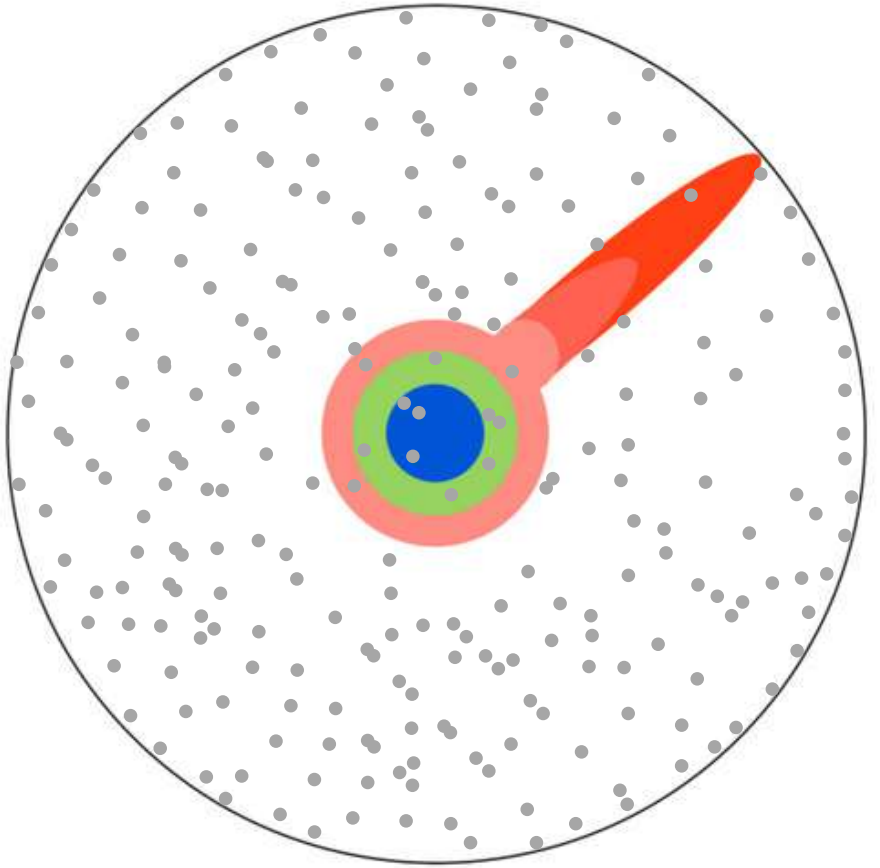
a story of accumulation of nonsense ?

The ***real*** Knowledge Universe



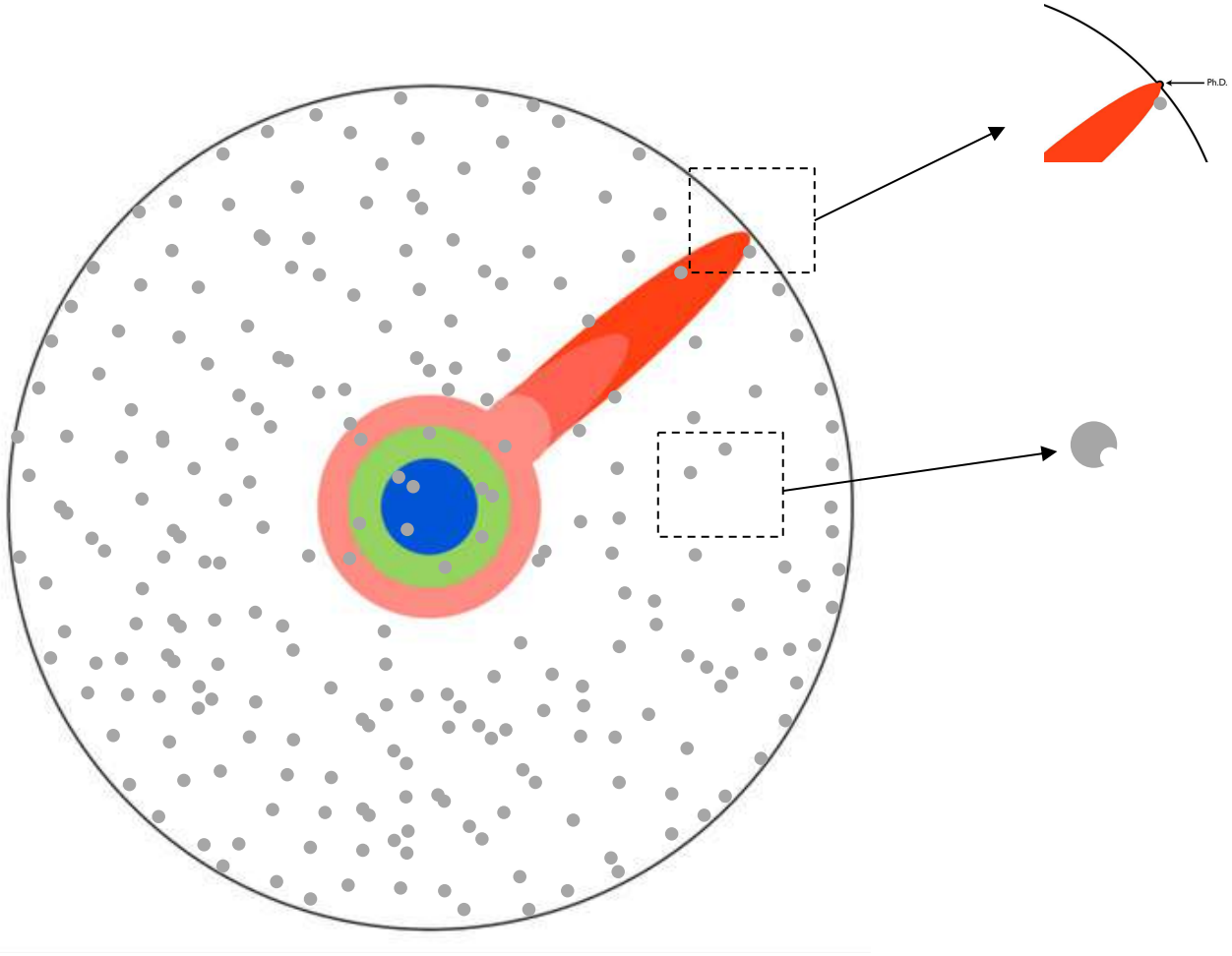
The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

The ***real*** Knowledge Universe



adapted from: The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

The ***real*** Knowledge Universe



adapted from: The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

The view that

scientific texts are edifices built on previous science

may well be obsolete.

It has become impossible to follow new publications even in limited areas of research, and the speed of method development (e.g. in molecular analyses) means data produced today are not comparable to data produced 4 years ago …

Science is changing from …

… an edifice that builds on previous achievements

… to a conversation and a huge amount of misinformation.

Devaluing science

Not everything needs a citation

Journal of Animal Husbandry and Dairy Science
Volume 5, Issue 1, 2021, PP 1-9
ISSN 2637-5354
DOI: https://doi.org/10.22259/2637-5354.0501001

Effects of Allium Sativum Powder on in Vitro Digestibility of Maize Stover in Cattle

Lemoufouet Jules[1*], Kana Jean Raphael[1], Taboumda Evariste[1], Mube Kuitche Hervé[1], Mekuiko Watsop Hippolyte[2], Miégoué Emile[1], Tendonkeng Fernand[1], Mouchili Mama[1], Matumuini Ndzani Essie Ference[3] et Pamo Tedonkeng Etienne[1]

According to Meyer et *al*. (2010), animals ingest food to meet their energy needs.

Meyer K and Hummel J, Clauss M: 2010. The relationship between forage cell wall content and voluntary food intake in mammalian herbivores. *Mammal Review* 40: 221-245.

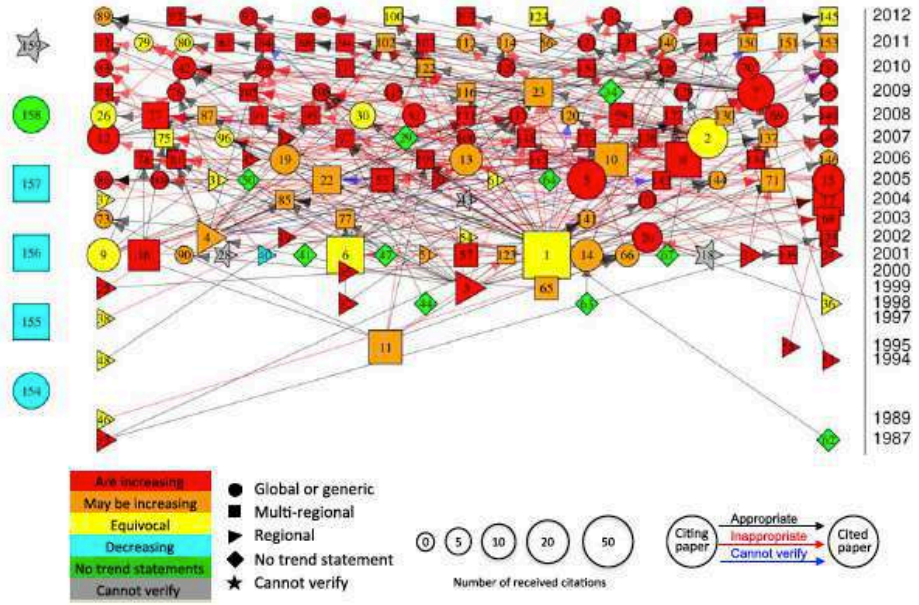
Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2016)

CONCEPT PAPER

Flawed citation practices facilitate the unsubstantiated perception of a global trend toward increased jellyfish blooms

Marina Sanz-Martín[1,2]*, Kylie A. Pitt[3], Robert H. Condon[4], Cathy H. Lucas[5], Charles Novaes de Santana[6] and Carlos M. Duarte[7]

Analyses showed that 48.9% of publications misinterpreted the conclusions of cited sources, with a bias towards claiming jellyfish populations are increasing, with a single review having the most influence on the network. Collectively, these disparities resulted in a network based on unsubstantiated statements



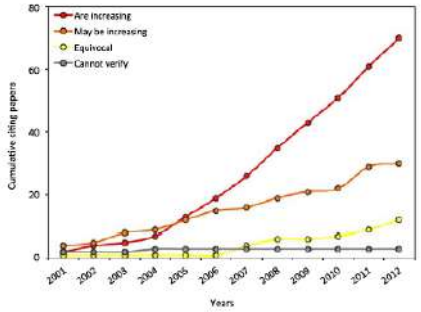


Figure 1 Chronological network of citation threads regarding jellyfish population trends. Nodes represent papers, their size and their numerical label represent the frequency at which they have been cited by other papers in the network, their shape represents the spatial category and their colours/shades represent the affirmation degree stated in support of jellyfish trends. Arrows represent the appropriateness assessment of the citations. Data set available in Sanz-Martín *et al.* (2016).

Integrity

a language of superlatives

Use of positive and negative words in scientific PubMed abstracts between 1974 and 2014: retrospective analysis

Christiaan H Vinkers *assistant professor*[1], Joeri K Tijdink *psychiatrist*[2], Willem M Otte *assistant professor*[3 4]

Box 1: Words used in PubMed search queries and Google books search engine

Positive words

Amazing, assuring, astonishing, bright, creative, encouraging, enormous, excellent, favourable, groundbreaking, hopeful, innovative, inspiring, inventive, novel, phenomenal, prominent, promising, reassuring, remarkable, robust, spectacular, supportive, unique, unprecedented

Negative words

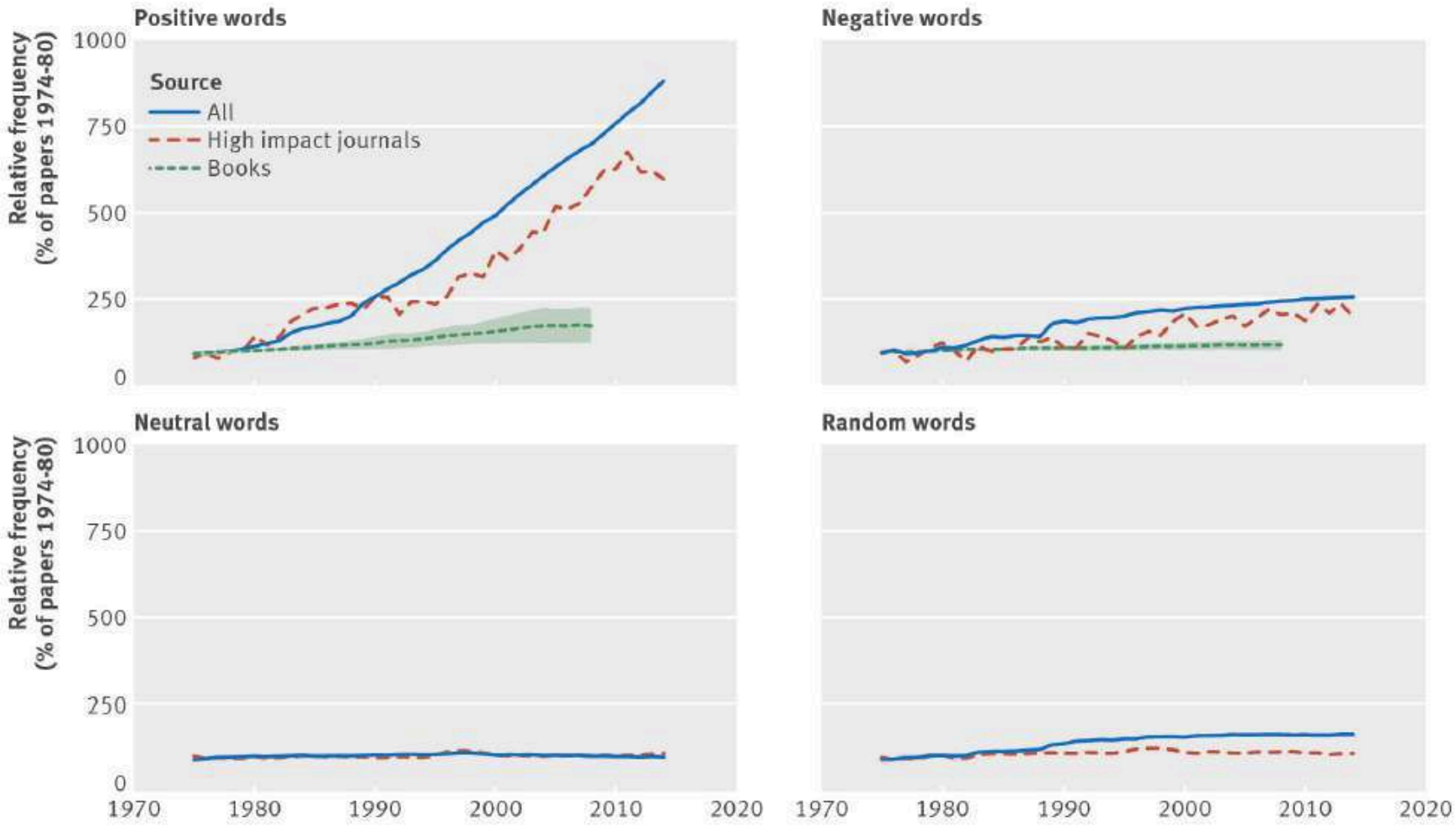
Detrimental, disappointing, disconcerting, discouraging, disheartening, disturbing, frustrating, futile, hopeless, impossible, inadequate, ineffective, insignificant, insufficient, irrelevant, mediocre, pessimistic, substandard, unacceptable, unpromising, unsatisfactory, unsatisfying, useless, weak, worrisome

Neutral words

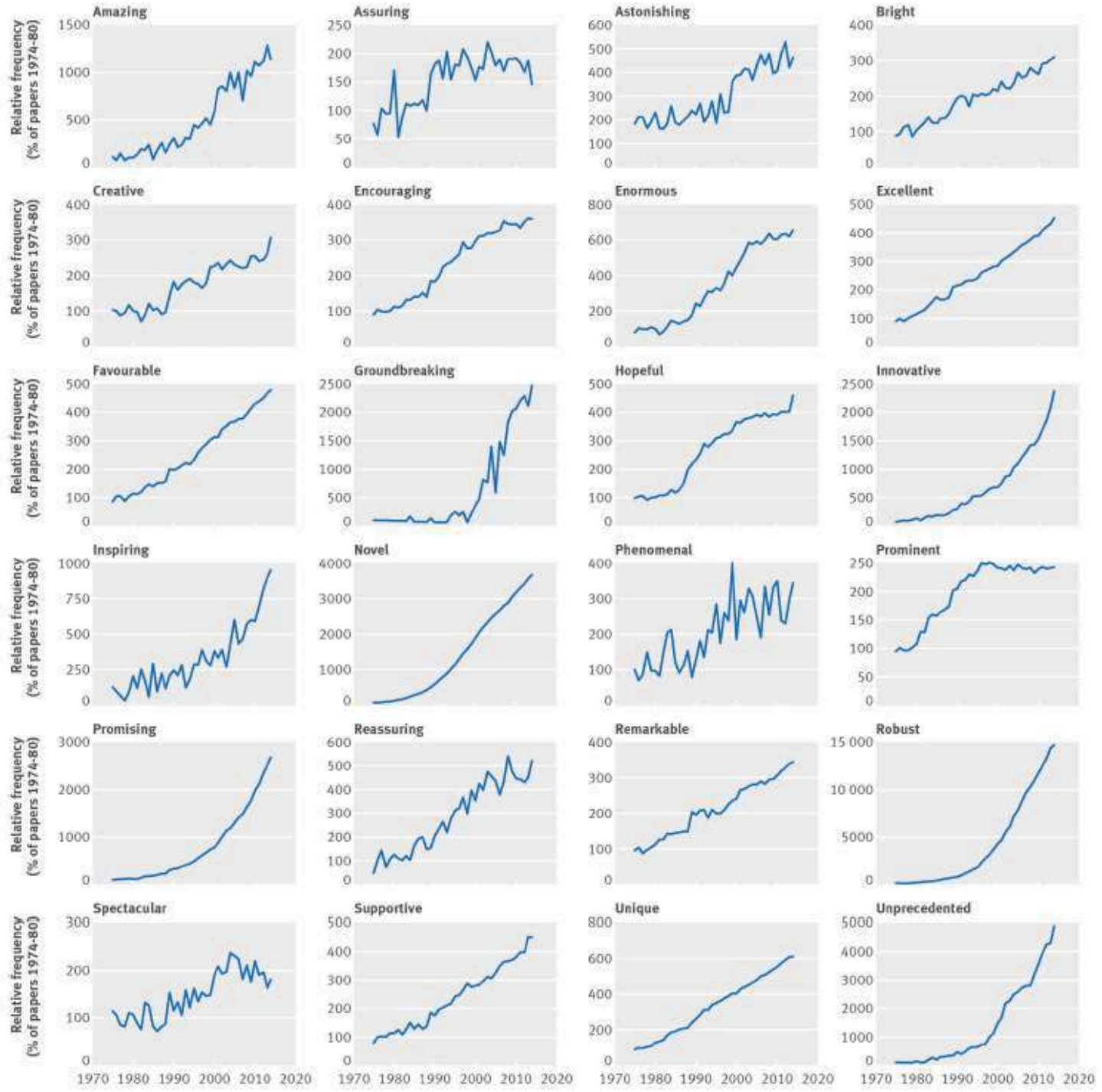
Animal, blood, bone, brain, condition, design, disease, experiment, human, intervention, kidney, liver, man, men, muscle, patient, prospective, rodent, significant, skin, skull, treatment, vessel, woman, women

Self-praise

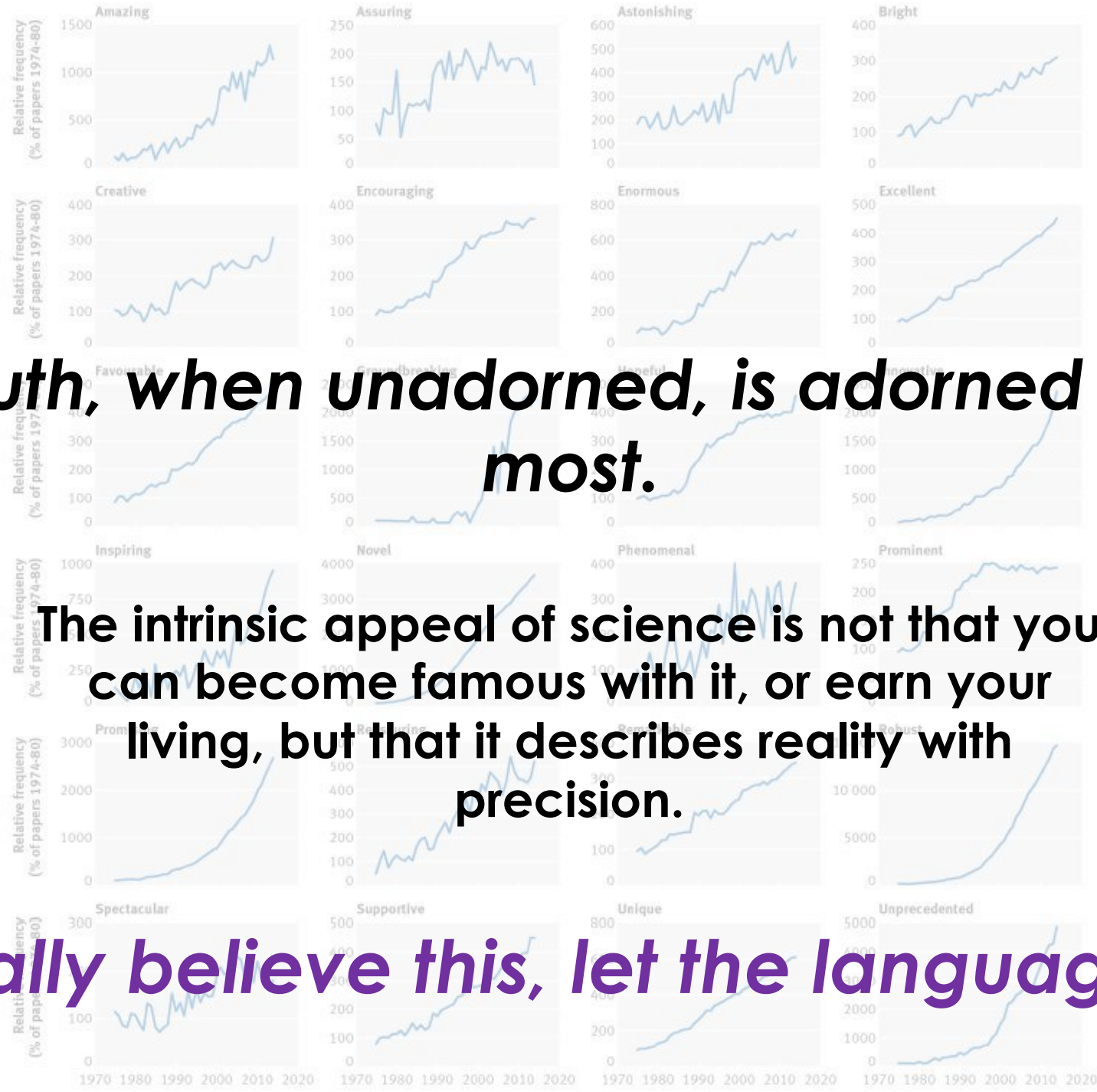
Use of positive and negative words in scientific PubMed abstracts between 1974 and 2014: retrospective analysis



Self-praise


Amazing
Assuring
Astonishing
Bright
Creative
Encouraging
Enormous
Excellent
Favourable
Groundbreaking
Hopeful
Innovative
Inspiring
Novel
Phenomenal
Prominent
Promising
Reassuring
Remarkable
Robust
Spectacular
Supportive
Unique
Unprecedented
Relative frequency (% of papers 1974-80)
1970 1980 1990 2000 2010 2020

Self-praise



Truth, when unadorned, is adorned the most.

The intrinsic appeal of science is not that you can become famous with it, or earn your living, but that it describes reality with precision.

if you really believe this, let the language show it

Self-praise

Palaeontology
The Palaeontological Association
www.palass.org
[Palaeontology, 2022, e12599]

Relative skull size evolution in Mesozoic archosauromorphs: potential drivers and morphological uniqueness of erythrosuchid archosauriforms

by JORDAN BESTWICK[1]*, PEDRO L. GODOY[2,3], SUSANNAH C. R. MAIDMENT[1,4], MARTÍN D. EZCURRA[1,5], MIA WROE[1], THOMAS J. RAVEN[4,6], JOSEPH A. BONSOR[4,7] *and* RICHARD J. BUTLER[1]

> One pattern of particular interest concerns the repeated occupation of terrestrial hypercarnivorous niches (a diet comprising more than 70% meat; Holliday & Steppan 2004)

Paleobiology, 30(1), 2004, pp. 108–128

Evolution of hypercarnivory: the effect of specialization on morphological and taxonomic diversity

Jill A. Holliday and Scott J. Steppan

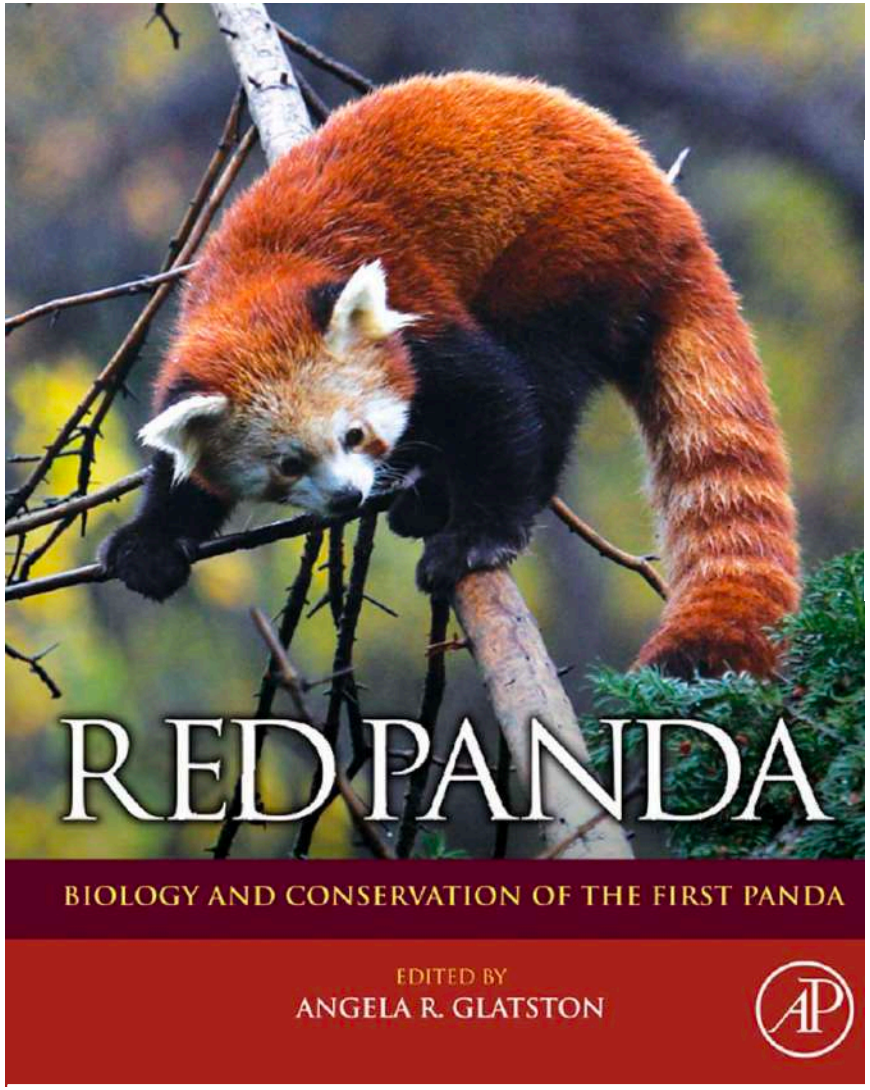
Of the recognized carnivoran ecomorphs, the niche of the meat specialist, or hypercarnivore, is associated with a diet comprising more than 70% meat, in contrast to the generalist (Van Valkenburgh 1988, 1989), which may eat 50–60% meat with vegetable matter and invertebrates making up the remainder of the diet.

Paleobiology, 17(4), 1991, pp. 340–362

Iterative evolution of hypercarnivory in canids (Mammalia: Carnivora): evolutionary interactions among sympatric predators

Blaire Van Valkenburgh

Hypercarnivores are here defined as species, such as living felids, whose diets consist almost entirely of vertebrate flesh.



Advanced Members of the Ailuridae (Lesser or Red Pandas – Subfamily Ailurinae)

Steven C. Wallace

Though the early ailurids are typically carnivorous, with a tendency towards hypercarnivory (eating exclusively meat like a lion or a polar bear), the ailurines exhibit a trend towards hypocarnivory (eating mostly or only vegetation).

A hyper-robust sauropodomorph dinosaur ilium from the Upper Triassic–Lower Jurassic Elliot Formation of South Africa: Implications for the functional diversity of basal Sauropodomorpha

Blair W. McPhee [a, b, *], Jonah N. Choiniere [a, b]

Journal of African Earth Sciences 123 (2016) 177–184

basal Sauropodomorpha managed the inherited behavioural and biomechanical challenges of increasing body-size, hyper-herbivory, and a forelimb primarily adapted for use in a bipedal context.

Achieving Landscape-Scale Deer Management for Biodiversity Conservation: The Need to Consider Sources and Sinks

KRISTIN WÄBER,[1] *School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*

JONATHAN SPENCER, *Principal Adviser Natural Environment, Forestry Services, Forestry Commission England, 620 Bristol Business Park, Bristol BS16 1EJ, UK*

PAUL M. DOLMAN, *School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*

The Journal of Wildlife Management 77(4):726–736; 2013;

ABSTRACT Hyper-herbivory following predator removal is a global issue.

A global carbon and nitrogen isotope perspective on modern and ancient human diet

PNAS 2021 Vol. 118 No. 19 e2024642118

Michael I. Bird[a,b,1], Stefani A. Crabtree[c,d], Jordahna Haig[a,b], Sean Ulm[a,e], and Christopher M. Wurster[a,b]

Humans have been shown, through their hyper-omnivory and prey-switching ability, to have consumed a wider variety of organisms than any other taxon in their respective systems (4, 59).

Integrity

an obsession with being first

(what is the only valid test whether something is true ? if someone else does the same and gets the same result)

Omitting sources or sloppy research

Hibernation in a tropical primate

Even in the wound-down hibernating state, this lemur can warm up without waking up.

NATURE | VOL 429 | 24 JUNE 2004

The Madagascan fat-tailed dwarf lemur, *Cheirogaleus medius*, hibernates in tree holes for seven months of the year, even though winter temperatures rise to over 30 °C. Here we show that this tropical primate relies on a flexible thermal response that depends on the properties of its tree hole: if the hole is poorly insulated, body temperature fluctuates widely, passively following the ambient temperature; if well insulated, body temperature stays fairly constant and the animal undergoes regular spells of arousal. Our findings indicate that arousals are determined by maximum body temperatures and that hypometabolism in hibernating animals is not necessarily coupled to a low body temperature.

Temperate and Arctic hibernators in deep burrows are buffered against fluctuations in cold winter temperatures[1]. Tropical animals, on the other hand, may use poorly insulated sites such as tree holes[2] and so face the problems of recurrent high temperatures and wide daily fluctuations in temperature during the tropical winter.

Our field study of *C. medius* reveals that its body temperature (T_b) during hibernation varies to an extent previously unknown in mammals (for methods, see supplementary information). Most lemurs showed a wide daily fluctuation in T_b of almost 20 °C, which closely followed the air temperature of their tree holes (T_h) in range and rate of change (Fig. 1a); the greatest fluctuation was 24.9 °C, the lowest recorded T_b was 9.3 °C and the highest was 35.9 °C.

The daily ranges and heating rates of T_b and T_h were not significantly different (Table 1), and the difference between T_b and T_h was usually very small (1.81 ± 0.91 °C; $N = 15$, $n = 16{,}560$ where N was the number of animals tested and n the number of data points). This passive thermal response to T_h continued over many weeks or even months and the lemurs remained ectothermic as long as T_b regularly exceeded 30 °C. At no point was hibernation interrupted by periodic euthermic arousals. Such arousals are energetically very expensive, last for 12–24 hours[3,4], and were previously considered to be obligatory during hibernation[5,6].

Some lemurs hibernated in tree holes that were better insulated; their T_b stayed below 30 °C because the ambient temperature fluctuated less. Occasionally, these animals actively raised their T_b above 30 °C after the T_b had increased T_h to its daily maximum (Fig. 1b).

Other lemurs hibernated in well insulated holes in large, thick-walled (over 20 cm) trees (*Commiphora guillaumini*) where there were only minor fluctuations in T_h during the day and T_b stayed at about 25 °C for many days (Fig. 1c). Unlike the other lemurs, these animals had an arousal with an increase in T_b about once a week (6.7 ± 3.9 d). Compared with arousals in temperate and Arctic hibernators, however, these were short: T_b was maintained above 33 °C for less than 6 h.

The amplitude of T_b during arousals was comparable to the daily T_b amplitude of passively thermoregulating lemurs in poorly

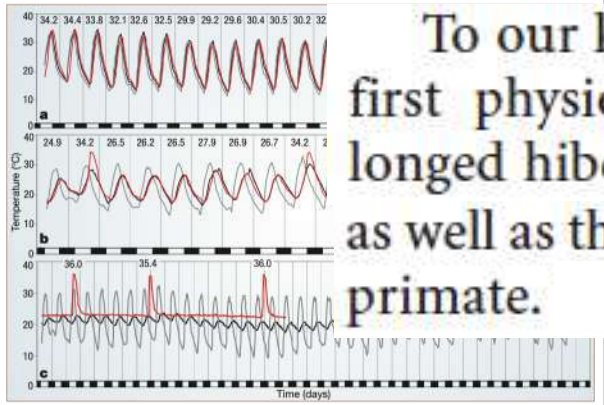


Figure 1 Body temperature of *Cheirogaleus medius* during the hibernation p… continuously in tree holes that were **a**, poorly insulated, measured over 24 d; **b** … insulated (*Commiphora guillaumini*; 18 d and 17 d; tree-hole temperature was … fluctuations than animal temperature). Vertical lines, midnight; black bars, dark … temperature. Numbers (top) give the daily maximum body temperature (**a**, **b**) or t…

Table 1 **Comparison of heating phases in hibernating lemurs**

	N	n	Amplitude (°C)	Heating time (h:min)	Heating rate (°C per h)
T_h	24	1,003	12.4 ± 4.1	8:49 ± 0:52	1.4 ± 0.6
T_b	30	1,423	12.5 ± 3.3	9:09 ± 0:44	1.4 ± 0.4
T_b*	5	25	12.0 ± 1.8	3:42 ± 0:43†	3.4 ± 1.0†
X^2			0.22	15.34	13.08
P			> 0.05	< 0.01	< 0.01

Features of heating phases are shown with daily fluctuations, measured from daily minima to daily maxima during the hibernation period, for tree-hole temperature (T_h) and body temperature (T_b) of *Cheirogaleus medius*, both in poorly insulated tree holes, and for the body temperature of *C. medius* (T_b*) in well insulated tree holes during arousal. N, number of different animals tested; n, number of data points analysed, pooled for all animals tested.
† Post-hoc multiple comparisons following Kruskal–Wallis test showed T_b* differed significantly from T_h and T_b.

To our knowledge, our findings are the first physiological confirmation of prolonged hibernation by a tropical mammal as well as the first proof of hibernation in a primate.

Joanna Fietz · Jörg U. Ganzhorn

Feeding ecology of the hibernating primate *Cheirogaleus medius*: how does it get so fat?

Oecologia (1999) 121:157–164

fall below 10°C (Ganzhorn and Sorg 1996). *C. medius* is exceptional among primates, because it spends up to 7 months hibernating in tree holes (Hladik et al. 1980; Petter 1978; Petter-Rousseaux 1980). Animals emerge from hibernation in November and mate at the beginning of the rainy season during December (Fietz 1999; Hladik et al. 1980). After a gestation period of 61–64 days (Foerg 1982), females usually give birth to two young. In April, adults start hibernating after accumulating a great quantity of fat (Hladik et al. 1980; Petter 1978; Petter et al. 1977; Petter-Rousseaux 1980). The fat-tailed dwarf

first physiological confirmation of prolonged hibernation by a tropical mammal

Integrity

justifying your work

Conceptualizing science: two types

storytellers

historians of all scales: **history of mankind, all life, the universe**

explainers of all scales:

function of atoms, concepts, organs, organisms, ecosystems, the universe

engineers

applied sciences

& preparing basic research

patents, solutions, products, procedures

medicine, pharmacists, engineers, architects, agriculturists, lawyers, conservationists

this is not a distinction between humanities/arts and natural sciences

Conceptualizing science: two types

storytellers

historians of all scales: history of mankind, all life, the universe

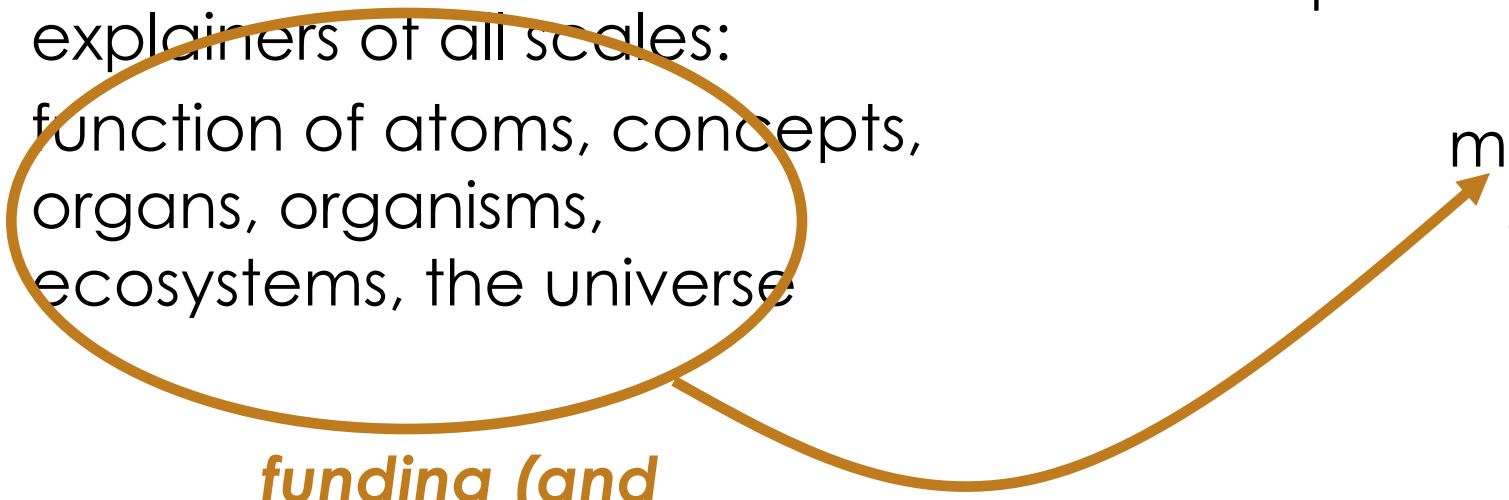
explainers of all scales: function of atoms, concepts, organs, organisms, ecosystems, the universe

engineers

applied sciences & preparing basic research

patents, solutions, products, procedures

medicine, pharmacists, engineers, architects, agriculturists, lawyers, conservationists



funding (and justification) for this ...

... by claiming this

ORIGINAL RESEARCH

Ecology and Evolution Open Access WILEY

Effects of diet, habitat, and phylogeny on the fecal microbiome of wild African savanna (*Loxodonta africana*) and forest elephants (*L. cyclotis*)

Kris Budd[1] | Joe C. Gunn[1] | Tabitha Finch[1,2] | Katy Klymus[1,3] | Noah Sitati[4] | Lori S. Eggert[1]

Ecology and Evolution. 2020;10:5637–5650.

We found 58 bacterial orders, representing 16 phyla, across all African elephant samples. The most common phyla were Firmicutes, Proteobacteria, and Bacteroidetes. The microbiome of *L. africana* was dominated by Firmicutes, similar to other hindgut fermenters, while the microbiome of *L. cyclotis* was dominated by Proteobacteria, similar to more frugivorous species. Alpha diversity did not differ across species, habitat type, or diet, but beta diversity indicated that microbial communities differed significantly among species, diet types, and habitat types. Based on predicted KEGG metabolic pathways, we also found significant differences between species, but not

Understanding the digestive capabilities of these elephant species could aid in their captive management and ultimately their conservation.

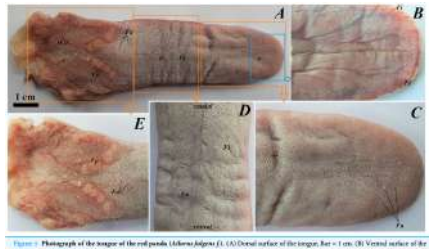
Intelligence insults

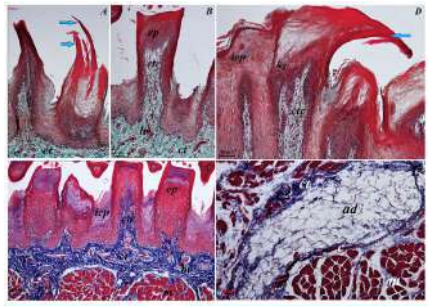
Intelligence insults

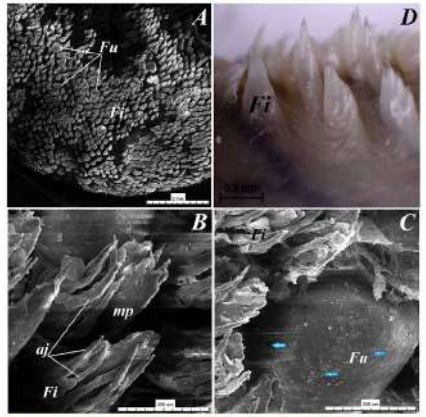
(2021), *PeerJ*, DOI 10.7717/peerj.12559

The tongue of the red panda (*Ailurus fulgens fulgens* Cuvier, 1825)—a stereoscopy, light microscopy and ultrastructural analysis

Karolina Goździewska-Harłajczuk[1], Pavla Hamouzová[2], Joanna Klećkowska-Nawrot[1] and Petr Čížek[3]







The results of these studies may be useful especially for veterinarians specializing in working with exotic animals and people dealing with wildlife conservation.

Integrity

blatantly insulting the readerships' intelligence

J. Dairy Sci. 100:2395–2403
https://doi.org/10.3168/jds.2016-11607

Influence of breed, milk yield, and temperature-humidity index on dairy cow lying time, neck activity, reticulorumen temperature, and rumination behavior

A. E. Stone,* B. W. Jones,† C. A. Becker,† and J. M. Bewley†[1]

ABSTRACT

The objective of this study was to compare weekly mean lying time (LT), neck activity (NA), reticulorumen temperature (RT), and rumination time (RU) among 3 breed groups, milk yield (MY), and temperature-humidity index (THI). Cows (n = 36; 12 Holstein, 12 crossbred, and 12 Jersey) were blocked by parity group (primiparous or multiparous), days in milk, and MY. Lying time, NA, RT, RU, and MY were recorded and averaged by day and then by week for each cow. For study inclusion, each cow was required to have 10 wk of LT, NA, RT, and RU data. Maximum THI were recorded and averaged daily. Mean (±SE) days in milk, LT, MY, RT, RU, NA, and maximum THI were 159.0 ± 6.0 d, 11.1 ± 0.1 h/d, 28.7 ± 0.5 kg/d, 38.8 ± 0.0°C, 6.4 ± 0.1 h/d, 323.8 ± 3.8 activity units, and 56.5 ± 0.6, respectively. The MIXED Procedure of SAS (SAS Institute Inc., Cary, NC) was used to evaluate fixed effects of breed, MY, parity, THI, and their interactions on LT, NA, RT, and RU with cow nested within breed as subject. All main effects remained in each model regardless of significance level. Stepwise backward elimination was used to remove nonsignificant interactions. The interactions of breed × parity group and maximum THI × parity group were associated with RT. Increasing THI coincided with increasing RT. Least squares means LT for multiparous cows was significantly greater than LT for primiparous cows (11.4 ± 0.3 and 10.5 ± 0.5 h/d, respectively). Least squares means NA for primiparous cows was greater than for multiparous cows of all breeds (372.1 ± 10.9 and 303.4 ± 7.8, respectively). The CORR Procedure of SAS was used to evaluate relationships among RT, RU, LT, NA, and MY. Rumination time was positively correlated with MY (r = 0.30) and negatively correlated with LT (r = −0.14). Reticulorumen temperature was negatively correlated with MY (r = −0.11). Rumination time was positively correlated with NA (r = 0.18) and negatively correlated with LT (r = −0.14). Lying time and NA were negatively correlated (r = −0.43). Neck activity was positively correlated with MY (r = 0.14). Lying time was negatively correlated with MY (r = −0.25). Milk yield was associated with RU, which may be related to cows with greater MY also having a greater feed intake. Lying time increased and NA decreased with increasing parity, which may be effects of social hierarchy, where primiparous cows are more susceptible to being pushed away from the feed bunk and freestalls. Milk yield was positively associated with RU. Greater milk production requires greater feed intake, which may result in longer RU than for low-yielding cows. Lying time decreased as milk yield increased. The behavioral and physiological differences observed in this study provide new insight into the effects that breed, parity, MY, and THI have on cows.

Key words: breed, precision dairy farming

Intelligence insults

Intelligence insults

frontiers | Frontiers in Microbiology

Characterising the Gut Microbiomes in Wild and Captive Short-Beaked Echidnas Reveals Diet-Associated Changes

Tahlia Perry[1,2], Ella West[1], Raphael Eisenhofer[2], Alan Stenhouse[1], Isabella Wilson[1], Belinda Laming[3], Peggy Rismiller[1,4], Michelle Shaw[1,5] and Frank Grützner[1,2]**

[1]The Environment Institute, School of Biological Sciences, The Univer
Excellence for Australian Biodiversity and Heritage, The University of A
Perth, WA, Australia, [4]Pelican Lagoon Research and Wildlife Centre, A
Centre, Taronga Conservation Society Australia, Mosman, NSW, Aust

OPEN ACCESS

Edited by:
David William Waite,
Ministry for Primary Industries,
New Zealand

Reviewed by:
Alice Risely,
Deakin University, Australia
Rochelle Soo,
The University of Queensland,
Australia

***Correspondence:**
Tahlia Perry
tahlia.perry@adelaide.edu.au
Frank Grützner
frank.grutzner@adelaide.edu.au

Specialty section:
This article was submitted to Microbial Symbioses, a section of the journal Frontiers in Microbiology

Received: 29 March 2021
Accepted: 16 May 2022
Published: 30 June 2022

Citation:
Perry T, West E, Eisenhofer R, Stenhouse A, Wilson I, Laming B, Rismiller P, Shaw M and Grützner F (2022) Characterising the Gut Microbiomes in Wild and Captive Short-Beaked Echidnas Reveals Diet-Associated Changes. Front. Microbiol. 13:687115. doi: 10.3389/fmicb.2022.687115

The gut microbiome plays a vital role in health and
number of studies are investigating microbiome ch
to improve conservation and welfare. The short-be
is an iconic Australian species, the most widespre
in zoos. Echidnas are cryptic animals, and much
their biology. Furthermore, some wild echidna pop
held in captivity can have severe gastric health p
and zoos to collect echidna scats from across
microbiome study on any native Australian animal
of scat samples, we characterised and compare
wild ($n = 159$) and managed ($n = 44$) populations,
echidna samples were highly variable, yet cor
fermenting bacteria, while echidnas in captivity w
plant-fermenting bacteria, suggesting plant matte
diet. This work demonstrates significant difference
as well as managed animals on different diets, re
the gut microbiomes in echidnas. This first analysis of echidna gut microbiome highlights
extensive microbial diversity in wild echidnas and
managed populations. This is a first step toward
understand diet, gastrointestinal biology, and impro

Keywords: EchidnaCSI, Australia, captive, herbivore, insects, n

INTRODUCTION

The influence of the gut microbiome on host heal
with many diseases and health problems associated
diabetes, and bowel disease (Turnbaugh et al., 2006;
and Blaser, 2012). How microbiomes affect the healt

Here, we used citizen science and zoos to collect echidna scats from across Australia to perform the largest gut microbiome study on any native Australian animal.

This first analysis of echidna gut microbiome highlights

Here, we present the first comparative gut microbiome study for wild and managed populations of echidnas, which is the largest and most geographically spread microbiome study of any Australian mammal to date.

This study is the first characterisation of the short-beaked echidna gut microbiome and the largest geographical microbiome study of any native Australian mammal.

This study investigates, for the first time, the microbial diversity and composition in the echidna gut;

This research has provided new insights and first steps towards understanding gut microbiota of an iconic Australian mammal.

Integrity

language matters

Sentences I would like to read less often

XYZ is a unique species …

… XYZ is vital for our understanding of …

Our study provides new insights into …

This study is the first to …

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

Competing interests. We declare we have no competing interests.

The historical development of juvenile mortality and adult longevity in zoo-kept carnivores

Zoo Biology. 2021;40:588–595.

Marco Roller[1] | Dennis W. H. Müller[2] | Mads F. Bertelsen[3] | Laurie Bingaman Lackey[4] | Jean-Michel Hatt[5] | Marcus Clauss[5]

CONFLICT OF INTERESTS

All authors are either employed by, or have major involvement with, zoological gardens.

Integrity

what do journal choices reveal ?

Predatory publishing

animals

Journal of Zoological and Botanical Gardens

MDPI

nutrients

ruminants

Predatory publishing

MDPI

From Wikipedia, the free encyclopedia

MDPI or **Multidisciplinary Digital Publishing Institute** is a publisher of open access scientific journals. Founded by **Shu-Kun Lin** as a chemical sample archive, it has established over 200 broad-scope journals.[2] MDPI is the largest open access publisher in the world and the fifth largest publisher overall in terms of journal paper output.[3] The number of published papers has been growing significantly in the last decade with year over year growth of over 50% in 2017, 2018 and 2019.[3]

As of December 2021, MDPI publishes 379 academic journals, including 83 with an impact factor out of 93 covered by the Science Citation Index Expanded.[4] Eight journals are indexed in the Social Sciences Citation Index.[5] MDPI journals are currently included in the Directory of Open Access Journals.[6] MDPI is a member of the Open Access Scholarly Publishers Association,[7] a participating publisher and supporter of the Initiative for Open Citations,[8] and a member of the Committee on Publication Ethics (COPE).[9]

MDPI's business practices have resulted in significant growth but have attracted criticism, with controversies related to the quality of its peer reviews and accusations of subordination of academic functions to business interests.[10][11][12][13] The publisher's business model is based on establishing entirely open access broad-discipline journals, with fast processing times from submission to publication and article processing charges paid by the author.[3] MDPI was included on Jeffrey Beall's list of predatory open access publishing companies in 2014[12][14] but was removed in 2015 following a successful appeal[13] and applying pressure to Beall's employer.[15] In 2021 five MDPI journals were among the initial 13 journals included in the Norwegian Scientific Index as possibly predatory journals, known as level X;[16] the publisher of the list, the National Publication Committee of Norway, linked its creation specifically to the expressions of concern regarding MDPI.[17] Since 2017, MDPI has a book publisher-level rating of "level 1" in the Norwegian Scientific Index, the standard rating designating a publisher as academic.[18]

MDPI AG

Status	Active
Founded	1996
Country of origin	Switzerland
Headquarters location	Basel, Switzerland
Distribution	Worldwide
Key people	Shu-Kun Lin
Publication types	Open access scientific journals
No. of employees	3536 (in 2020)[1]
Official website	www.mdpi.com

Predatory publishing

2018 Resignation of *Nutrients* editors

In August 2018, 10 senior editors (including the editor-in-chief) of the journal *Nutrients* resigned, alleging that MDPI forced the replacement of the editor-in-chief because of his high editorial standards and for resisting pressure to "accept manuscripts of mediocre quality and importance."[11]

Predatory publishing

Withdrawal of support by the Faculty of Science of the University of South Bohemia

In December 2021, the Faculty of Science of the University of South Bohemia in České Budějovice announced that it will stop financial support for publishing in MDPI journals, officially recommended against publishing in or reviewing for MDPI, and warned that publications in MDPI journals might not be taken into account for evaluations of employees and departments.[34]

Predatory publishing

Inclusion in Early Warning List of the Chinese Academy of Sciences

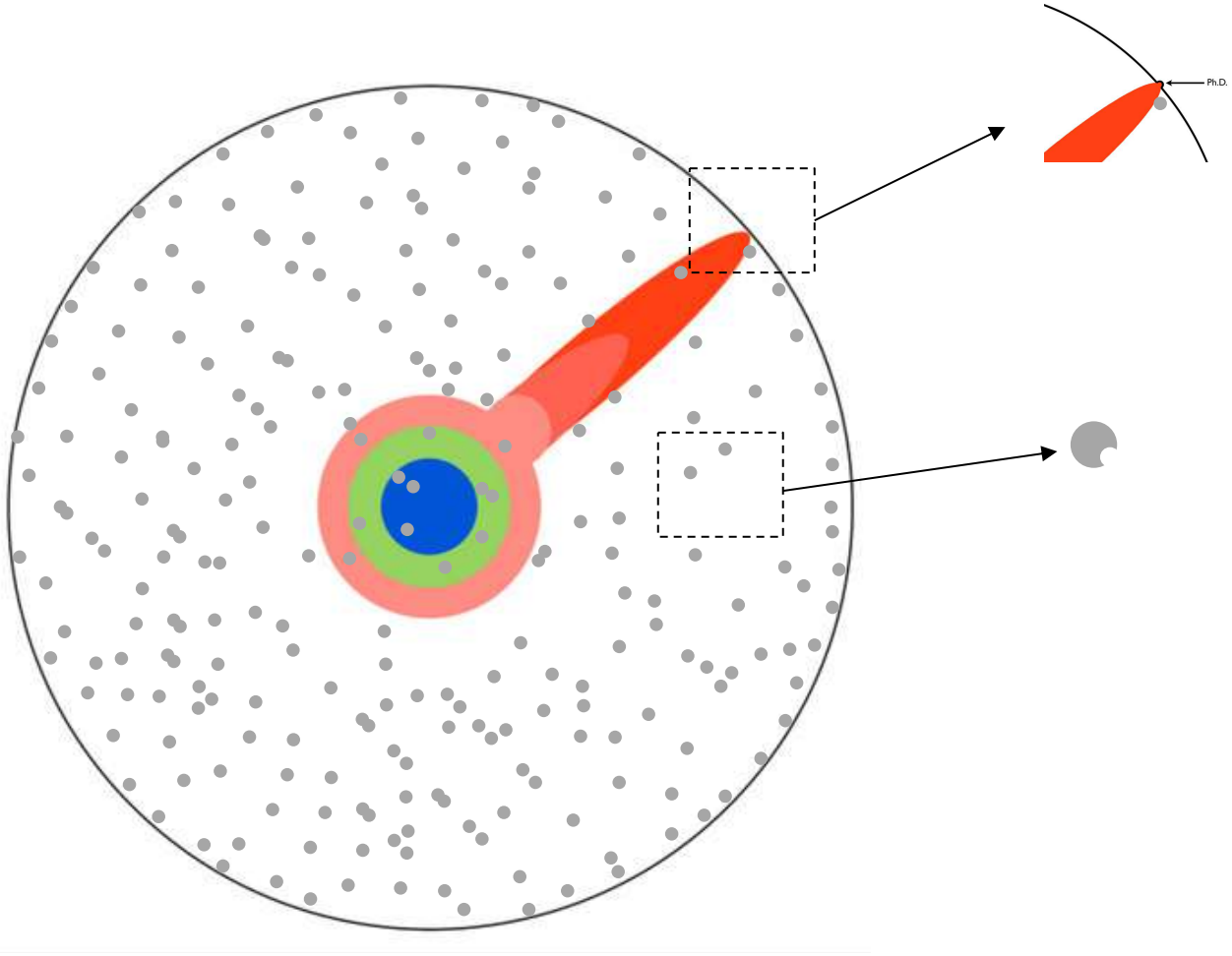
In December 2020, the Chinese Academy of Sciences published a list of journals that may suffer from issues of scientific quality and other risk characteristics.[35] There were 22 MDPI group journals in the 65 journals given in its initial list. MDPI responded to the list promising to communicate with the academy and improve its journals' parameters to remove the affected journals from the list as soon as possible.[36] The list was updated in December 2021 and reduced to only 41 journals, of which seven MDPI journals were included.[37]

Predatory publishing

Assessments in the Nordic countries

The National Publication Committee of Norway has assigned MDPI a book-publisher level rating of "1" in the Norwegian Scientific Index since 2017, the standard rating designating a publisher as academic.[18] Individual MDPI journals have separate journal-level ratings. As of 2021, 188 MDPI journals are listed in the Norwegian Scientific Index of which 173 have a rating of "level 1", 5 have a rating of "level X" and 10 have a rating of "level 0."[18] In 2021 the National Publication Committee of Norway conducted a survey of how MDPI is perceived among Norwegian researchers. It showed that many are outraged at the way authors and reviewers are treated, but that some also appreciate fast and open publishing.[38] In 2021 the executive committee of the National Publication Committee announced the creation of a new level X for possibly predatory journals and publishers, and linked the creation of the new level specifically to the many expressions of concern regarding MDPI.[17] The new level became active in September 2021, and five MDPI journals were among the initial 13 journals included in the level, making MDPI the largest publisher of level X-designated journals; the journals were *Arts*, *Sustainability*, *Geosciences*, *Processes* and *Axioms*.[16]

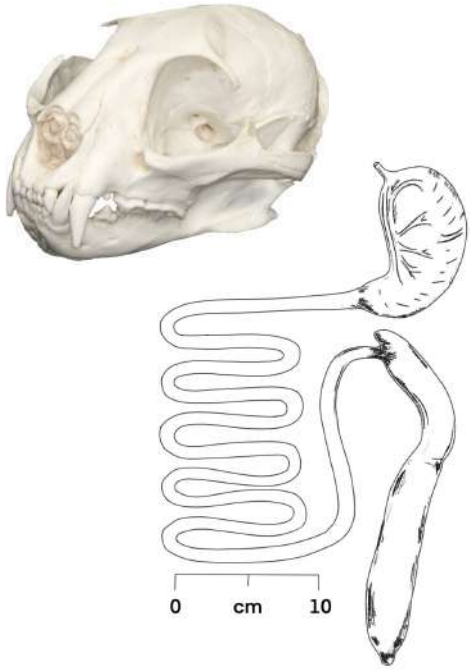
The ***real*** Knowledge Universe

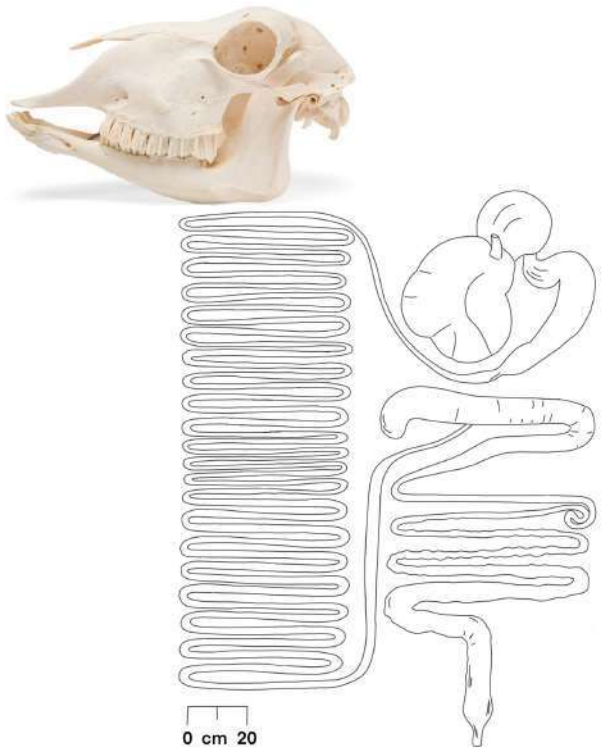


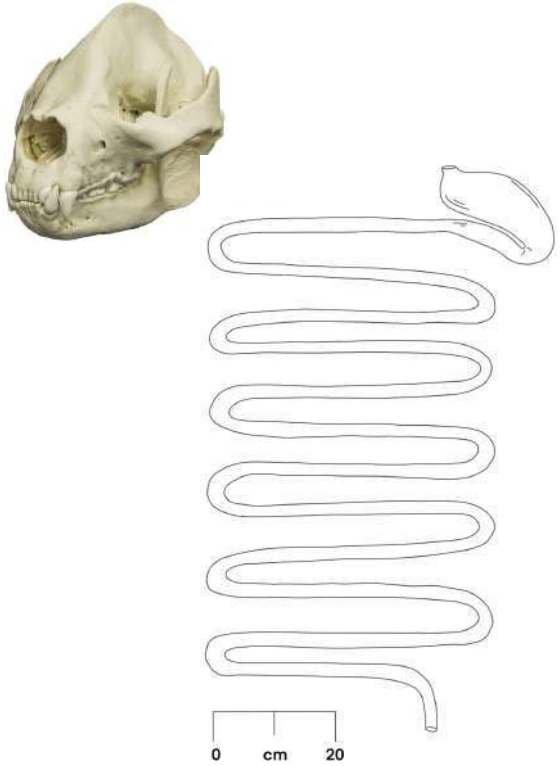
adapted from: The Illustrated Guide to the Ph.D., created by Matt Might (http://matt.might.net/articles/phd-school-in-pictures/; 2012)

Craving for rules

Principle of the correlation of parts

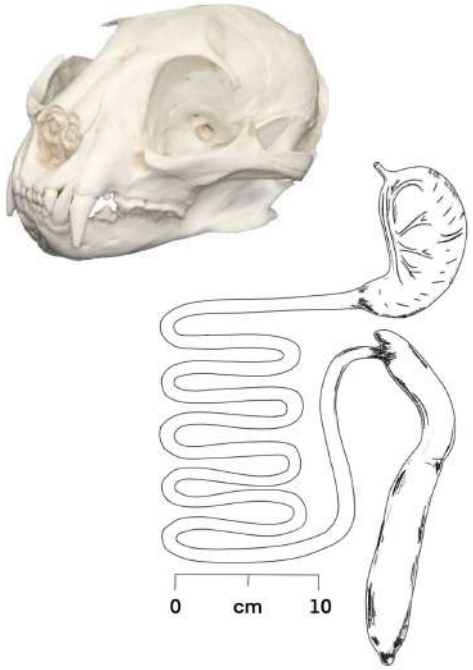


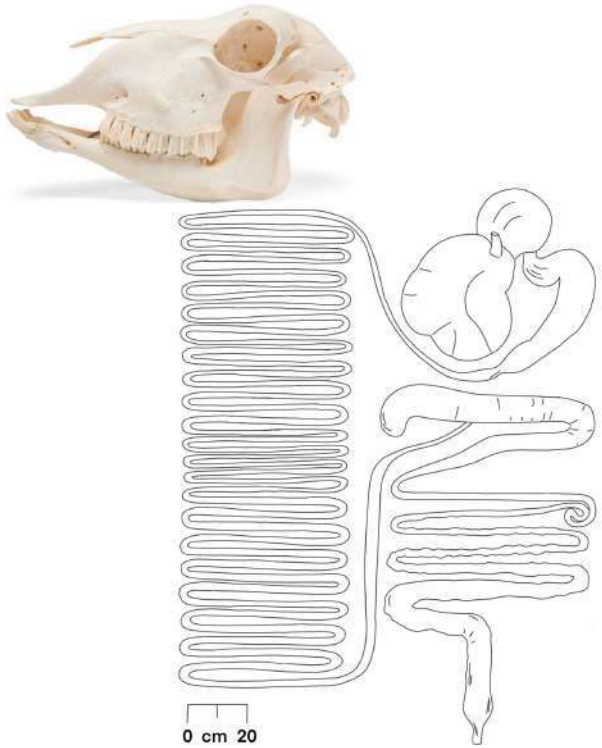


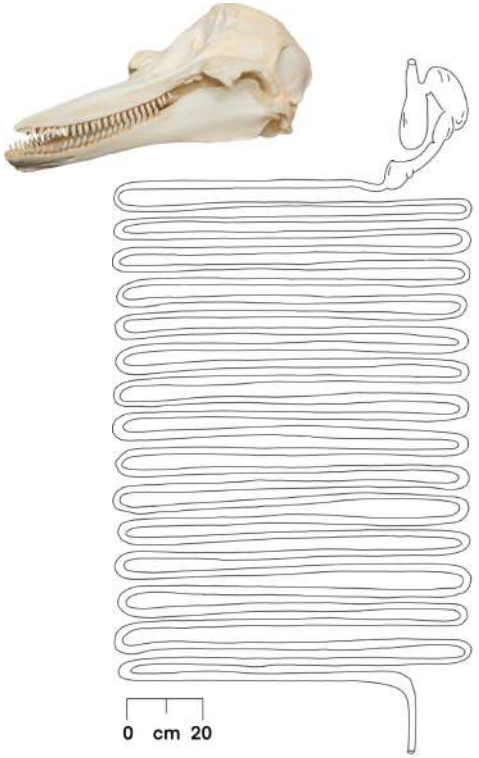


If an animal's teeth are such as they must be, in order for it to nourish itself with flesh, we can be sure without further examination that the whole system of its digestive organs is appropriate for that kind of food, and that its whole skeleton and locomotive organs, and even its sense organs, are arranged in such a way as to make it skilful at pursuing and catching its prey. For these relations are the necessary conditions of existence of the animal; if things were not so, it would not be able to subsist. (Cuvier)

Principle of the correlation of parts



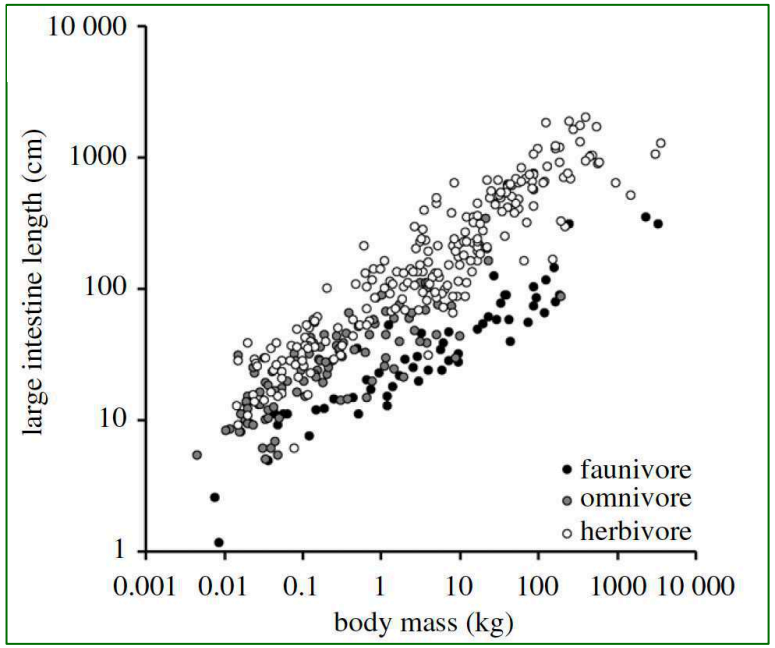




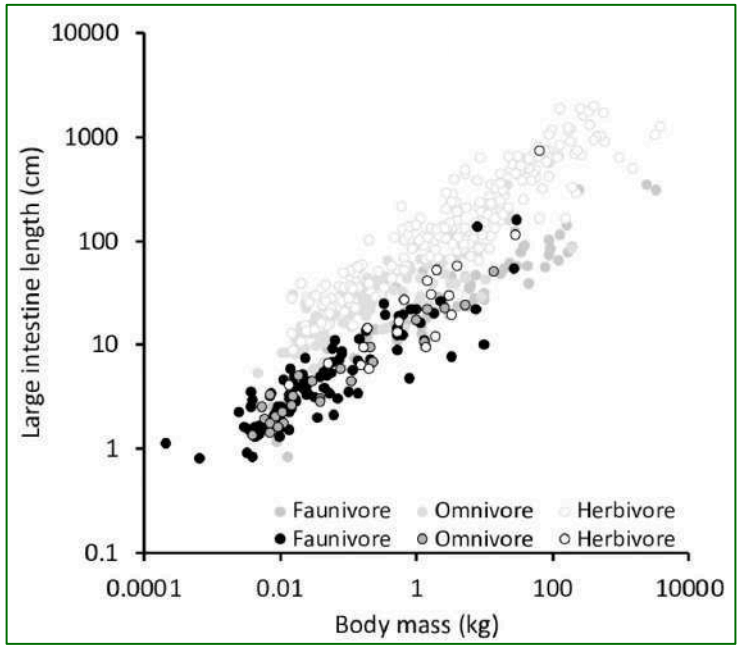
If an animal's teeth are such as they must be, in order for it to nourish itself with flesh, we can be sure without further examination that the whole system of its digestive organs is appropriate for that kind of food, and that its whole skeleton and locomotive organs, and even its sense organs, are arranged in such a way as to make it skllful at pursuing and catching its prey. For these relations are the necessary conditions of existence of the animal; if things were not so, it would not be able to subsist. (Cuvier)


Baleen Whales (Mysticeti)
facing right
WHALES of the WORLD
Whales, Dolphins, & Porpoises (Cetacea)
Toothed Whales (Odontoceti)
facing left
0
10 feet
10 metres

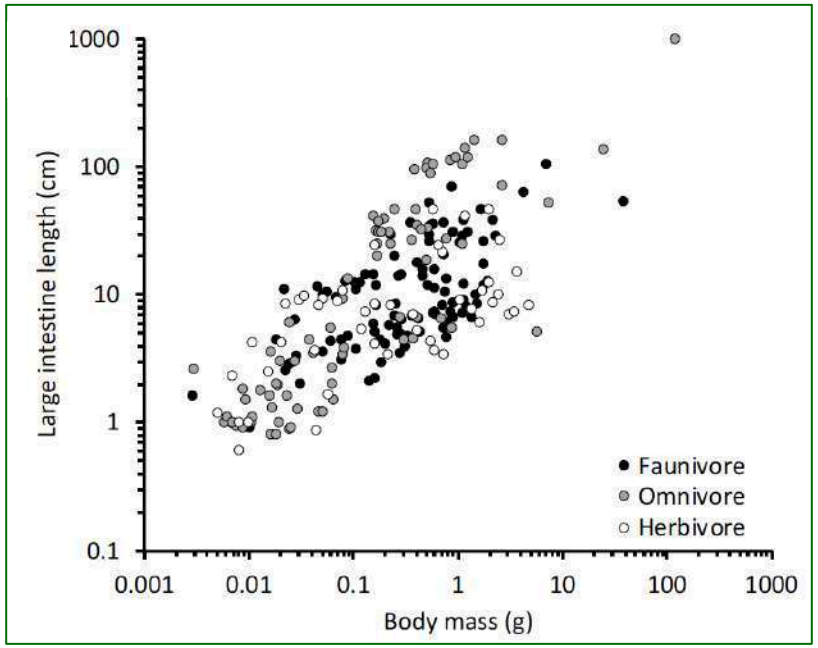
Form-function convergence ?



✔



✘



✘

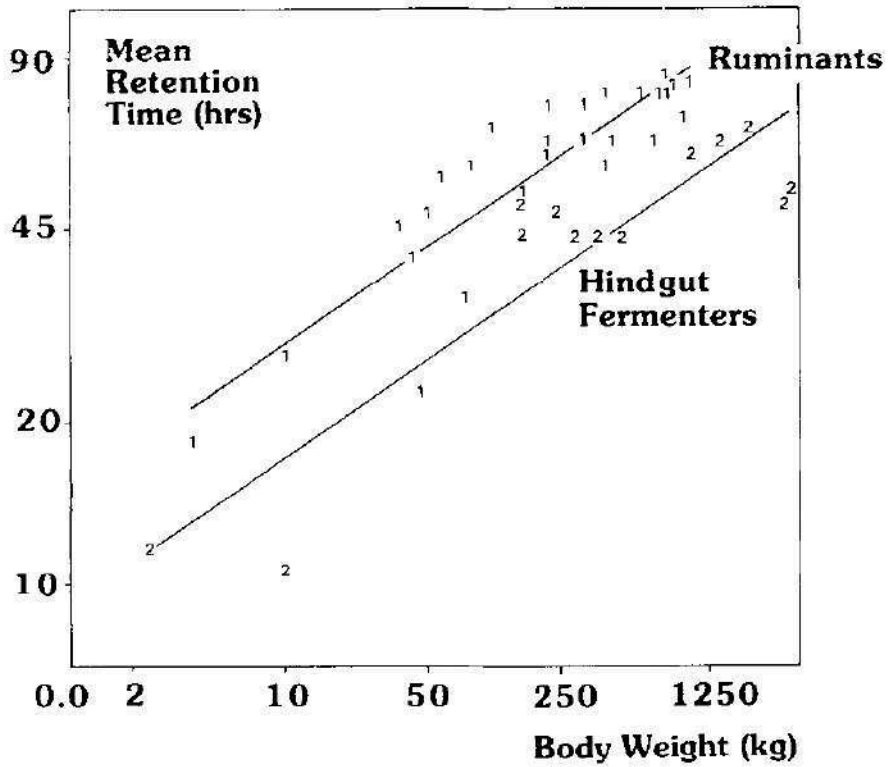
Duque-Correa et al. (2021), Hoppe et al. (2021), Duque-Correa et al. (2022)

The scaling of mammalian retention time

Modelling the nutritional ecology of ungulate herbivores: evolution of body size and competitive interactions

A.W. Illius[1] and I.J. Gordon[2,*] Oecologia (1992) 89:428–434

Allometric relationships between whole gut mean retention time (MRT, h) and weight (W) were: $MRT = 9.4\ W^{0.255}$ ($r^2 = 0.80$) for hindgut fermenters and $MRT = 15.3\ W^{0.251}$ ($r^2 = 0.76$) in ruminants.



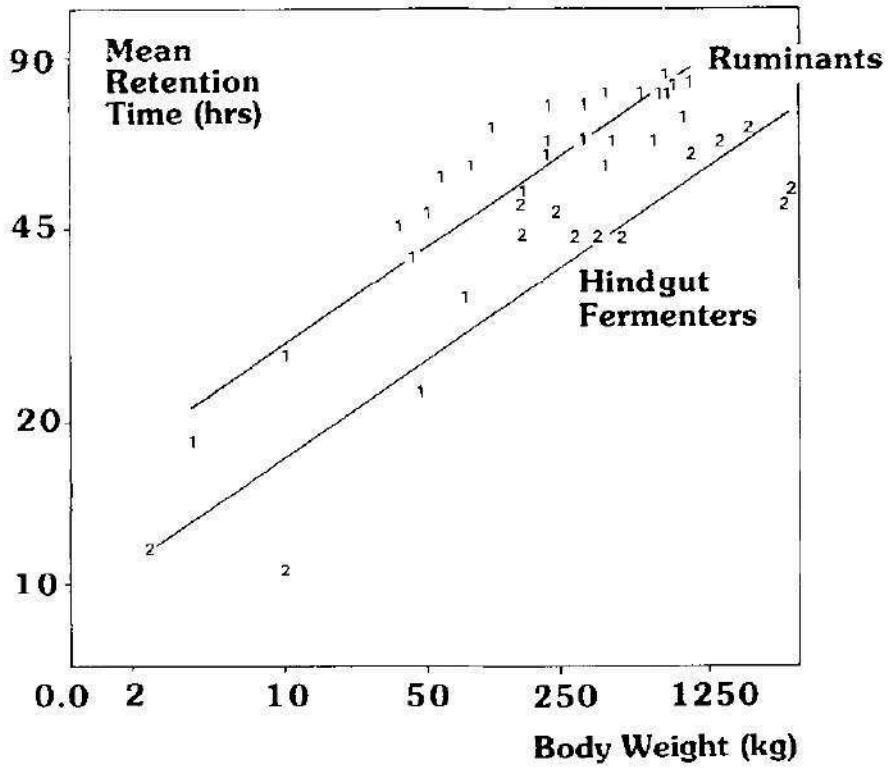
The scaling of mammalian retention time

Modelling the nutritional ecology of ungulate herbivores: evolution of body size and competitive interactions

A.W. Illius[1] and I.J. Gordon[2,*]

Oecologia (1992) 89:428–434

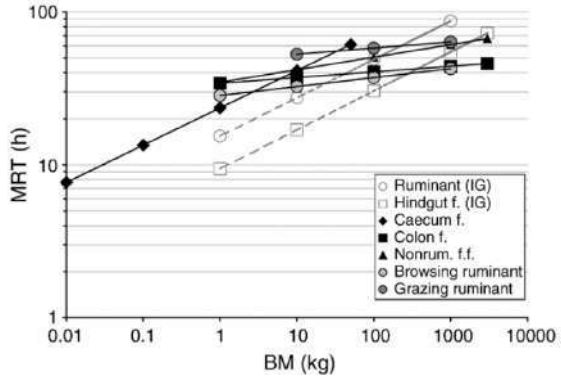
Allometric relationships between whole gut mean retention time (MRT, h) and weight (W) were: $MRT = 9.4\ W^{0.255}$ ($r^2 = 0.80$) for hindgut fermenters and $MRT = 15.3\ W^{0.251}$ ($r^2 = 0.76$) in ruminants.



A case of non-scaling in mammalian physiology? Body size, digestive capacity, food intake, and ingesta passage in mammalian herbivores☆

Marcus Clauss[a,*], Angela Schwarm[b], Sylvia Ortmann[b], W. Jürgen Streich[b], Jürgen Hummel[c]

Comparative Biochemistry and Physiology, Part A 148 (2007) 249–265

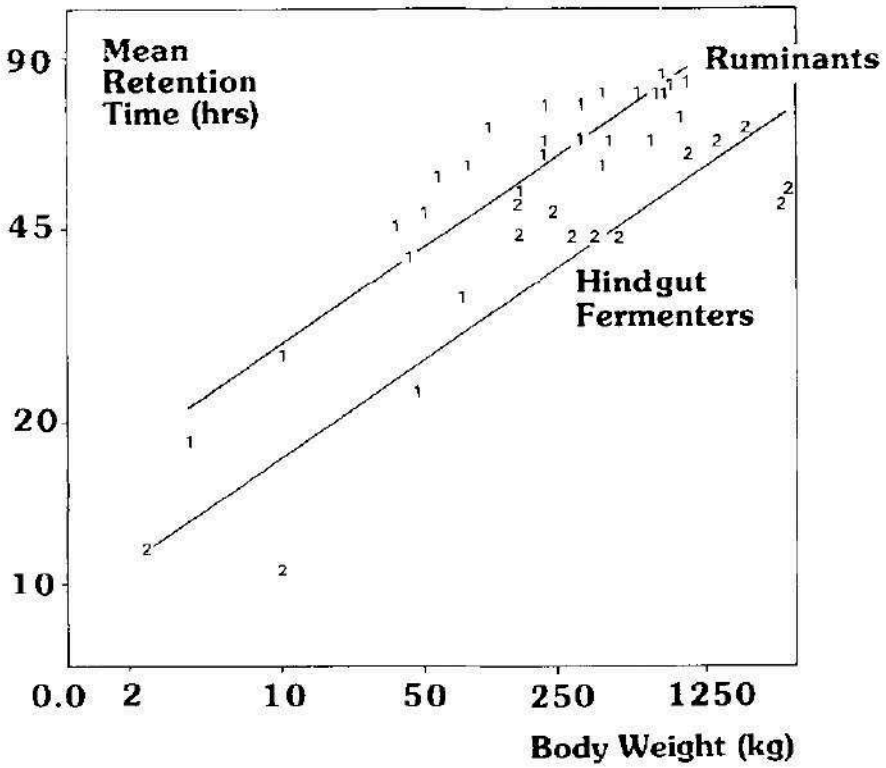


The scaling of mammalian retention time

Modelling the nutritional ecology of ungulate herbivores: evolution of body size and competitive interactions

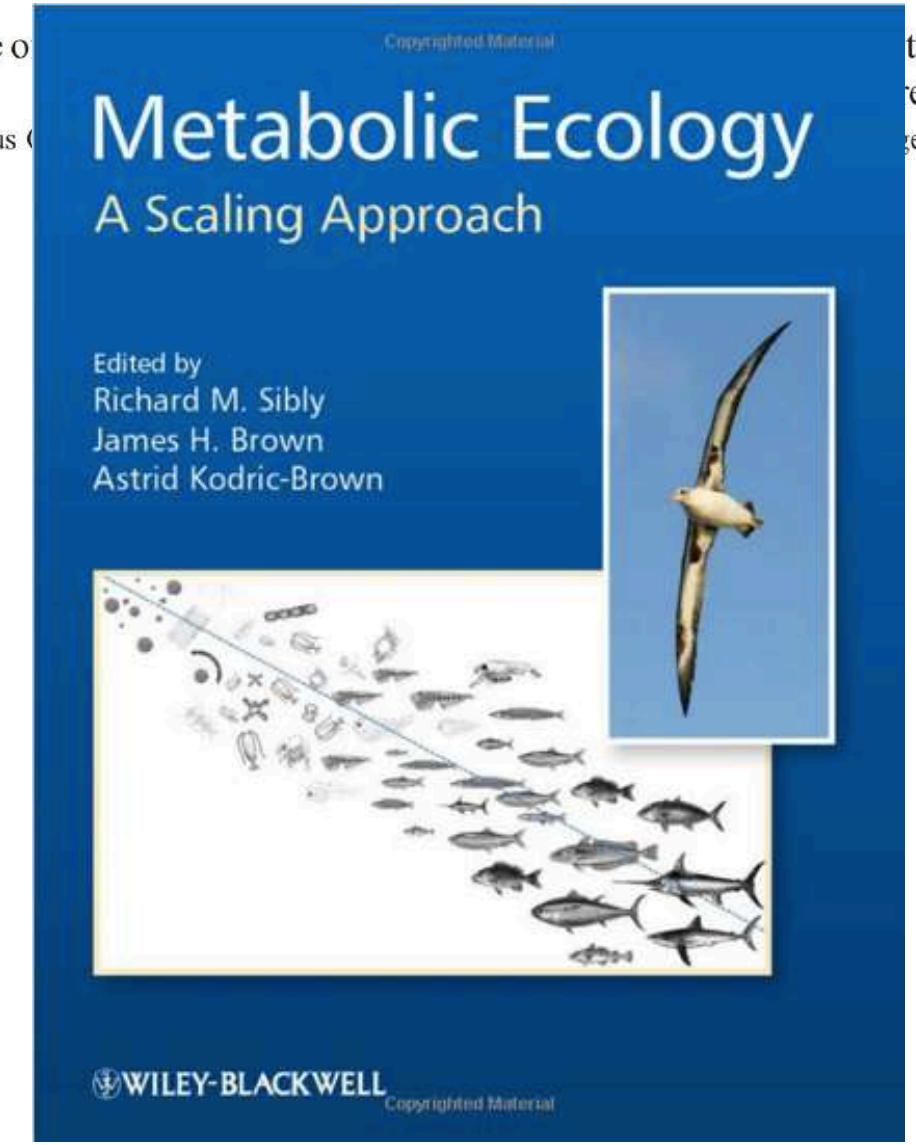
A.W. Illius[1] and I.J. Gordon[2,*] Oecologia (1992) 89:428–434

Allometric relationships between whole gut mean retention time (MRT, h) and weight (W) were: $MRT = 9.4\ W^{0.255}$ ($r^2 = 0.80$) for hindgut fermenters and $MRT = 15.3\ W^{0.251}$ ($r^2 = 0.76$) in ruminants.



A case o ... tive capacity, ... res ☆

Marcus (... gen Hummel [c]



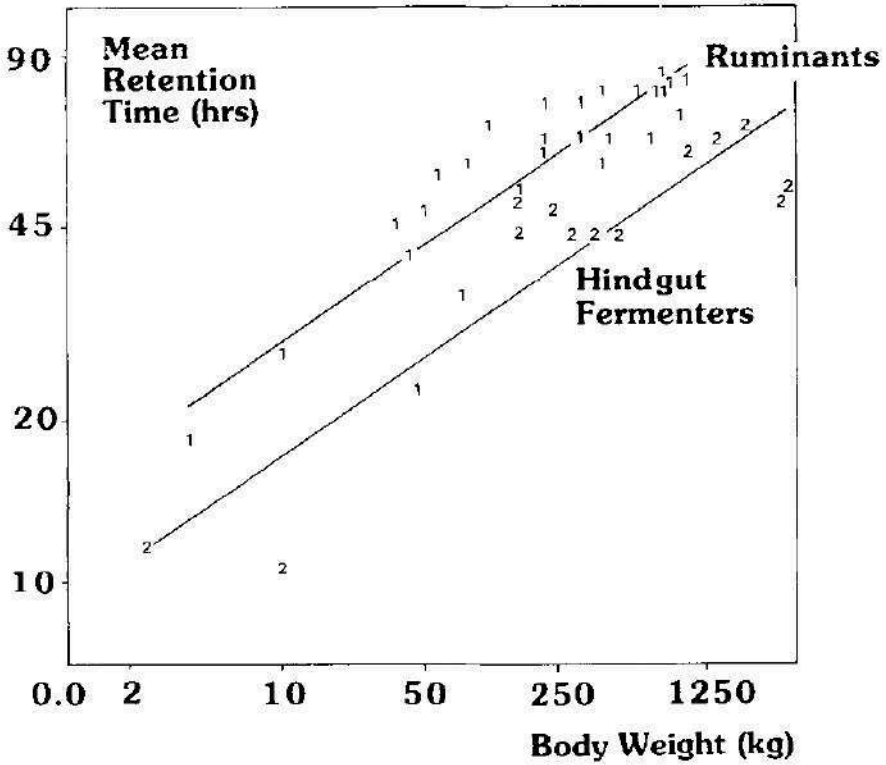
The scaling of mammalian retention time

Modelling the nutritional ecology of ungulate herbivores: evolution of body size and competitive interactions

A.W. Illius[1] and I.J. Gordon[2,*]

Oecologia (1992) 89:428–434

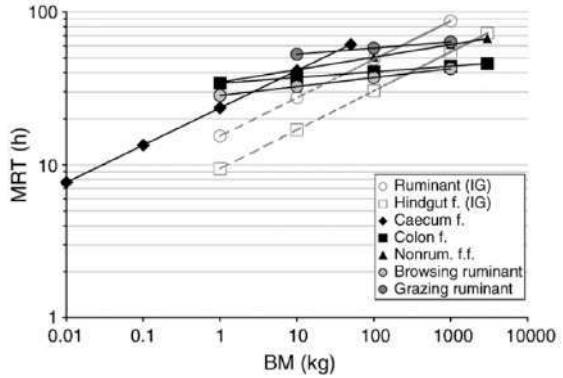
Allometric relationships between whole gut mean retention time (MRT, h) and weight (W) were: $MRT = 9.4\ W^{0.255}$ ($r^2 = 0.80$) for hindgut fermenters and $MRT = 15.3\ W^{0.251}$ ($r^2 = 0.76$) in ruminants.



A case of non-scaling in mammalian physiology? Body size, digestive capacity, food intake, and ingesta passage in mammalian herbivores☆

Marcus Clauss[a,*], Angela Schwarm[b], Sylvia Ortmann[b], W. Jürgen Streich[b], Jürgen Hummel[c]

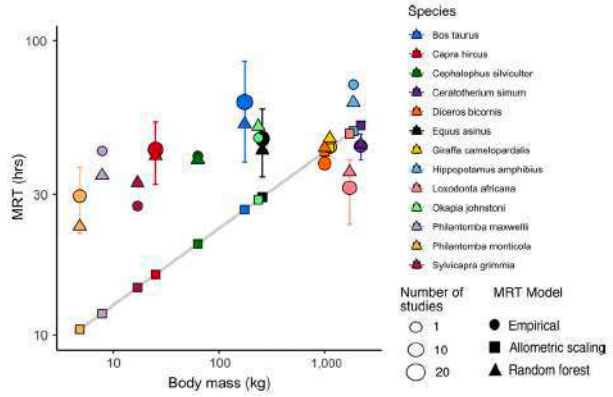
Comparative Biochemistry and Physiology, Part A 148 (2007) 249–265



Improved estimation of gut passage time considerably affects trait-based dispersal models

Functional Ecology. 2021;35:860–869.

Andrew J. Abraham[1,2] | Tomos O. Prys-Jones[1] | Annelies De Cuyper[3] | Chase Ridenour[1] | Gareth P. Hempson[4] | Toby Hocking[1] | Marcus Clauss[5] | Christopher E. Doughty[1]



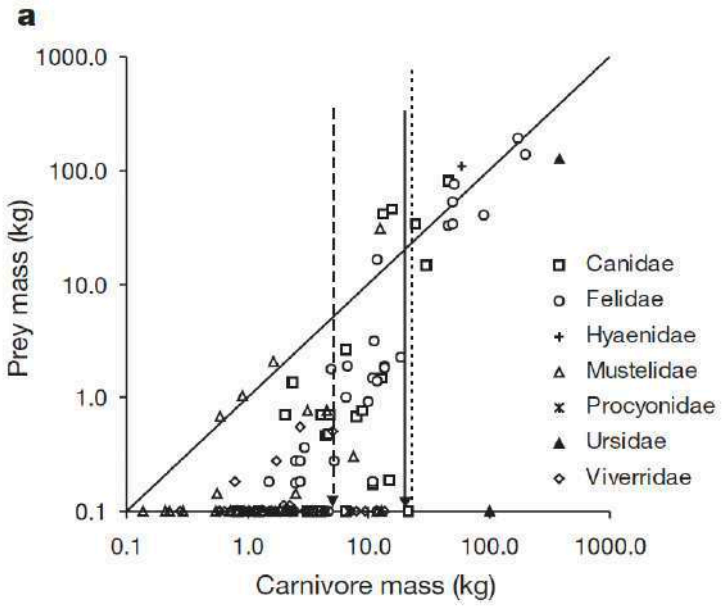
Predator-prey mass scaling

letters to nature

NATURE | VOL 402 | 18 NOVEMBER 1999

Energetic constraints on the diet of terrestrial carnivores

Chris Carbone*†, Georgina M. Mace*, S. Craig Roberts* & David W. Macdonald†



Iterative evolution of large-bodied hypercarnivory in canids benefits species but not clades

Mairin A. Balisi [1,2,3,4]✉ & Blaire Van Valkenburgh [2]

COMMUNICATIONS BIOLOGY | (2020)3:461 |

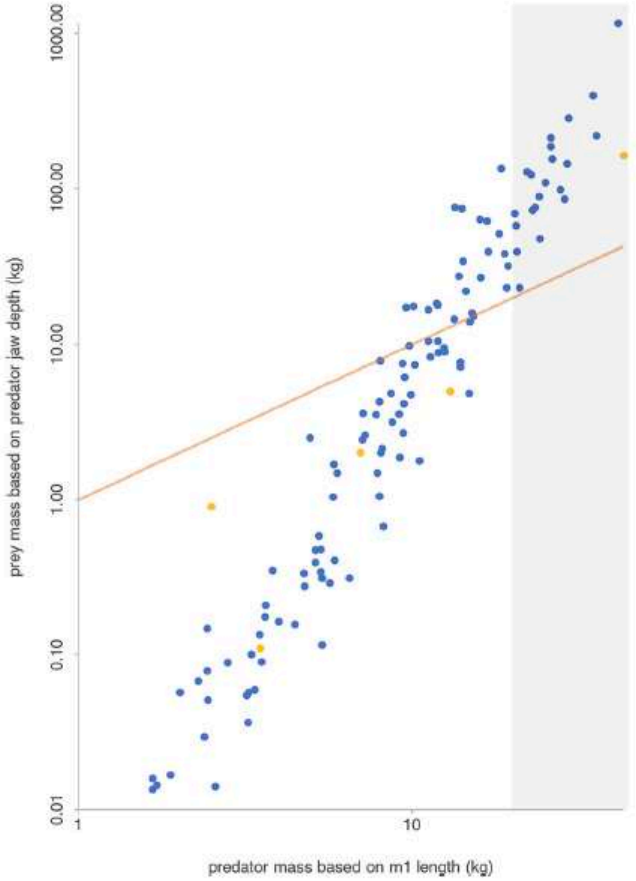
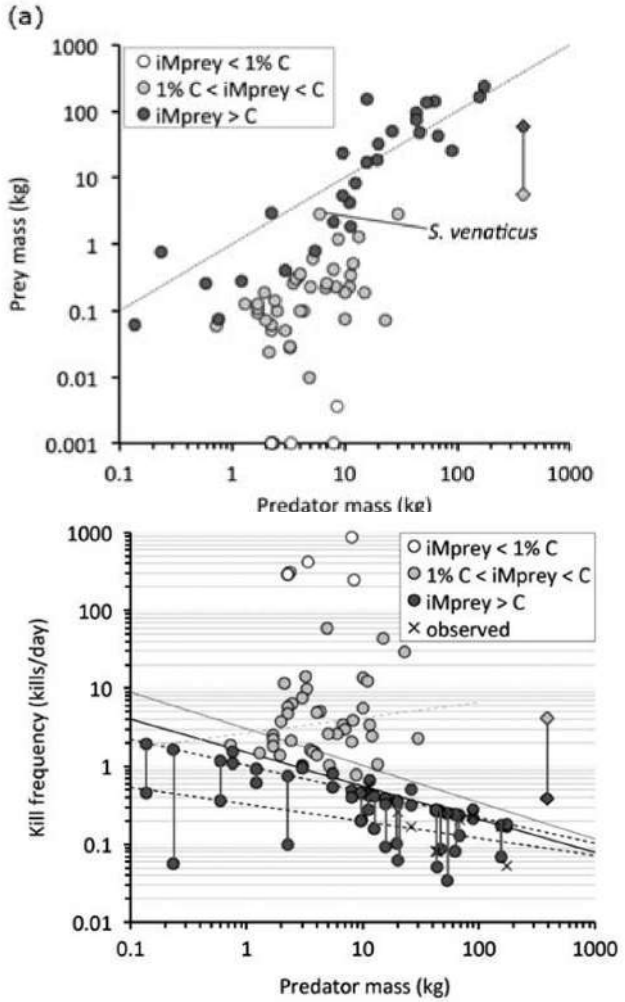


Fig. 1 Plot of typical prey mass (kg) against canid mass (kg) for 130 species of extinct canids (blue points) and five species of extant canids (yellow points).

Predator size and prey size–gut capacity ratios determine kill frequency and carcass production in terrestrial carnivorous mammals

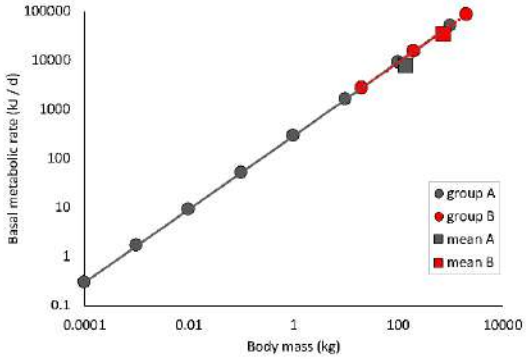
Annelies De Cuyper, Marcus Clauss, Chris Carbone, Daryl Codron, An Cools, Myriam Hesta and Geert P. J. Janssens

Oikos 128: 13–22, 2019



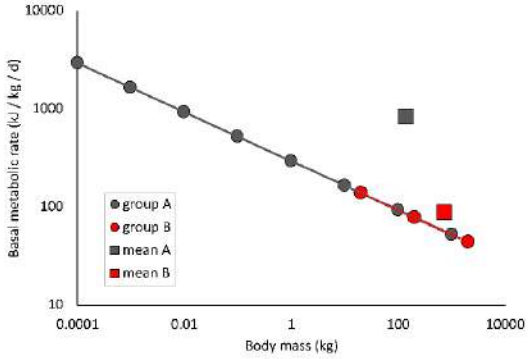
Using incoherent arguments

Metabolism scales to body mass$^{0.75}$



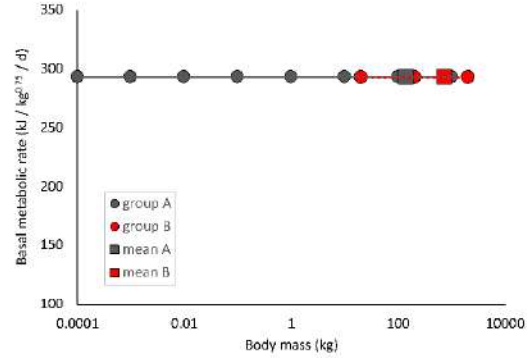
larger animals have higher absolute requirements (in joules (per day))

→ *larger animals need higher-quality food*



larger animals have lower 'mass-specific' requirements (in joules per kg (per day))

→ *larger animals can stand lower-quality food*



all animals have the same requirements (in joules per kg$^{0.75}$ (per day))

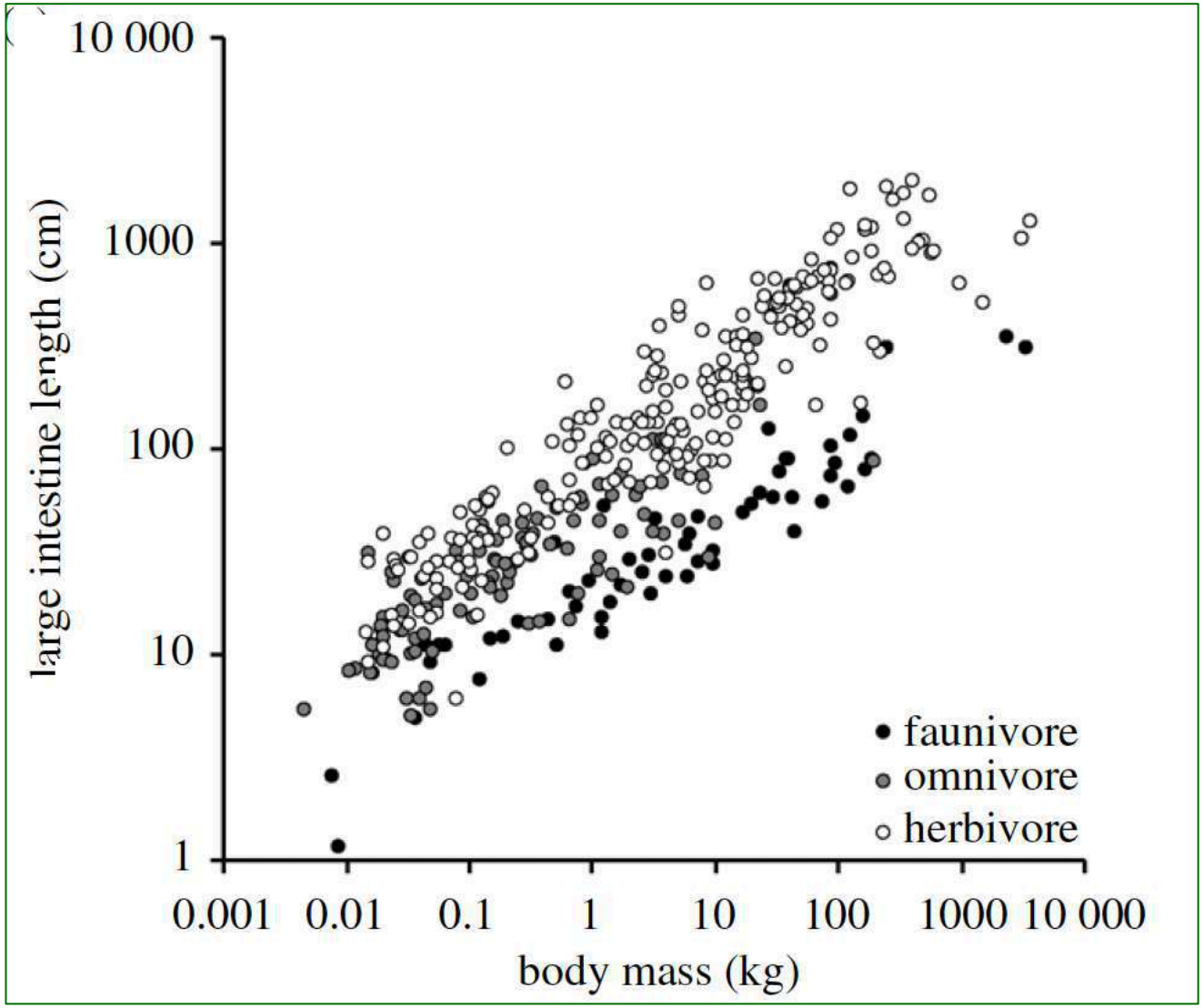
→ *animal size has nothing to do with food quality*

Clauss et al. (2013), Clauss (2019)

Investigating patterns I:

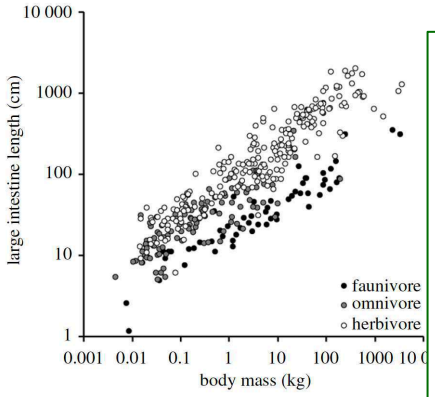
generation

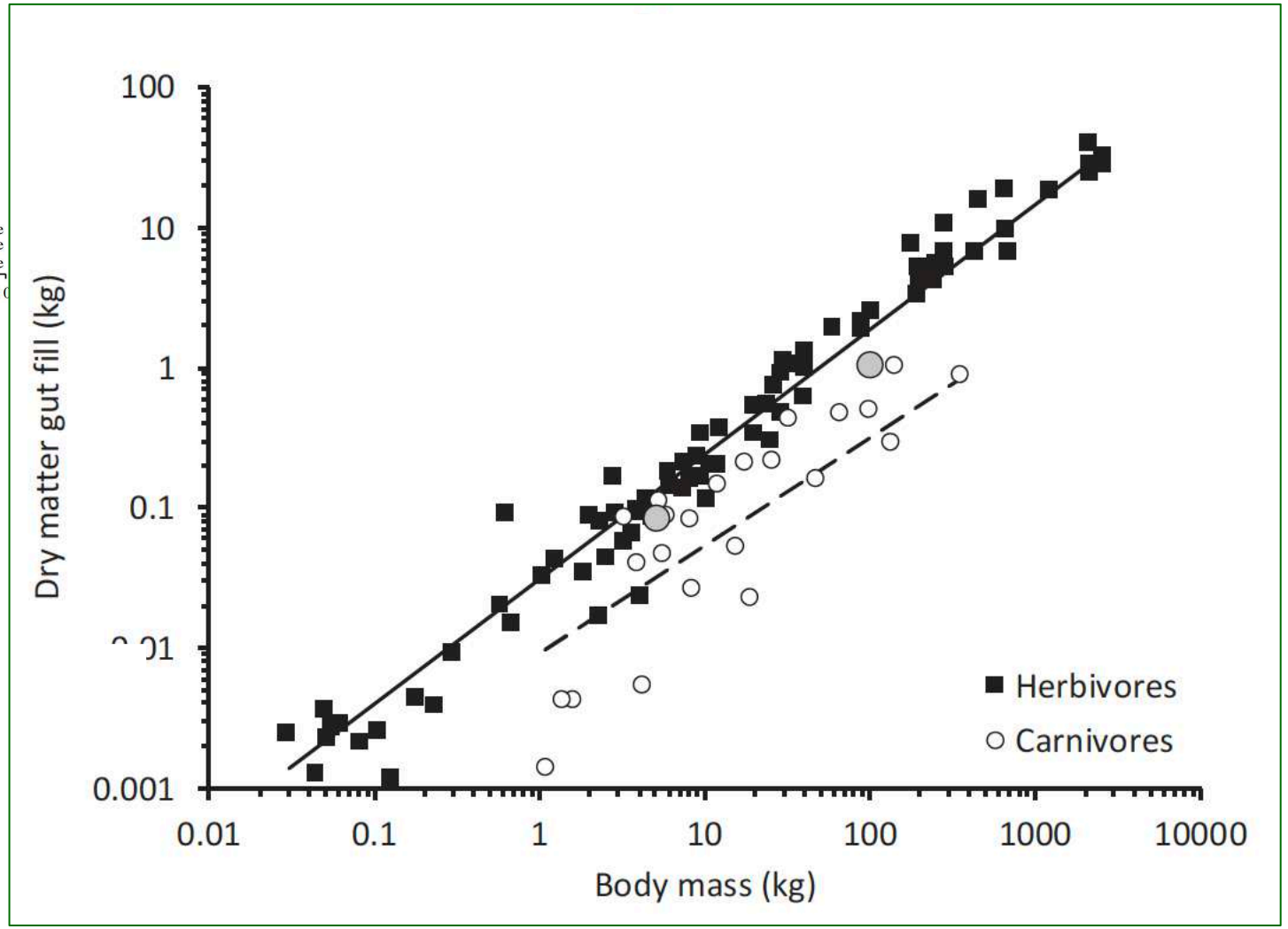
Broad patterns: anatomy



Duque-Correaa et al. (2021)

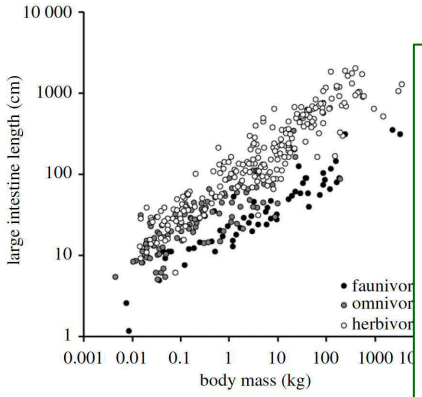
Broad patterns: anatomy, digestive physiology (gut fill

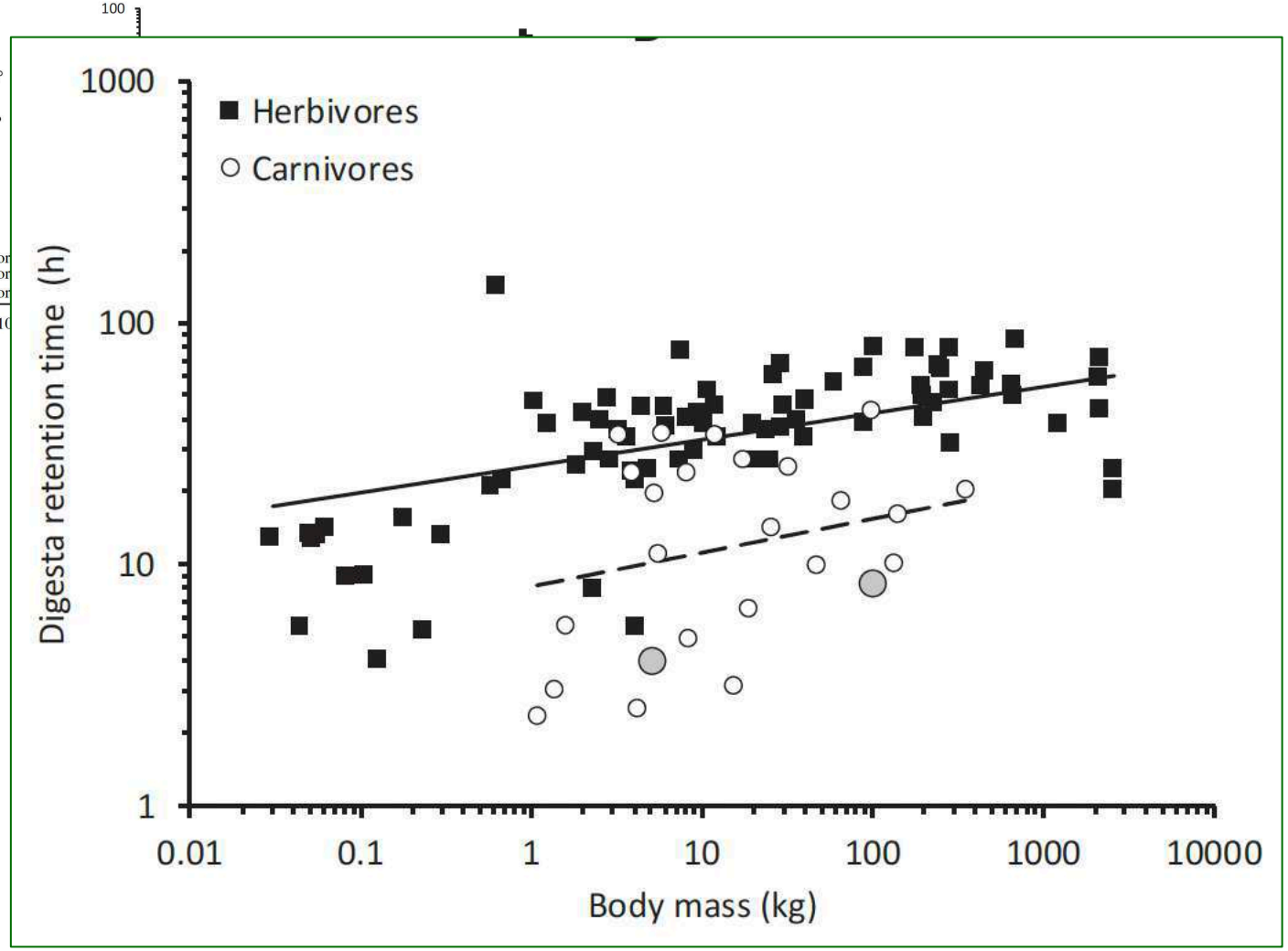




Duque-Correaa et al. (2021)
De Cuyper et al. (2020)

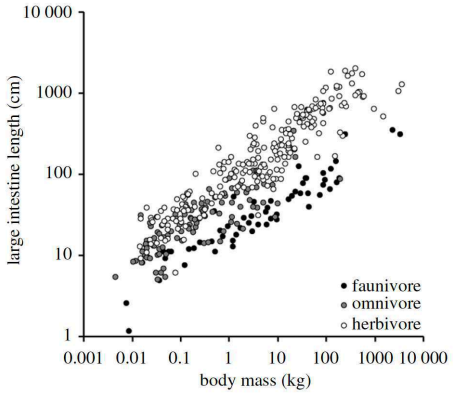
Broad patterns: anatomy, digestive physiology (gut fill, retention time

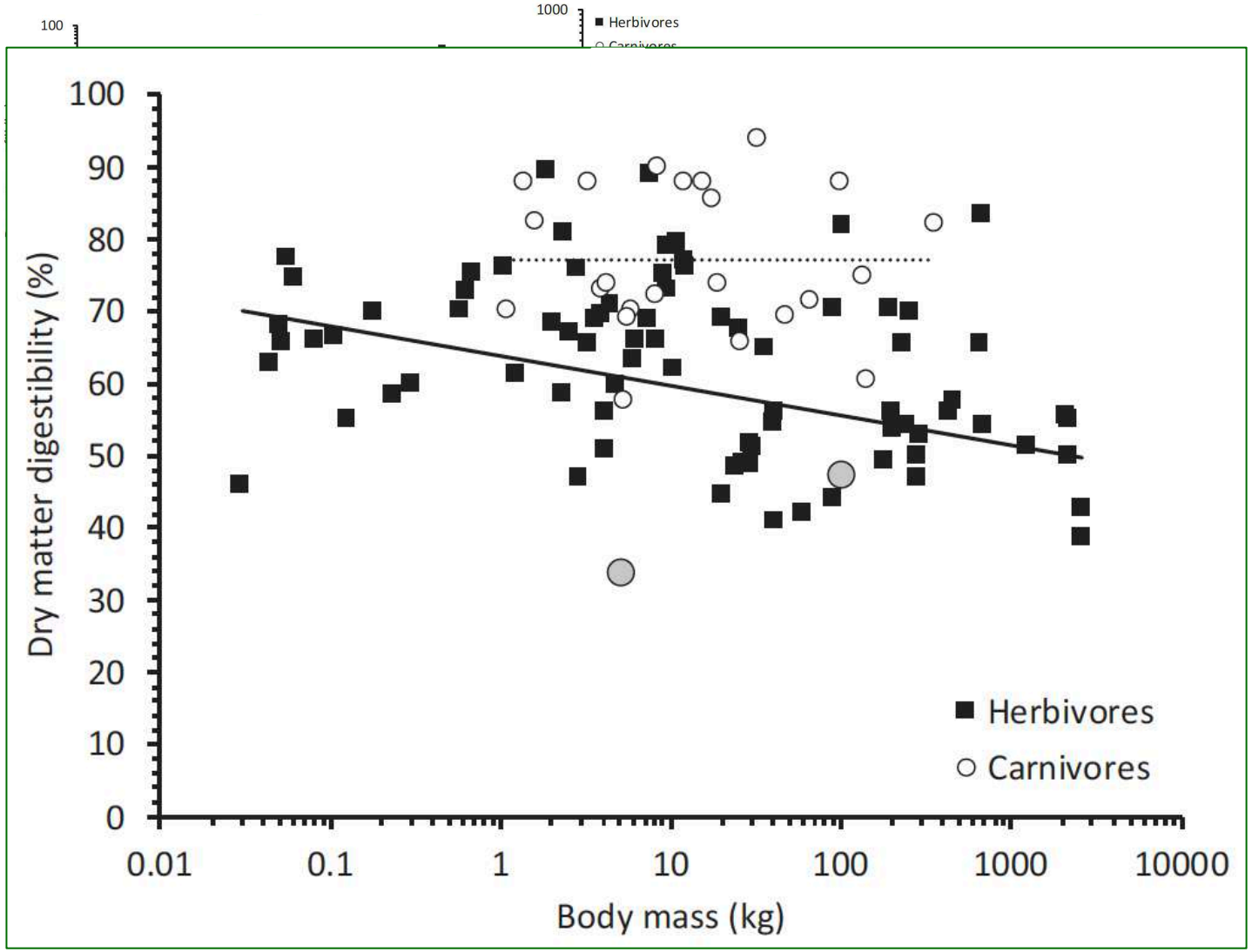




Duque-Correaa et al. (2021)
De Cuyper et al. (2020)

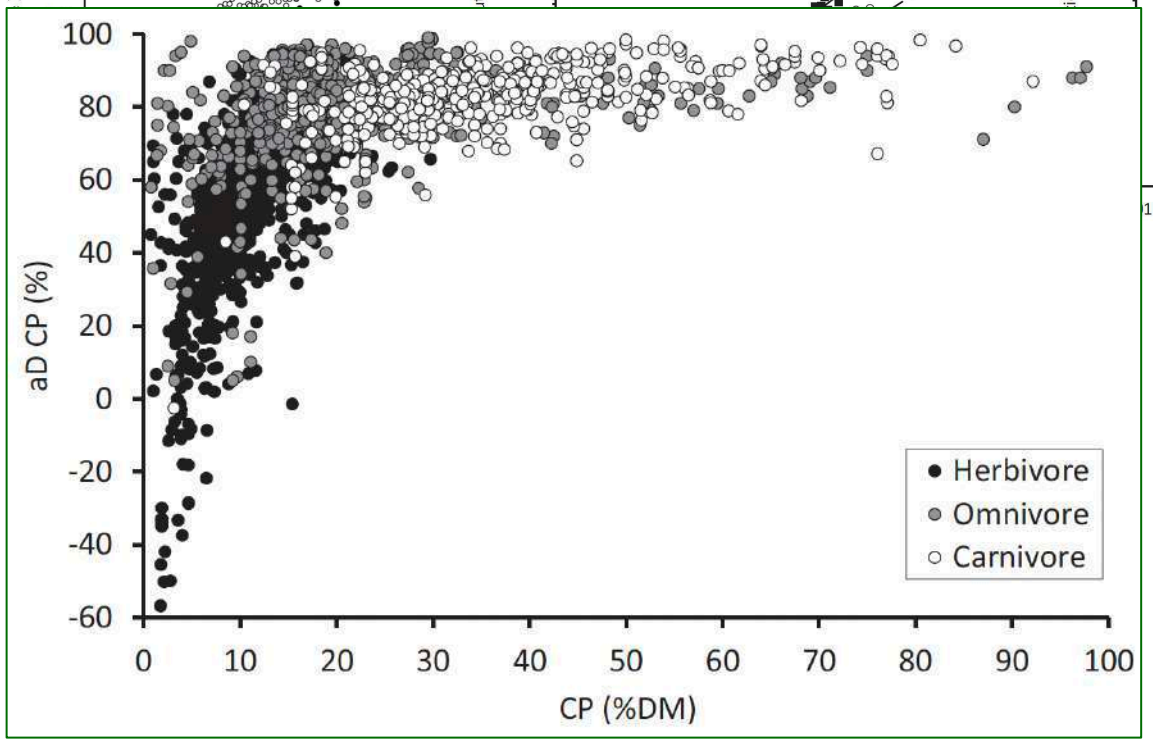
Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency

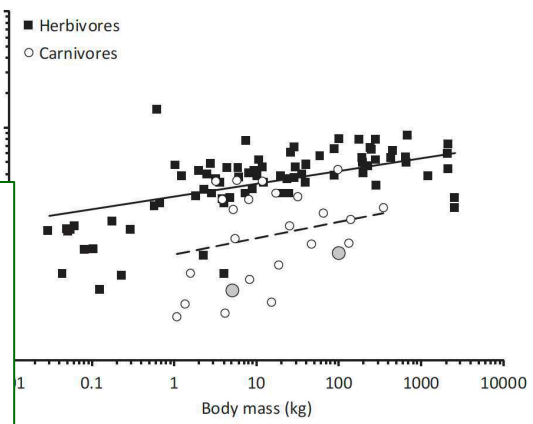


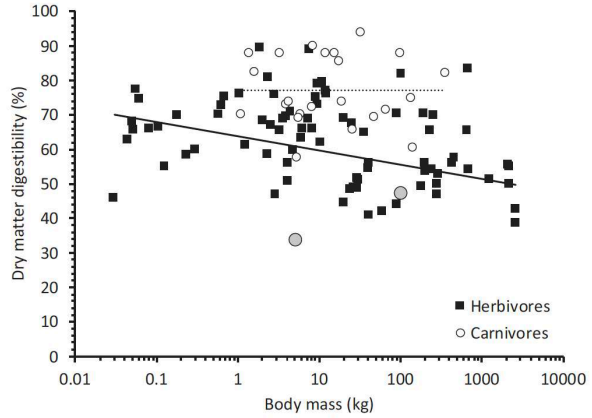


Duque-Correaa et al. (2021)
De Cuyper et al. (2020)

Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency

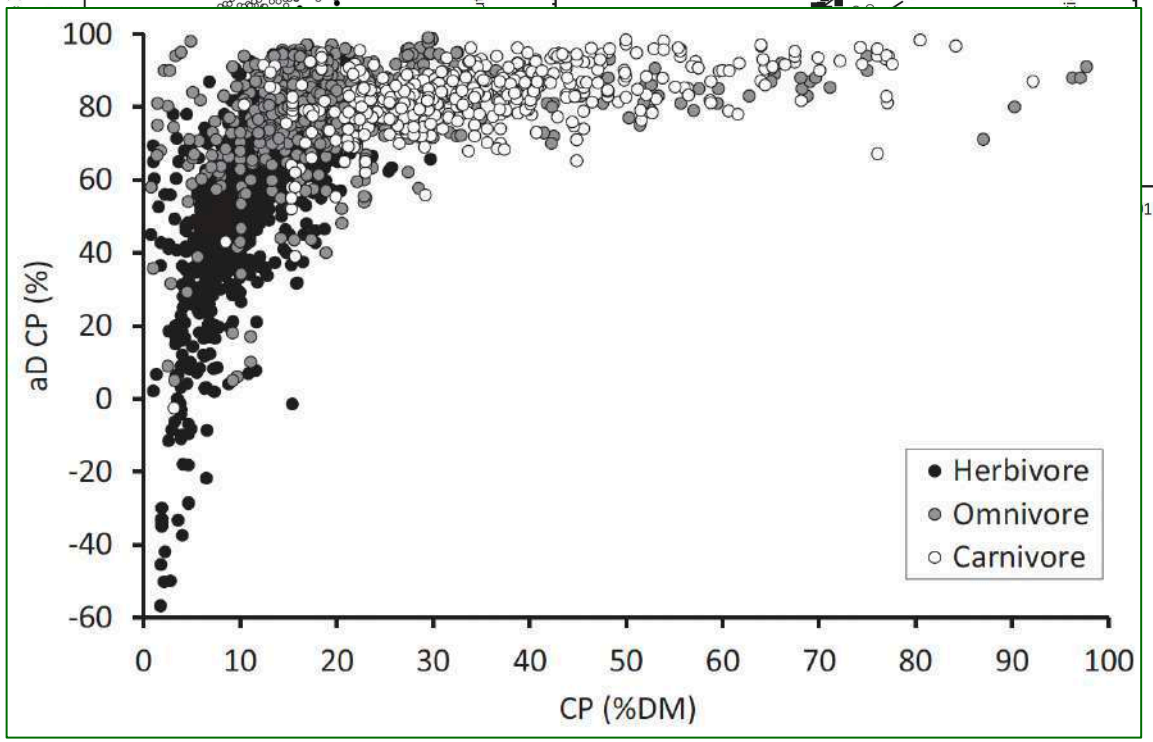


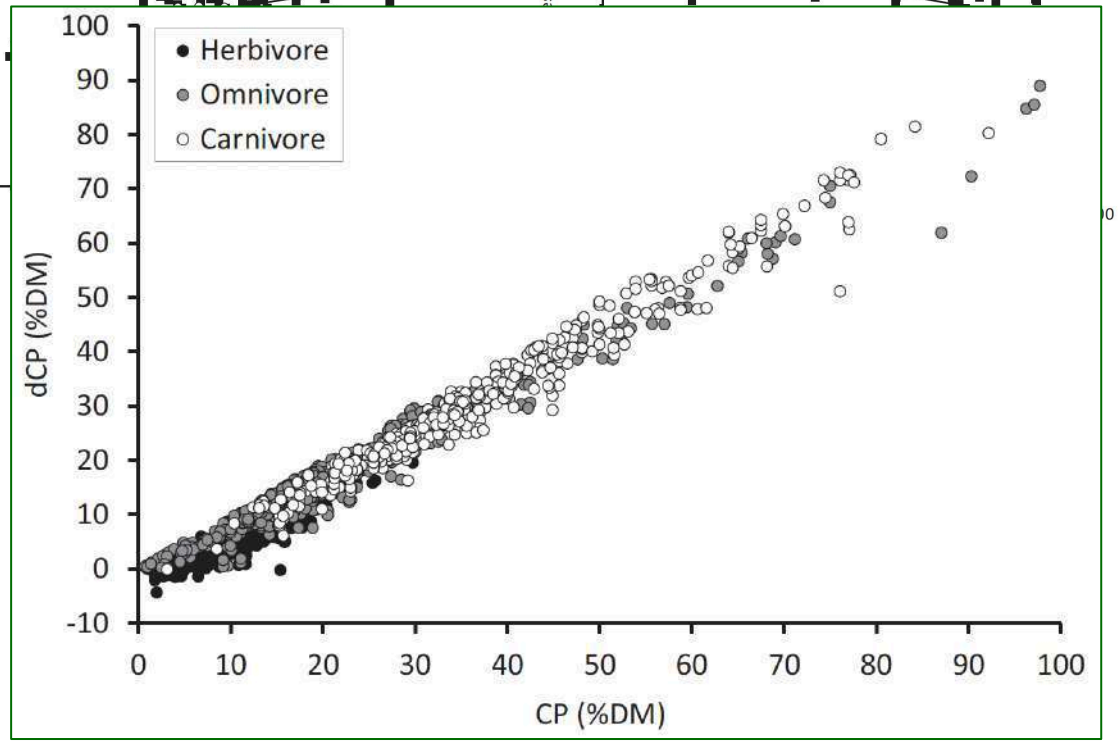




Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)

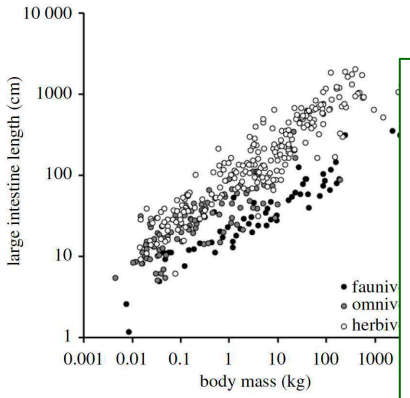
Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency

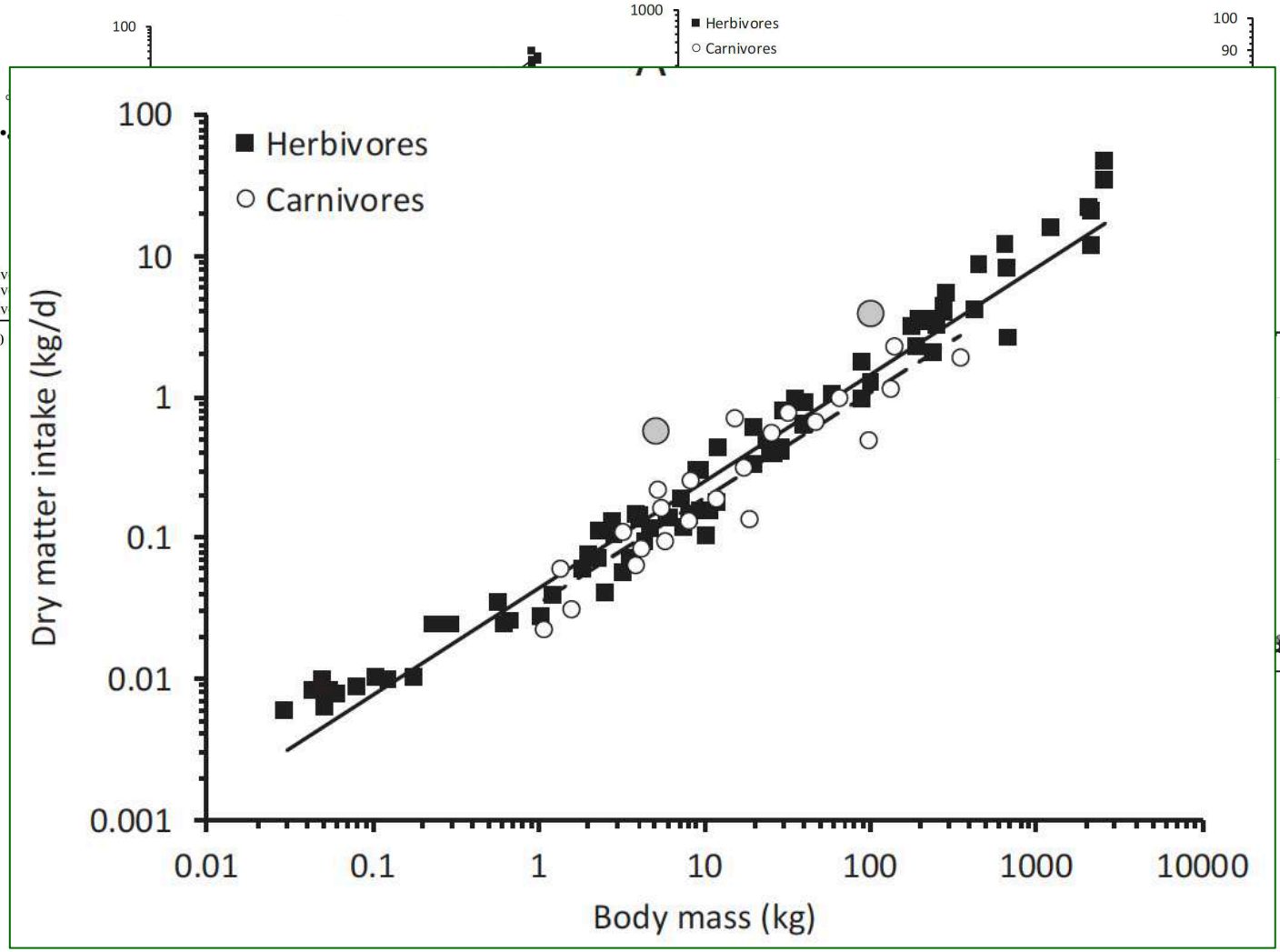


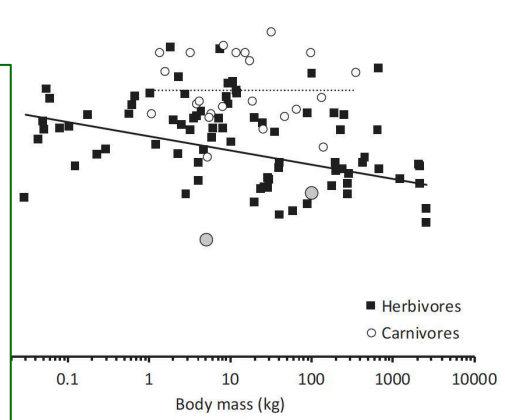


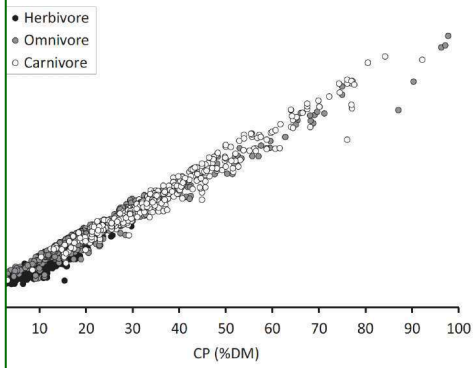
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)

Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake)



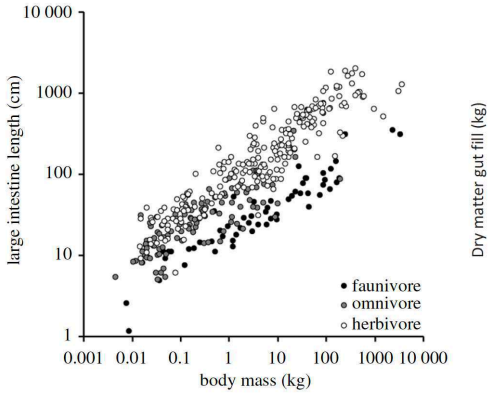


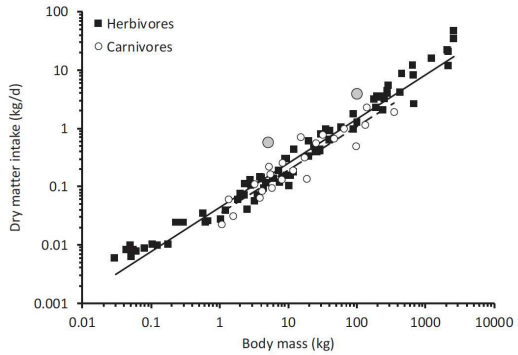


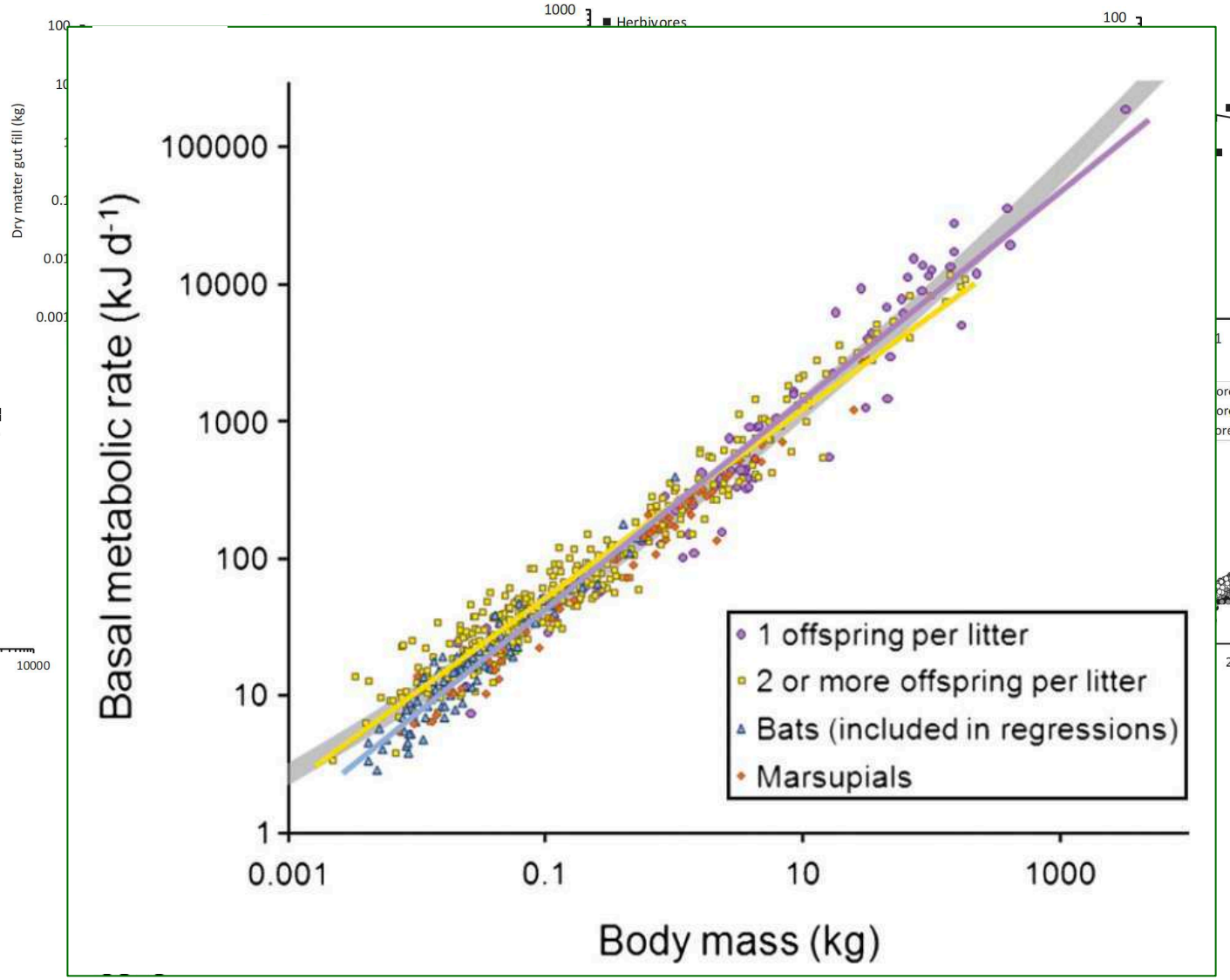


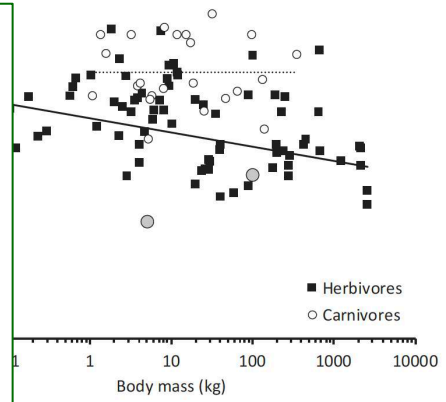
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)

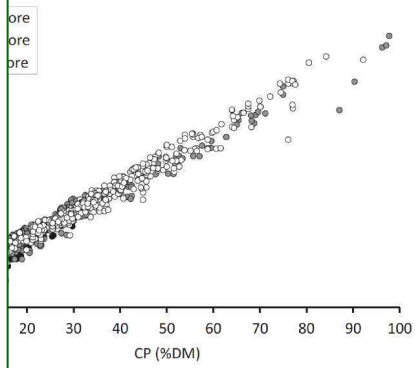
Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism





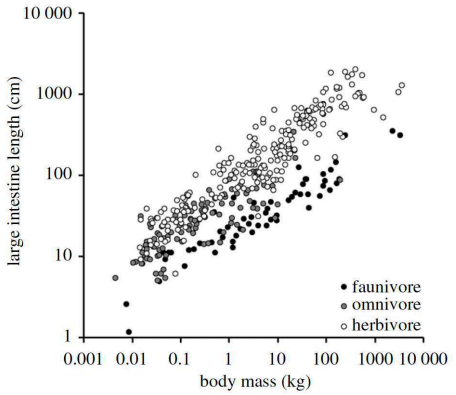


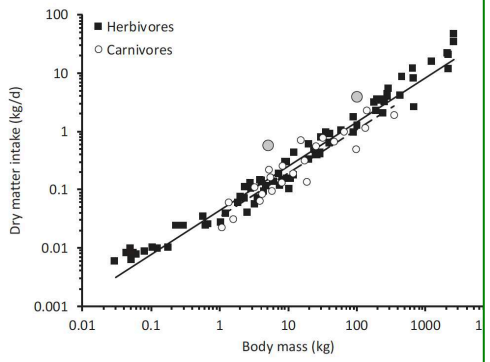


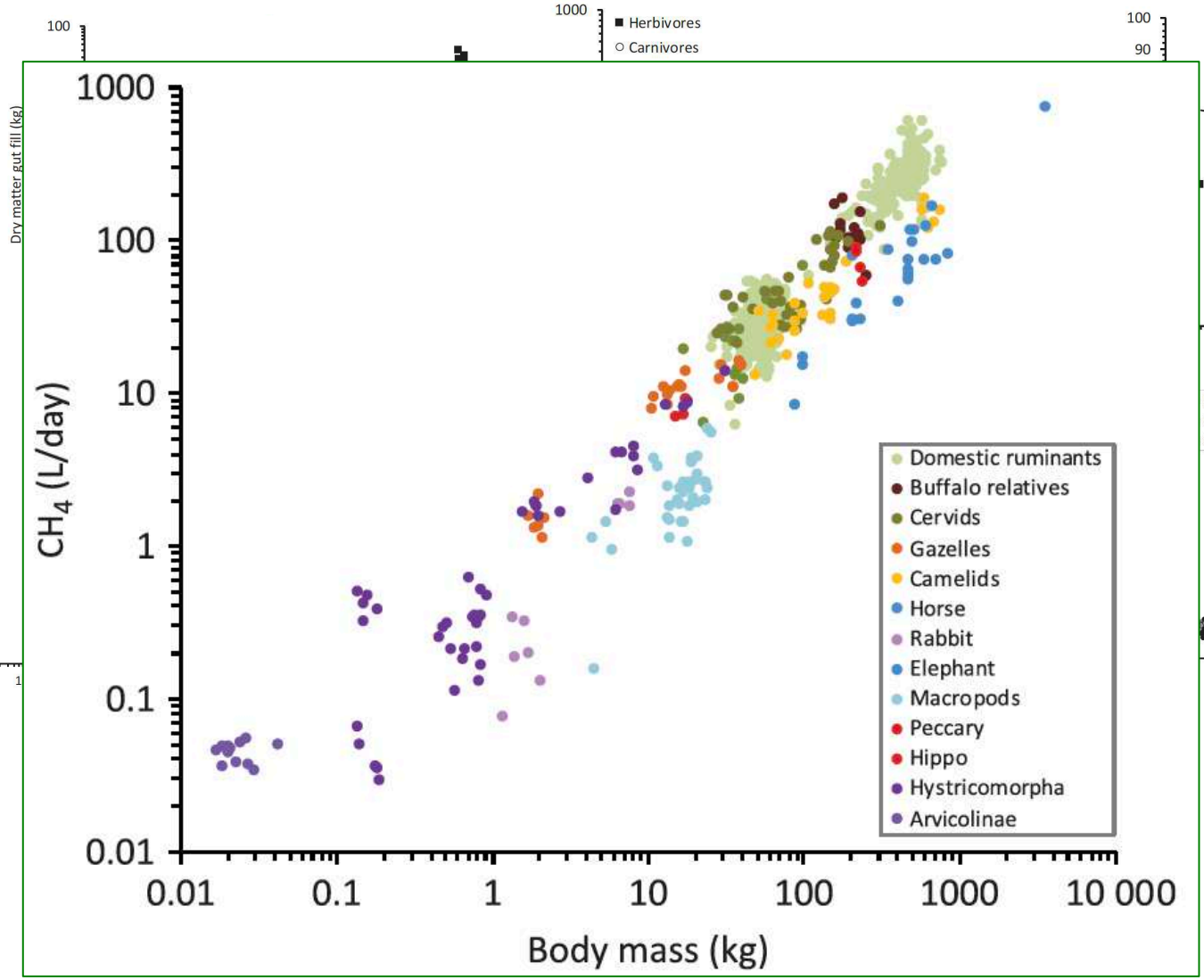


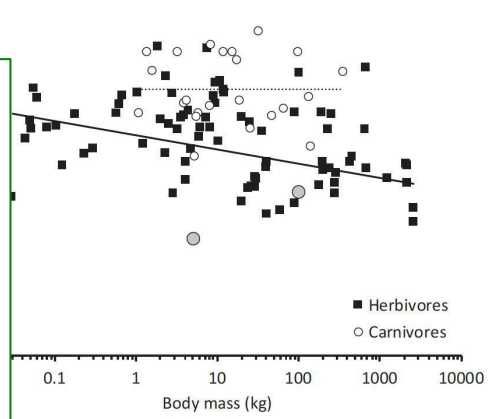
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)

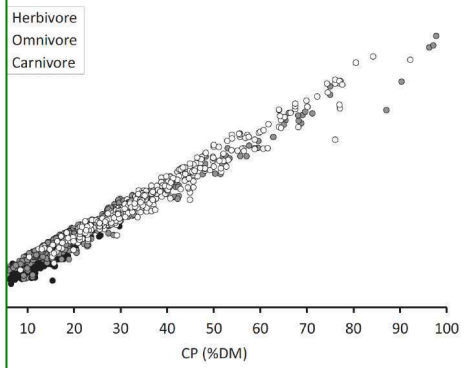
Broad patterns: anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production







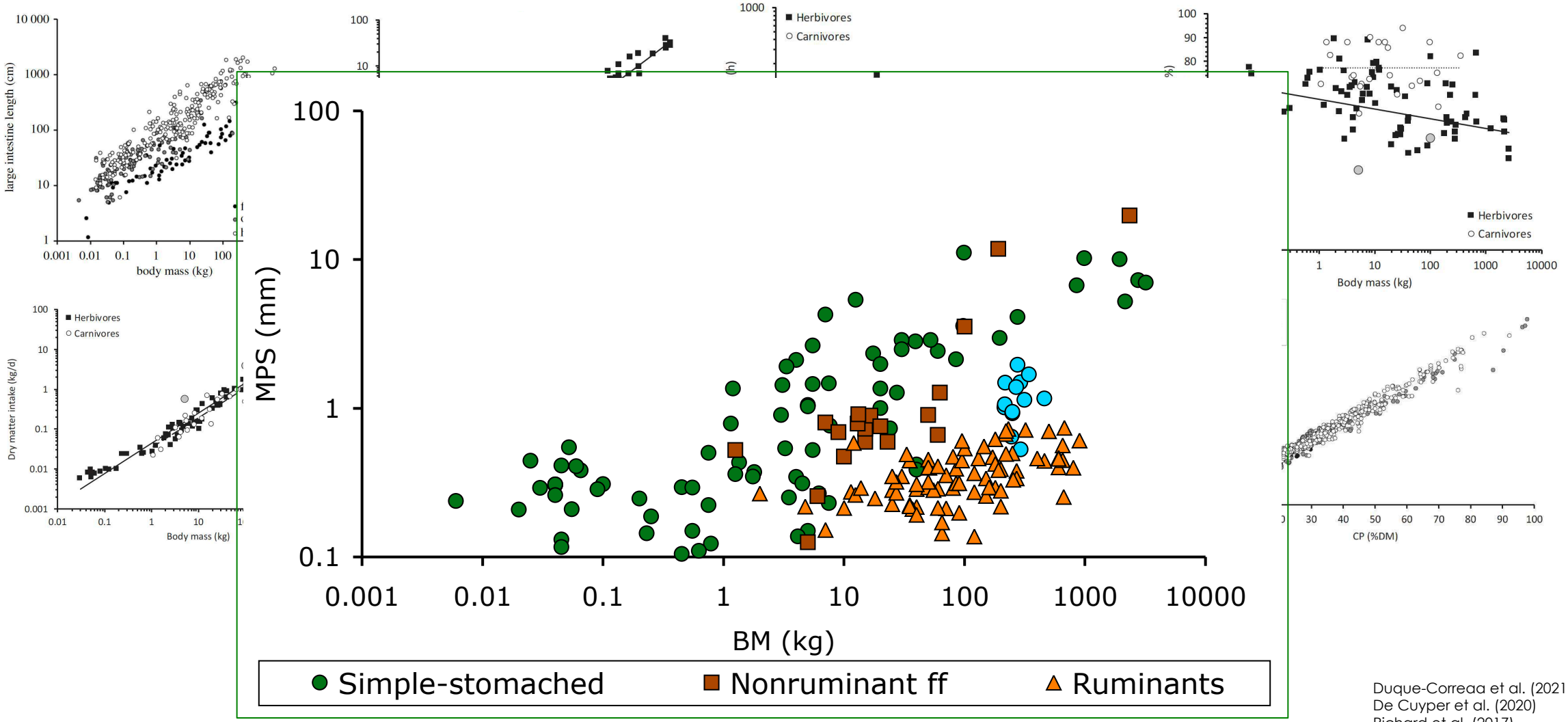




Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)

Broad patterns:

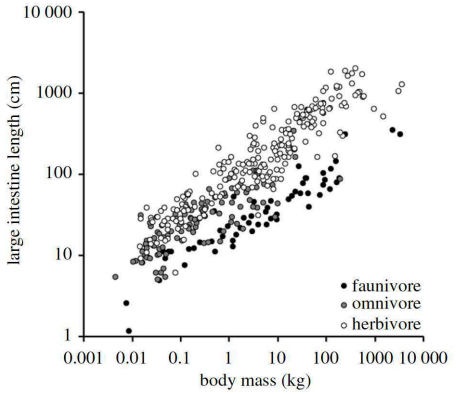
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency

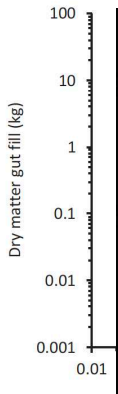


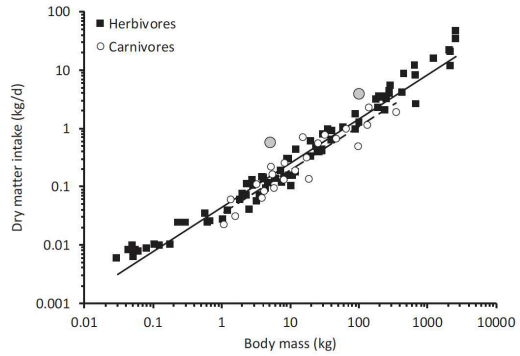
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)

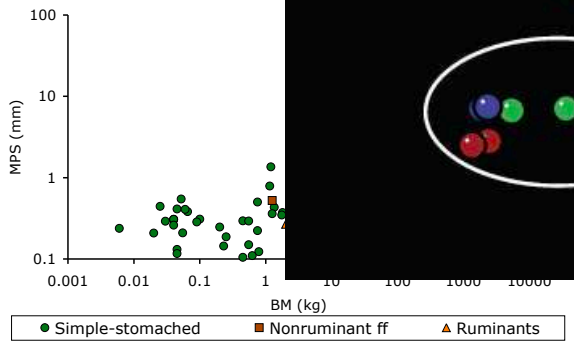
Broad patterns:

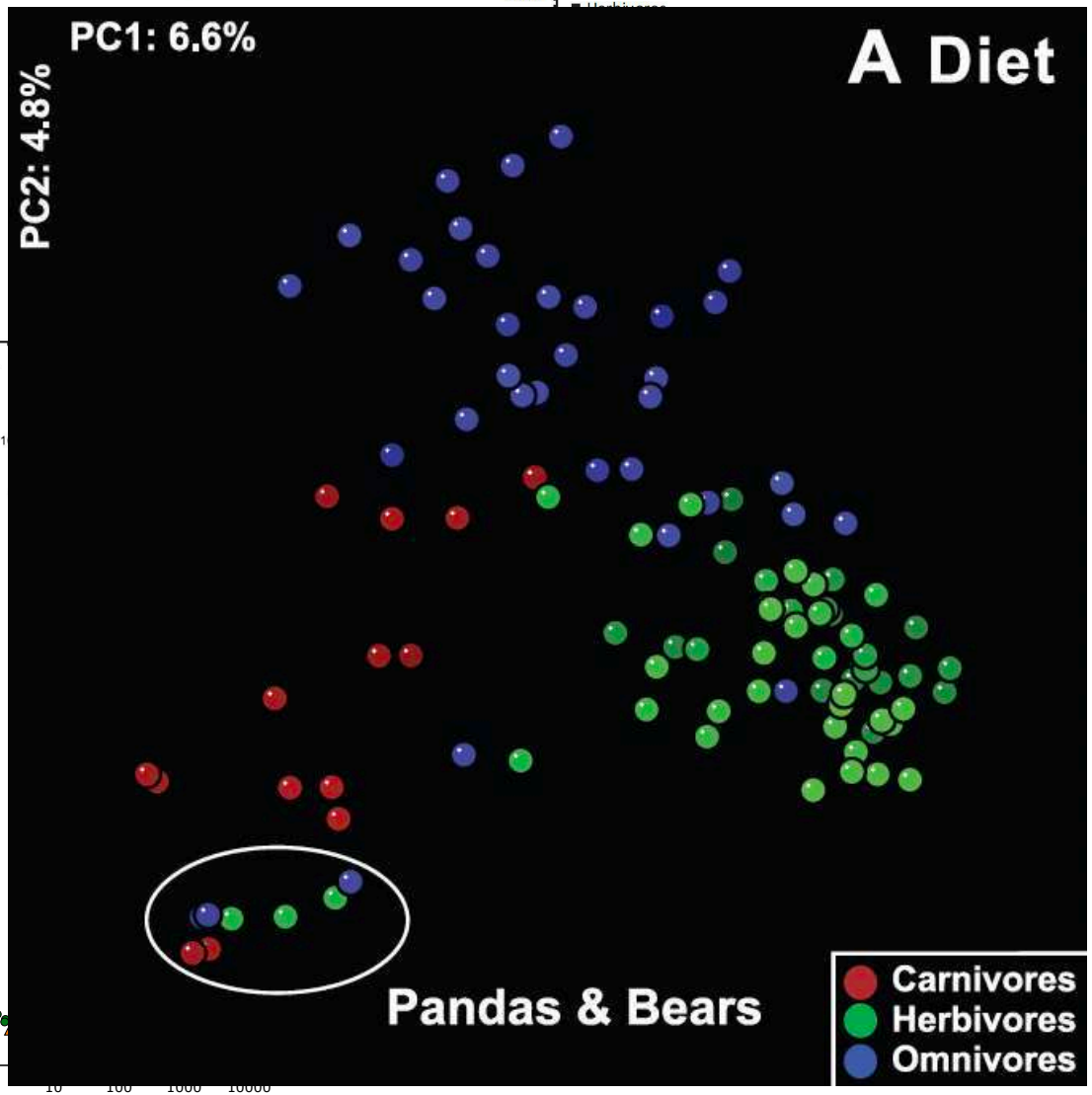
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency, gut microbiome

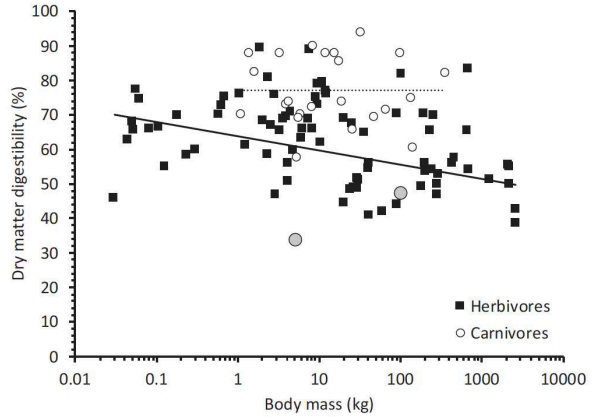


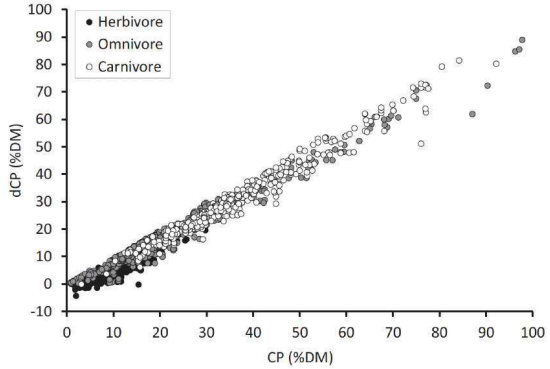








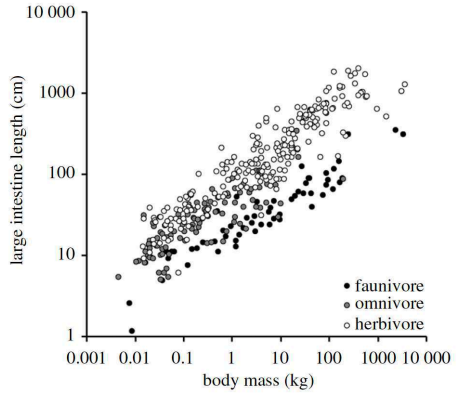


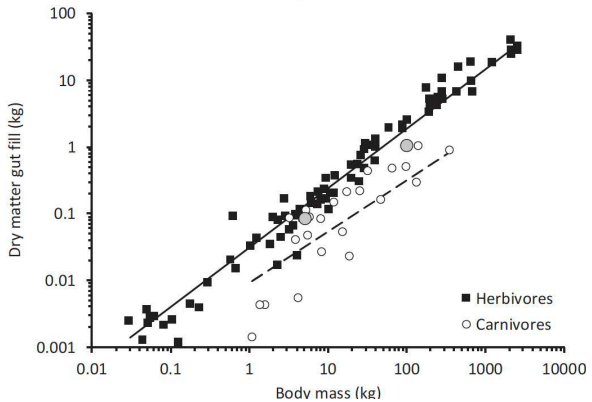


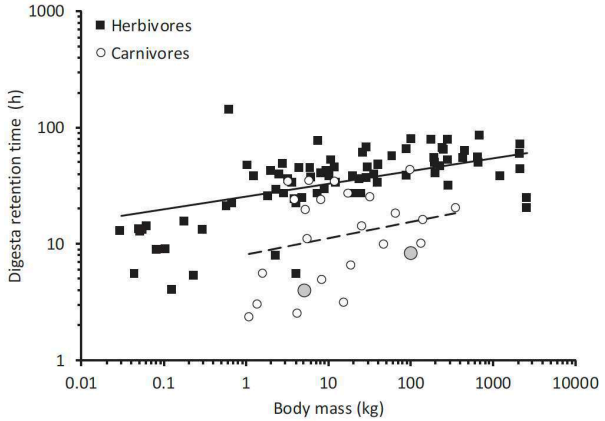
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

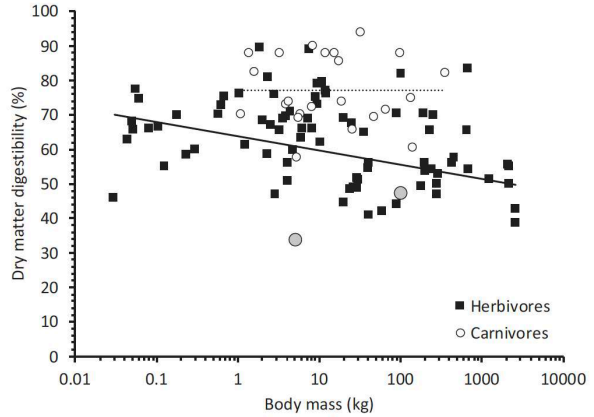
Broad patterns:

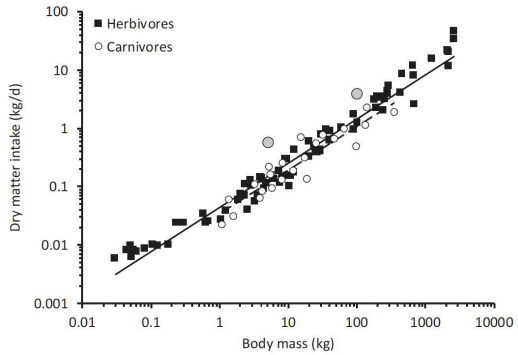
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency, gut microbiome

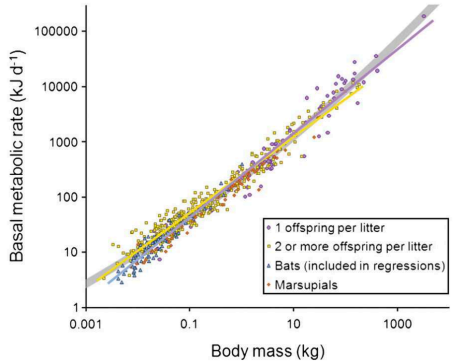


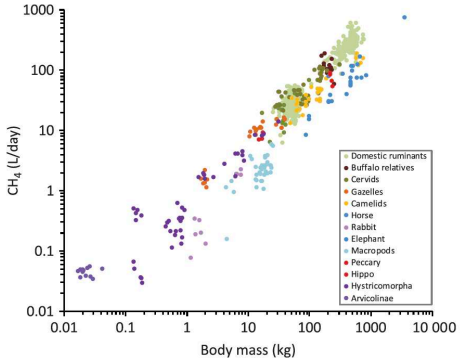


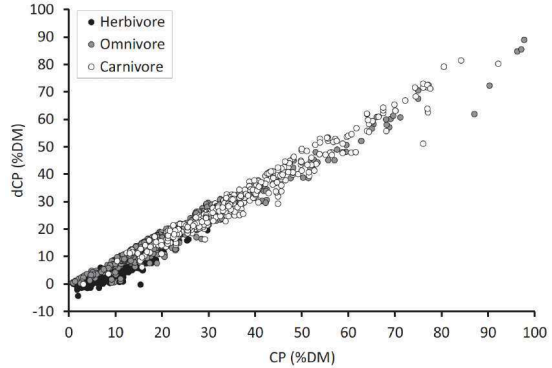


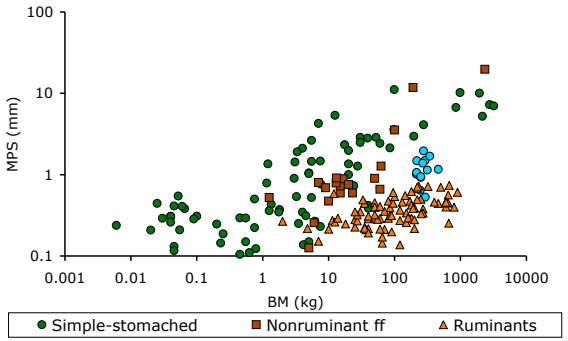


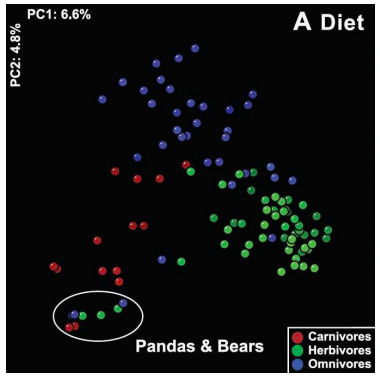










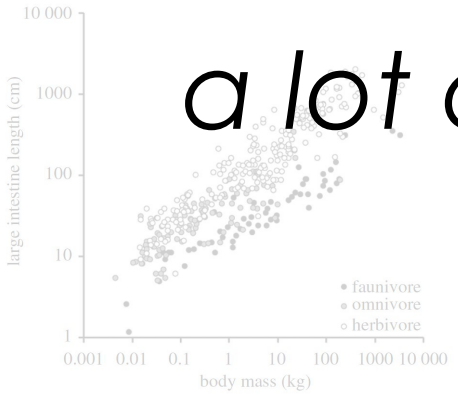


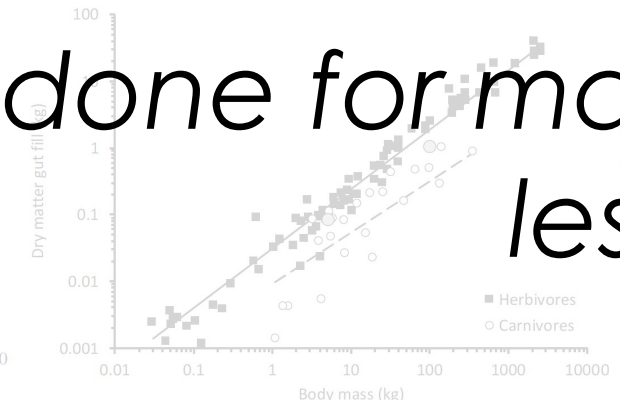
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

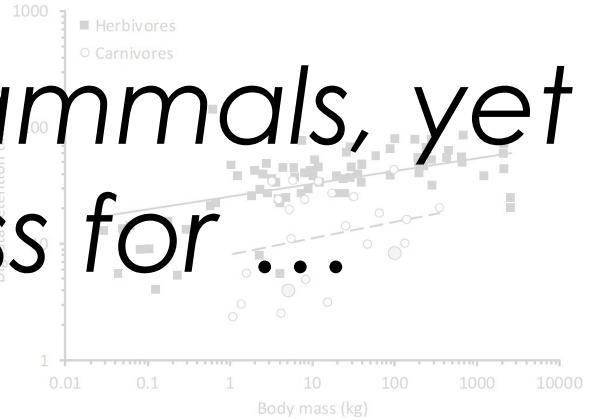
Broad patterns:

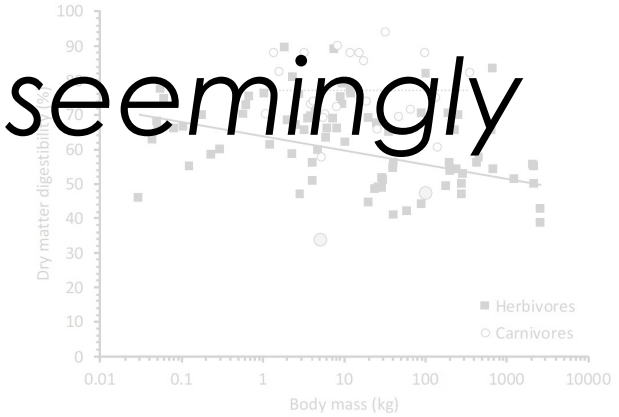
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency, gut microbiome

a lot done for mammals, yet seemingly less for …





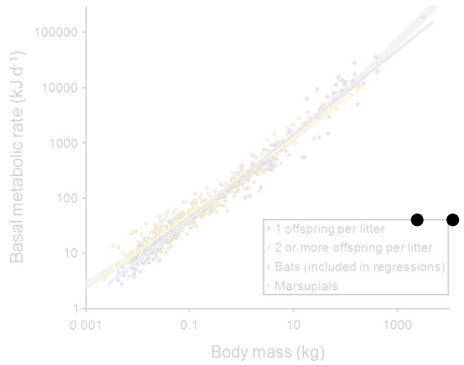


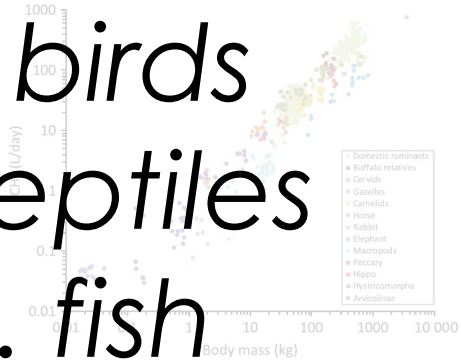


… birds

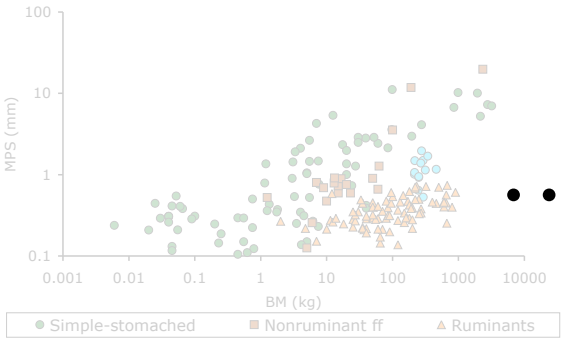
… reptiles

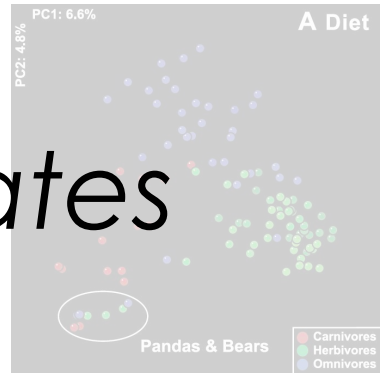
… fish





…invertebrates

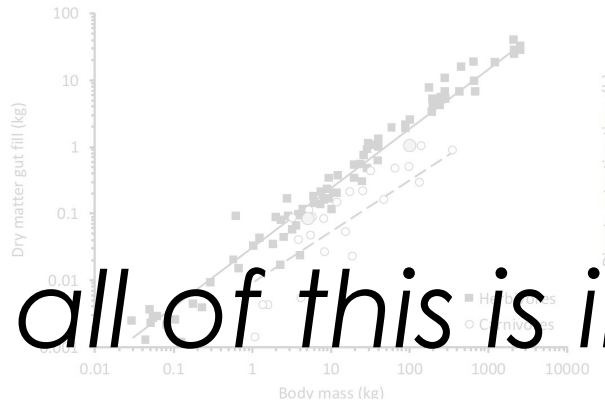


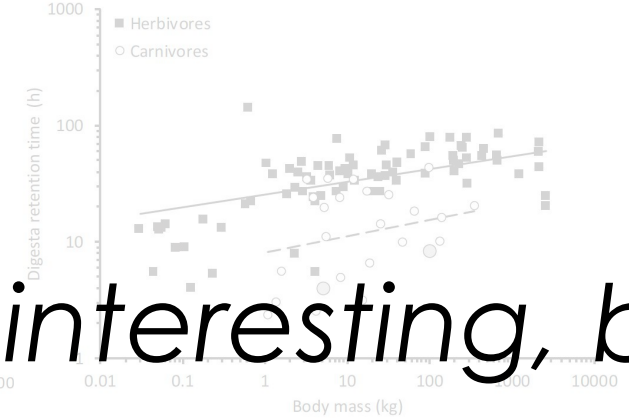


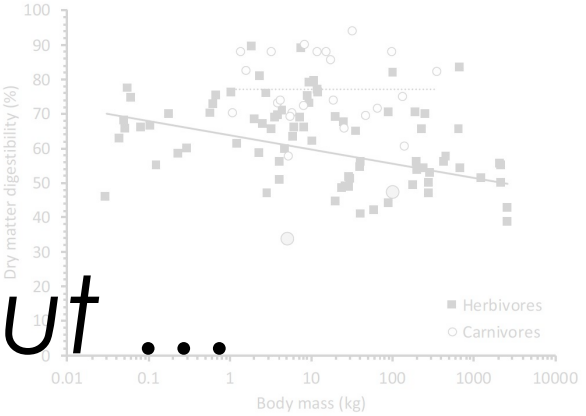
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

Broad patterns:

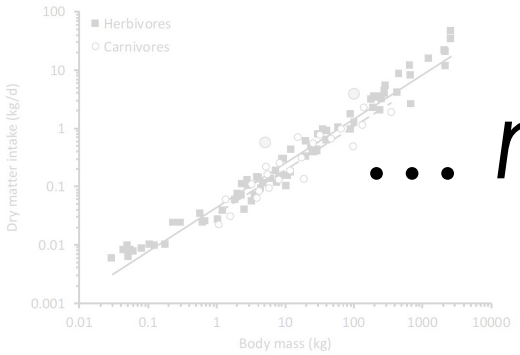
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency, gut microbiome

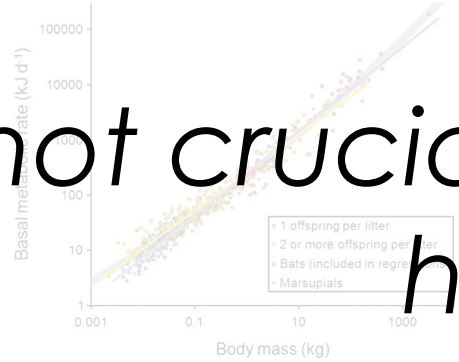


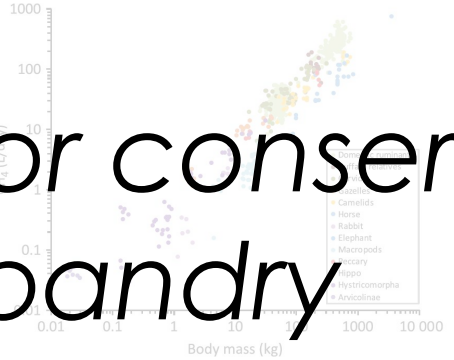


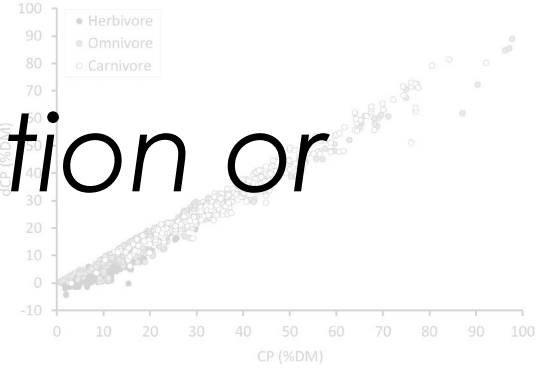


all of this is interesting, but …







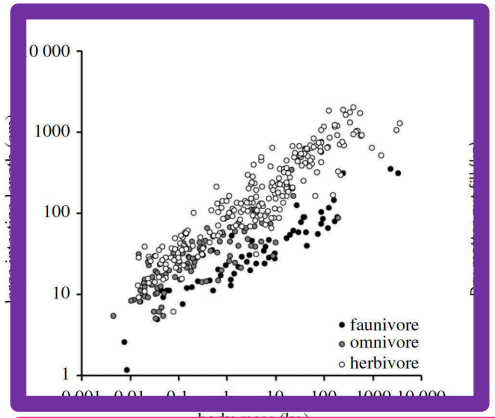


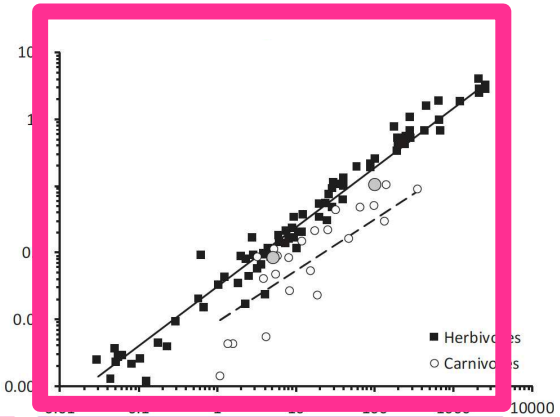
… not crucial for conservation or husbandry

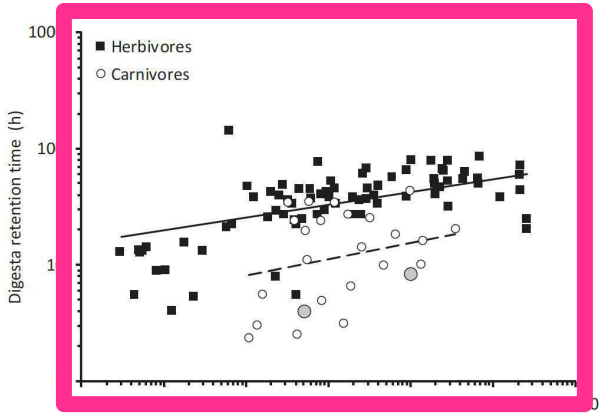
Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

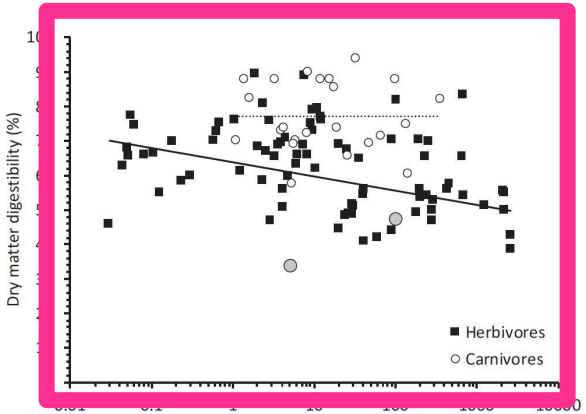
Broad patterns:

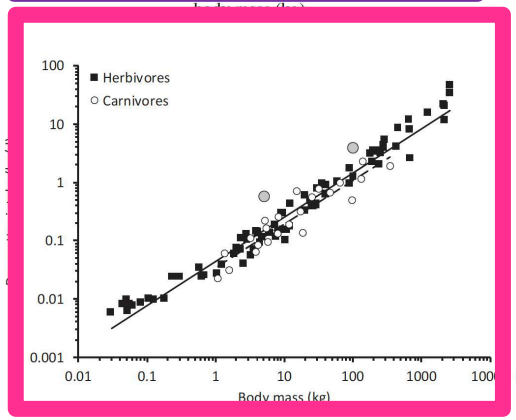
anatomy, digestive physiology (gut fill, retention time, digestive efficiency, intake), metabolism, methane production, chewing efficiency, gut microbiome

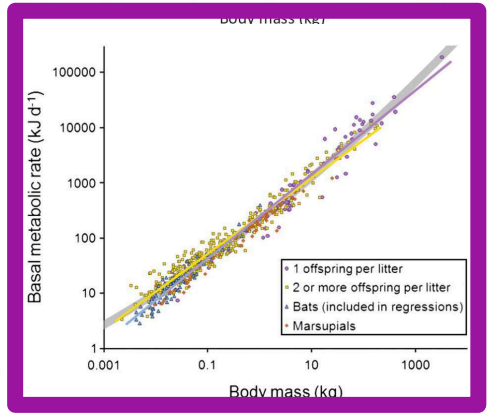


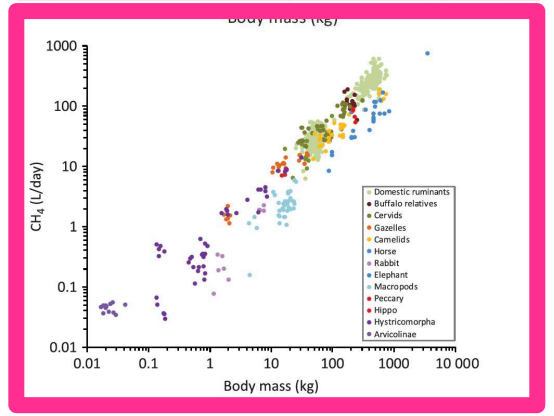


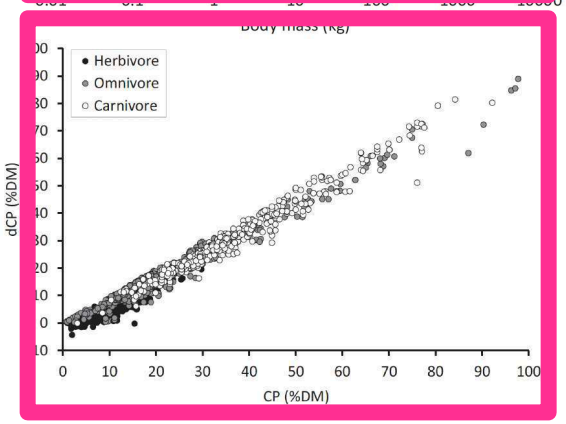


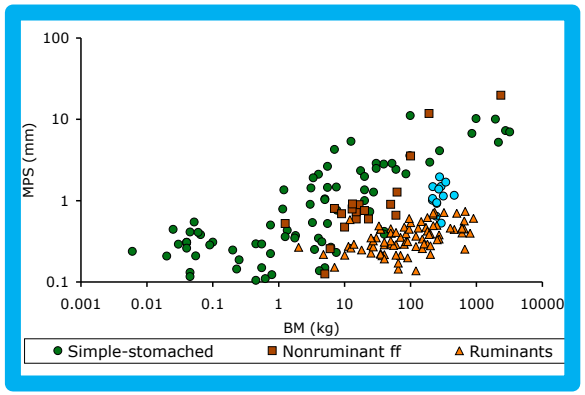


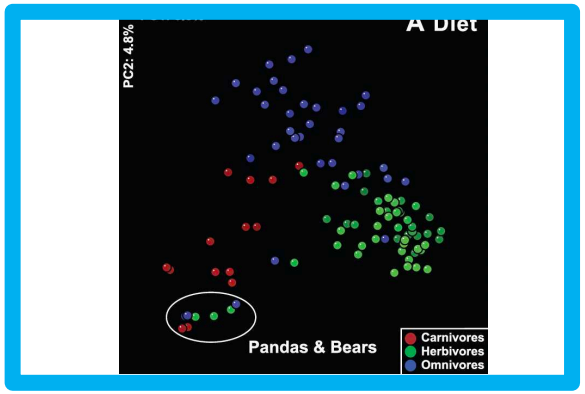












Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

Pakistan J. Zool., vol. 52(5), pp 1637-1646, 2020 DOI: https://dx.doi.org/10.17582/journal.pjz/20181031121013

Gut Microbiota enabled Goitered Gazelle (*Gazella subgutturosa*) to Adapt to Seasonal Changes

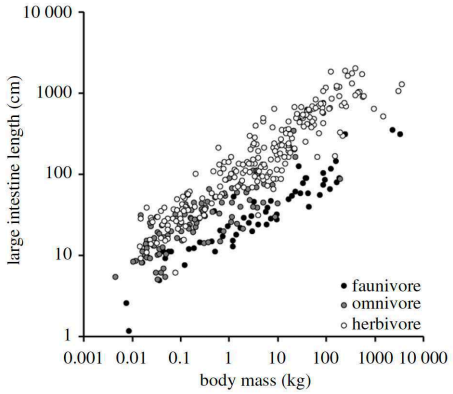
Wen Qin[1,2], YanGan Huang[1], Lei Wang[1], Gonghua Lin[1], Jundong Yang[1,2], Pengfei Song[1,2], Hongmei Gao[1,2], Jingjie Zhang[1,2] and Tongzuo Zhang[1,3,*]

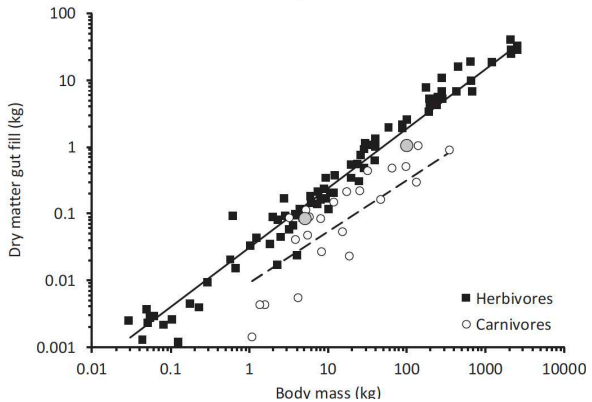
We commissioned Novogene Co., Ltd. to complete all experiments described in DNA extraction and PCR amplification, Library preparation and sequencing, and Data analysis.

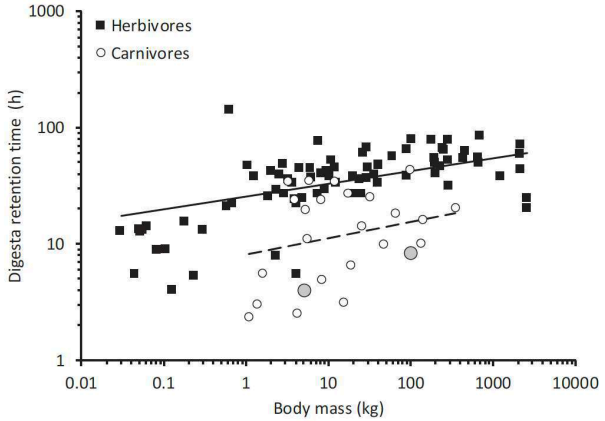
Seasonal variations in gut microbiota functions

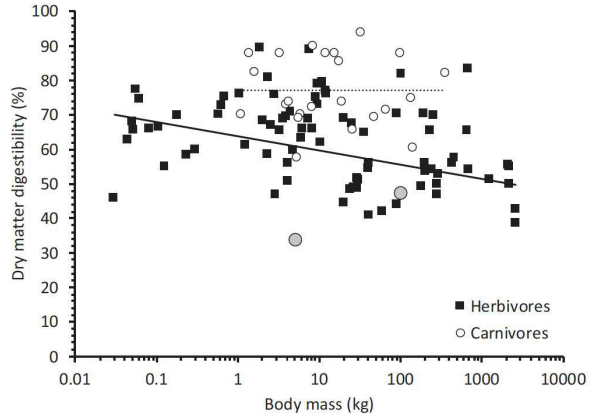
We predicted the gut microbiota functions of winter and summer groups groups with Tax4Fun using the KEGG database (https://www.kegg.jp/) and found a significant difference ($p < 0.05^{*}$) between winter and summer groups. The main functions are transporters and two-component systems, as shown in Figure 4. The main functions that were significantly improved ($p<0.01^{**}$) in the winter group were galactose metabolism, lipopolysaccharide biosynthesis, carbon fixation in photosynthetic organisms, vasopressin-regulated water reabsorption, fructose and

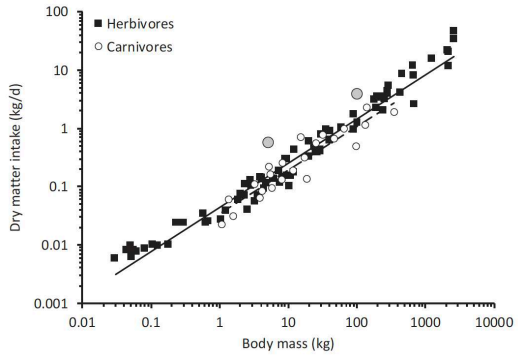
Trusting datasets

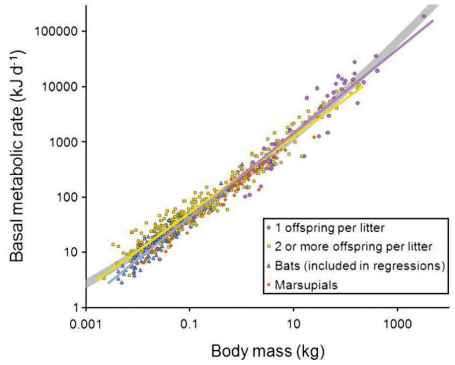


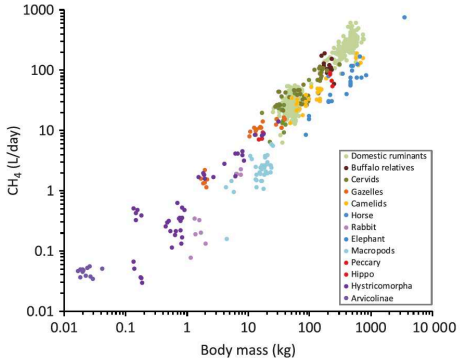


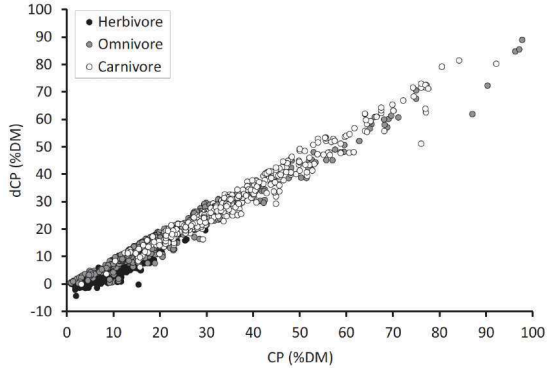


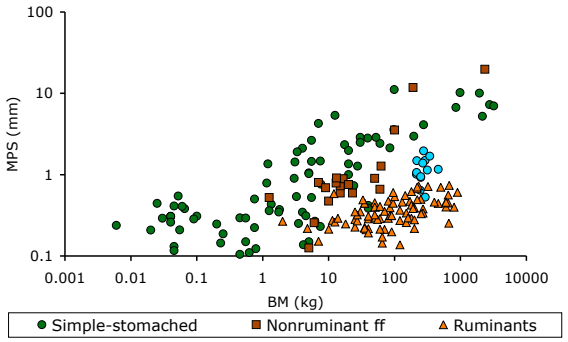


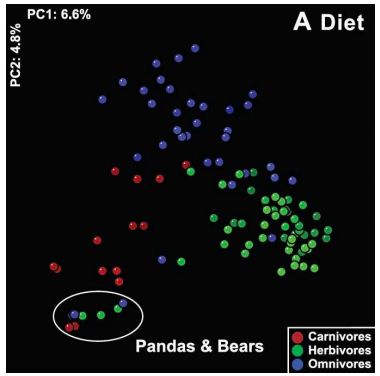








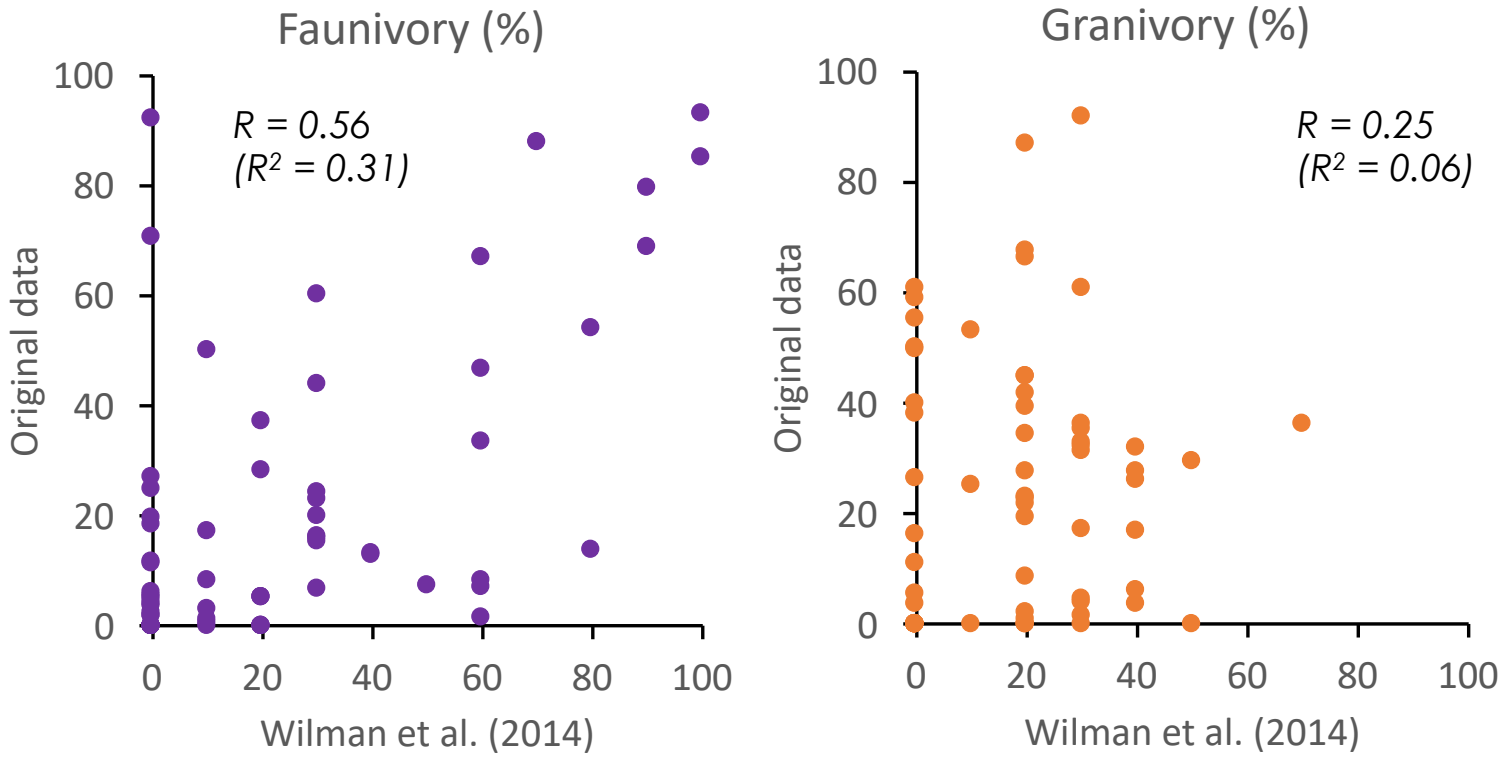




Duque-Correaa et al. (2021)
De Cuyper et al. (2020)
Richard et al. (2017)
Müller et al. (2012)
Clauss et al. (2020)
Fritz et al. (2009)
Ley et al. (2008)

Trusting databases

- reference libraries to derive identification and function from molecular data
- reference libraries on natural diets



Steiner et al. (2022)

Ecology, 95(7), 2014, p. 2027

EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals

Ecological Archives E095-178

HAMISH WILMAN,[1] JONATHAN BELMAKER,[1,2] JENNIFER SIMPSON,[1,3] CAROLINA DE LA ROSA,[1] MARCELO M. RIVADENEIRA,[4] AND WALTER JETZ[1,5,6]

[1]*Ecology and Evolutionary Biology Department, Yale University, 165 Prospect Street, New Haven, Connecticut 06511 USA*
[2]*Department of Zoology, George S. Wise Faculty of Life Sciences, Tel Aviv University, Tel Aviv 69978 Israel*
[3]*Scientific Technologies Corporation, 4400 East Broadway Boulevard Suite 705, Tucson, Arizona 85711 USA*
[4]*Centro de Estudios Avanzados en Zonas Áridas (CEAZA) and Universidad Católica del Norte, Av. Ossandón 877, C.P. 178168, Coquimbo, Chile*
[5]*Imperial College London, Silwood Park Campus, Buckhurst Road, SL5 7PY Ascot, Berkshire, United Kingdom*

Abstract. Species are characterized by physiological, behavioral, and ecological attributes that are all subject to varying evolutionary and ecological constraints and jointly determine species' role and function in ecosystems. Attributes such as diet, foraging strata, foraging time, and body size, in particular, characterize a large portion of the "Eltonian" niches of species. Here we present a global species-level compilation of these key attributes for all 9993 and 5400 extant bird and mammal species derived from key literature sources. Global handbooks and monographs allowed the consistent sourcing of attributes for most species. For diet and foraging stratum we followed a defined protocol to translate the verbal descriptions into standardized, semiquantitative information about relative importance of different categories. Together with body size (continuous) and activity time (categorical) this enables a much finer distinction of species' foraging ecology than typical categorical guild assignments allow. Attributes lacking information for specific species are flagged, and interpolated values based on taxonomy are provided instead. The presented data set is limited by, among others, these select cases missing observed data, by errors and uncertainty in the expert assessment as presented in the literature, and by the lack of intraspecific information. However, the standardized and transparent nature and complete global coverage of the data set should support an array of potential studies in biogeography, community ecology, macroevolution, global change biology, and conservation. Potential uses include comparative work involving these traits as focal or secondary variables, ecological research on the trait or trophic structure of communities, or conservation science concerned with the loss of function among species or in ecosystems in a changing world. We hope that this publication will spur the sharing, collaborative curation, and extension of data to the benefit of a more integrative, rigorous, and global biodiversity science.

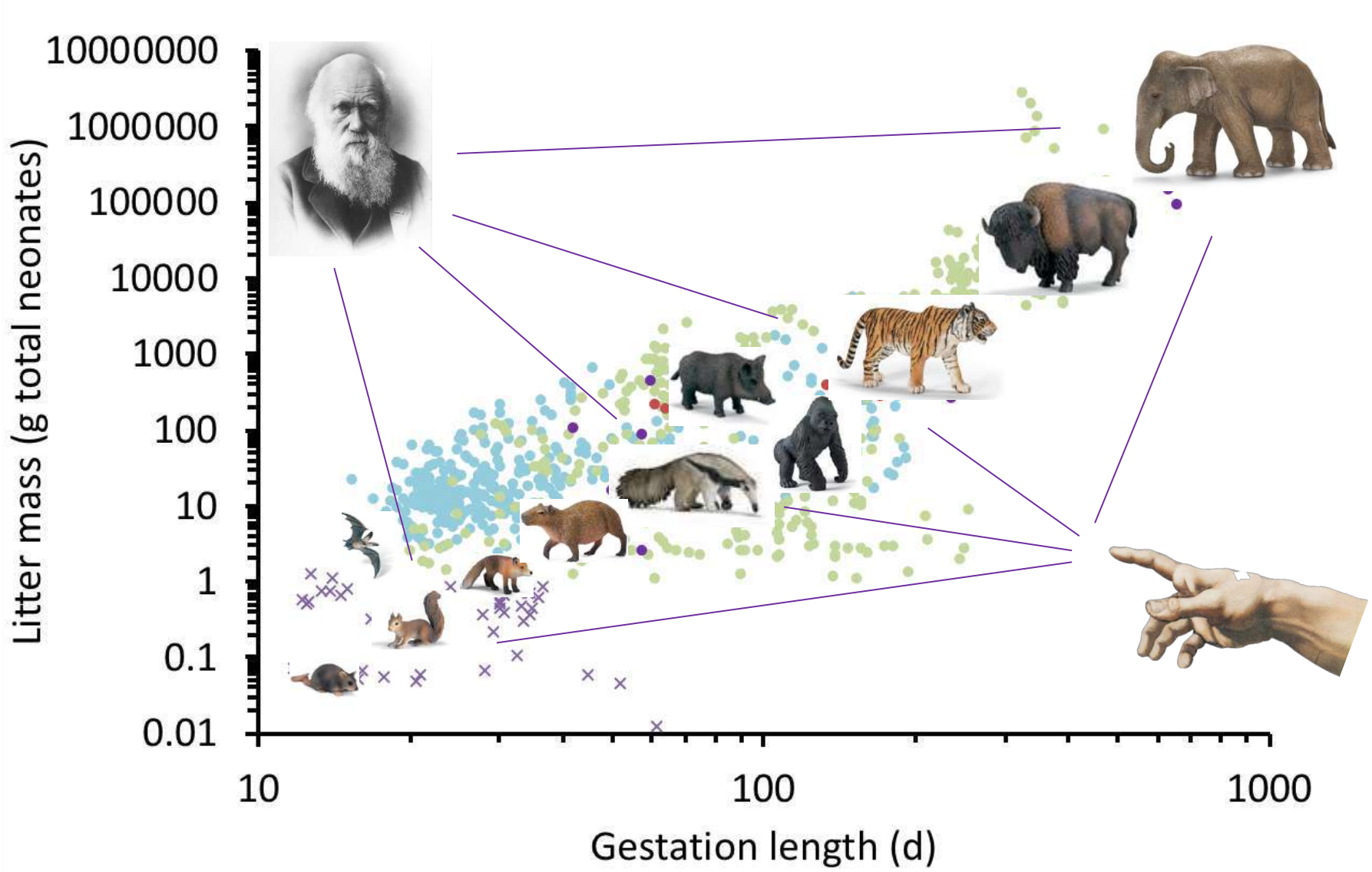
Key words: *bird; body size; diet; eco-informatics; foraging; function; mammal; mass; niche; stratum; traits; vertebrate.*

Manuscript received 13 October 2013; revised 17 March 2014; accepted 21 March 2014. Corresponding Editor: W. K. Michener.
[6] Corresponding author: walter.jetz@yale.edu

Investigating patterns II:

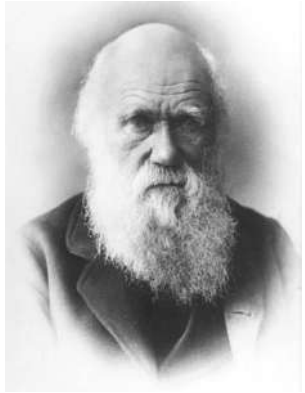
interpretation

Two ways of being a creationist

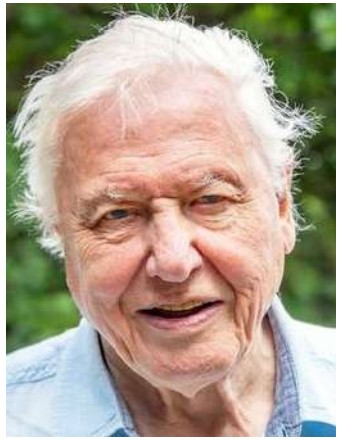


What separates a creationist from an evolutionist?

Not so much the agency
(the old man with the white beard)



but the narrative of the adaptation
('perfect' vs. 'adequate ***at the time***')



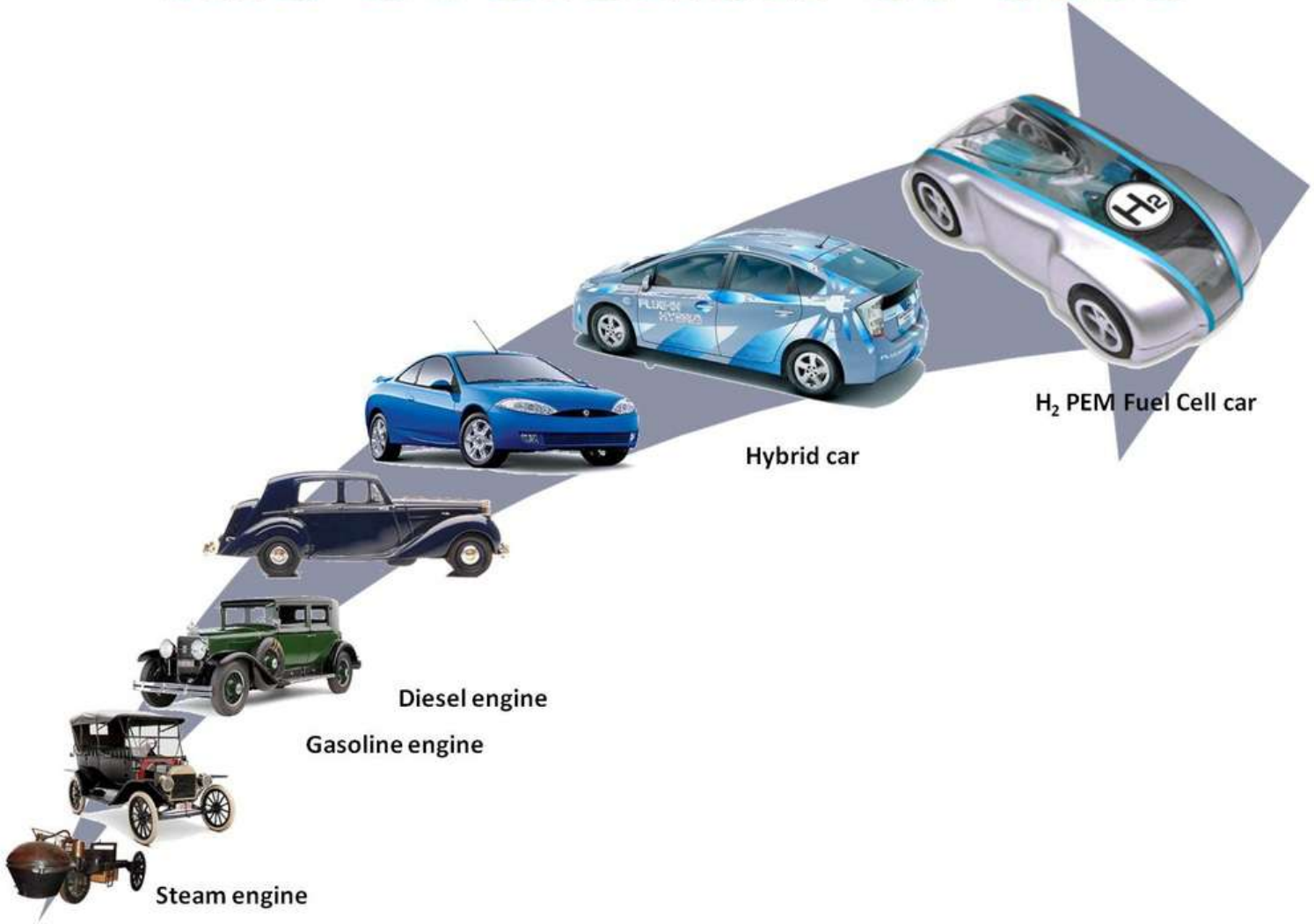
The trade-off fallacy

Saying that you either invest more into reproduction (live fast, produce many offspring at a time) or more into maintenance (live slower, produce less offspring at a time but over a longer period) …

… is like saying that with a given amount of fuel, you either transport a certain load a certain distance, or a higher load a shorter distance.

ignoring the possibility that someone might develop a more efficient engine

The evolution of cars



The trade-off fallacy

Saying that you either invest more into reproduction (live fast, produce many offspring at a time) or more into maintenance (live slower, produce less offspring at a time but over a longer period) …

… is like saying that if you want to have more meat on your chicken, you have to feed it more food for a longer period of time.

ignoring the possibility that someone might breed an animal that grows faster on less food

YEP, CHICKENS ARE BIGGER TODAY

	1957	1978	2005
0 DAYS	This chick was 4x as likely to die during its first 7 days than its modern counterpart		This chick was vaccinated against disease and will be under the care of a veterinarian its whole life
	 34g	 42g	 44g
28 DAYS	This chicken used 2x as much feed, land, water and fuel to produce 1lb of meat		This chicken lives in a climate-controlled barn, protected from predators and is fed by a certified nutritionist
	 316g	 632g	 1,396g
56 DAYS	This chicken still has 12 days until it's market-ready, and could only feed 2 people		This chicken was bred to have strong legs, has never been given hormones and can feed six people.
	 905g	 1,808g	 4,202g

It's no secret that today's chickens are bigger than in years past. They're also the healthiest they've ever been. Find out how at chickencheck.in

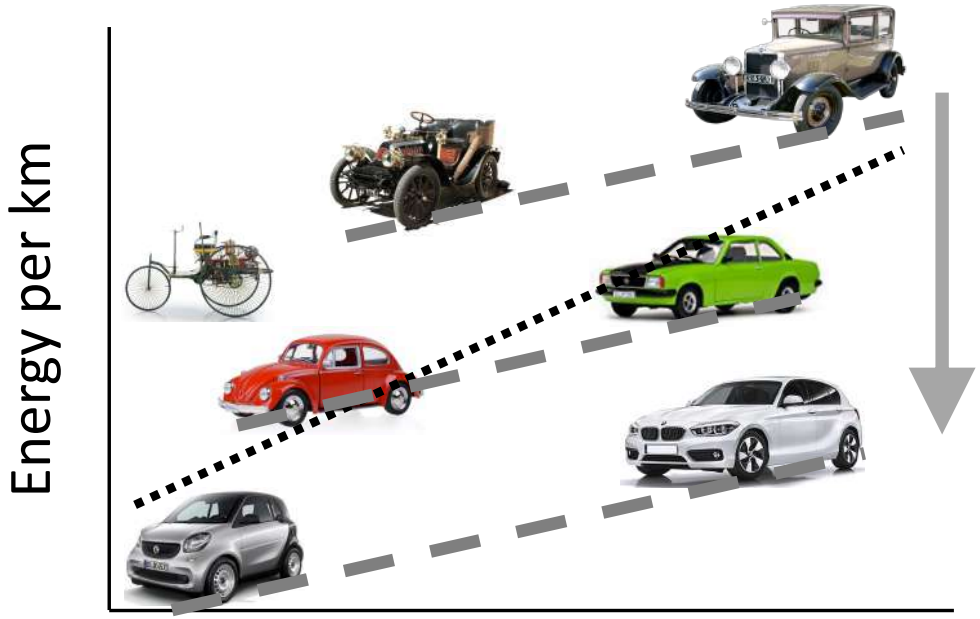
Chicken CHECK IN

Note: 1,000 grams equals 2.2 pounds
Source: University of Alabama Meat Center
Image Credit: https://www.washingtonpost.com/news/wonk/wp/2015/07/04/the-unbelievable-growth-of-americans-food-bodies-houses-and-cars-visualized/

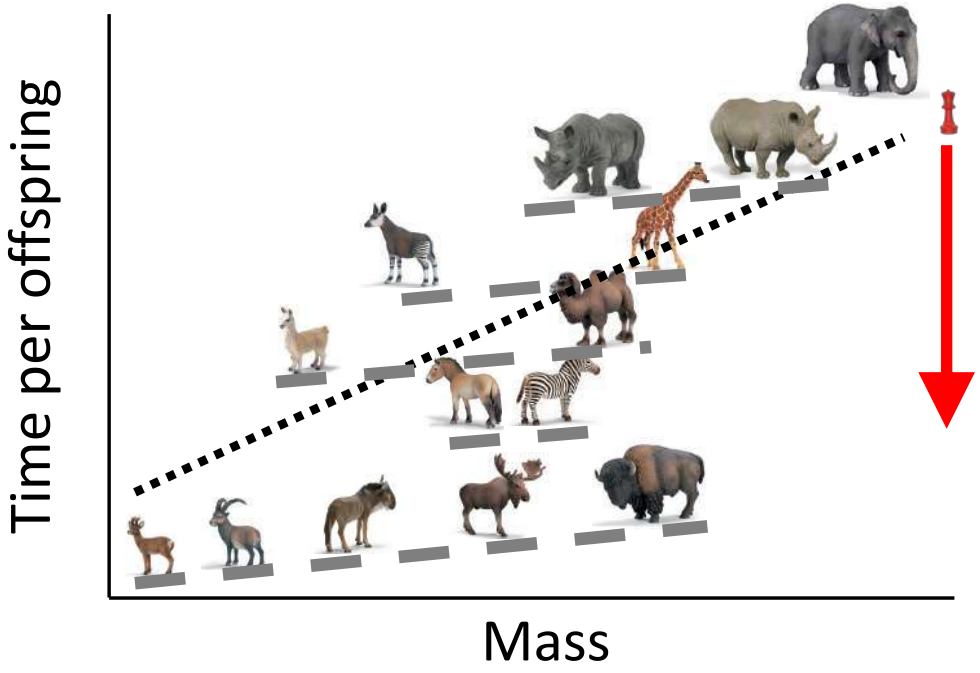
The trade-off fallacy

Saying that you either invest more into reproduction (live fast, produce many offspring at a time) or more into maintenance (live slower, produce less offspring at a time but over a longer period) …

… is like saying you do not believe that evolution can find new solutions.



You would not consider the overall pattern a fixed law, but consider it with respect to technical progress.

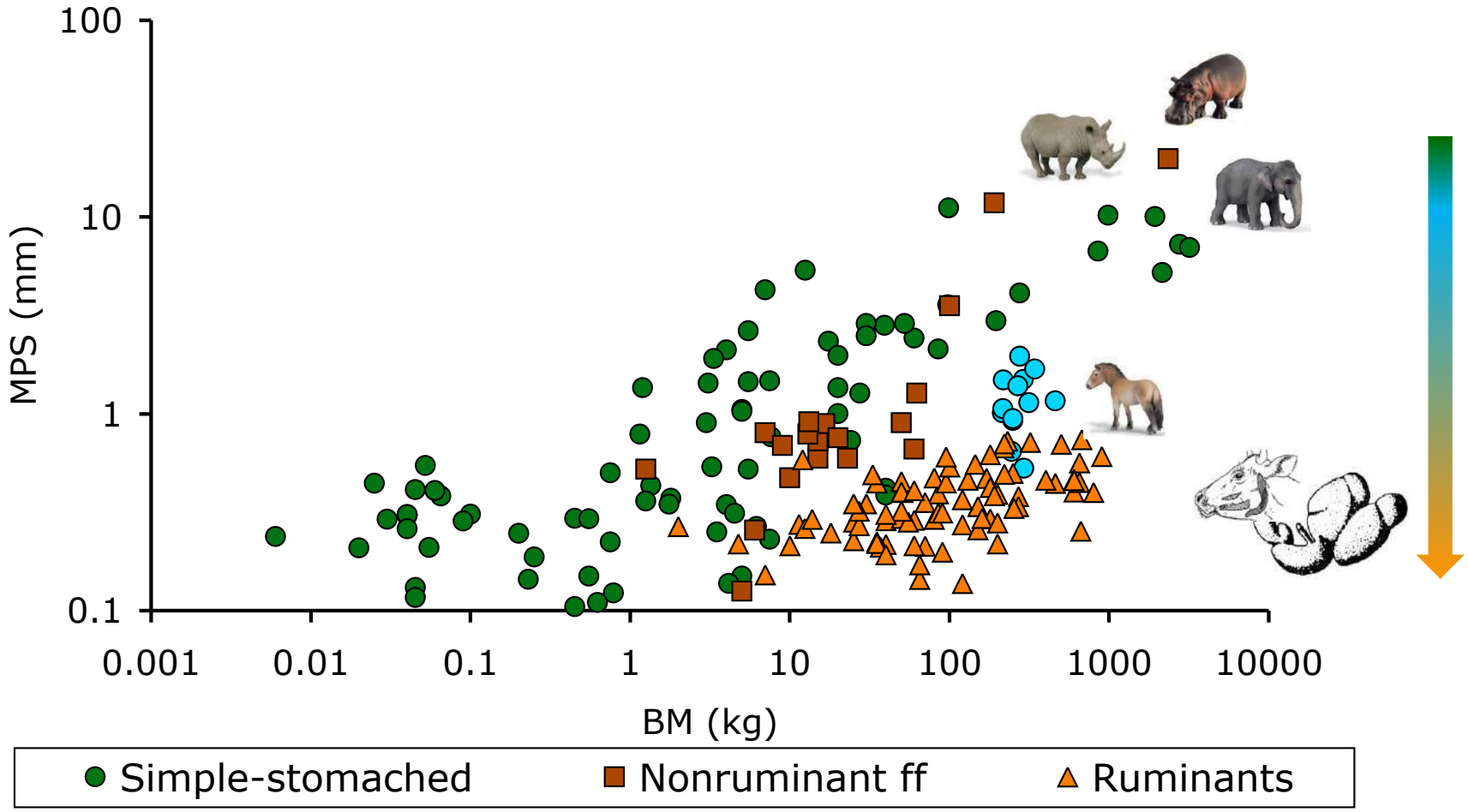


Why would you consider this a pattern due to fixed life history tradeoff laws, and not rather a snapshot in a process of optimization?

Comparative chewing efficiency in mammalian herbivores

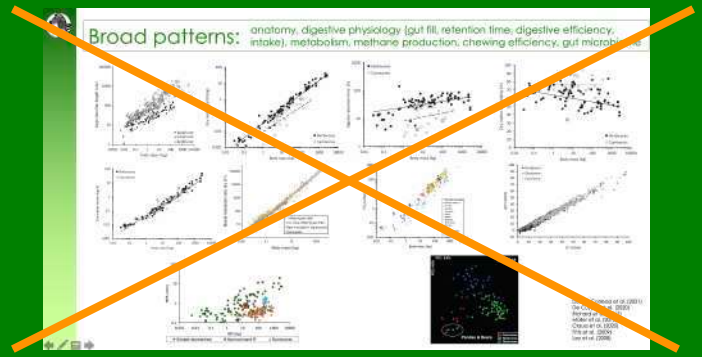
Julia Fritz, Jürgen Hummel, Ellen Kienzle, Christian Arnold, Charles Nunn and Marcus Clauss

Oikos 118: 1623–1632, 2009



The future of comparative nutrition?

Contributions to husbandry and animal welfare



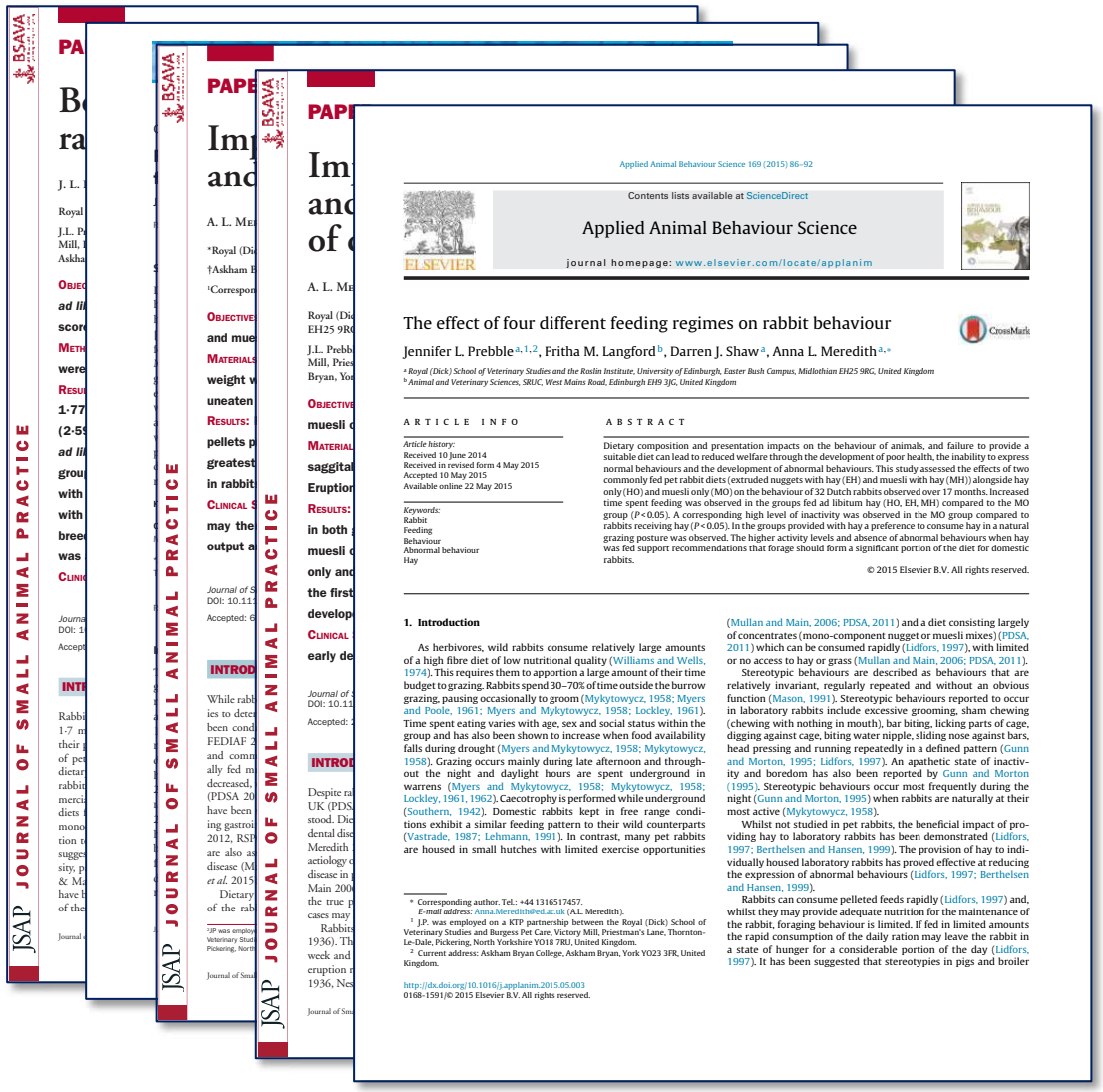
Possible contributions to husbandry and welfare

- freely shareable, reasonable dataset on nutrient composition of feeds
  - not a blind compilation of all data that exists
  - complete nutrient sets (no data gaps)
  - reasonable categories (emphasis on practical relevance rather than academic accuracy)

- reliable datasets on natural diets

- (experimental) recording of health- and welfare relevant measures

Rabbit example



Applied Animal Behaviour Science 169 (2015) 86–92

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

The effect of four different feeding regimes on rabbit behaviour

Jennifer L. Prebble[a,1,2], Fritha M. Langford[b], Darren J. Shaw[a], Anna L. Meredith[a,*]

[a] Royal (Dick) School of Veterinary Studies and the Roslin Institute, University of Edinburgh, Easter Bush Campus, Midlothian EH25 9RG, United Kingdom
[b] Animal and Veterinary Sciences, SRUC, West Mains Road, Edinburgh EH9 3JC, United Kingdom

ARTICLE INFO

Article history:
Received 10 June 2014
Received in revised form 4 May 2015
Accepted 10 May 2015
Available online 22 May 2015

Keywords:
Rabbit
Feeding
Behaviour
Abnormal behaviour
Hay

ABSTRACT

Dietary composition and presentation impacts on the behaviour of animals, and failure to provide a suitable diet can lead to reduced welfare through the development of poor health, the inability to express normal behaviours and the development of abnormal behaviours. This study assessed the effects of two commonly fed pet rabbit diets (extruded nuggets with hay (EH) and muesli with hay (MH)) alongside hay only (HO) and muesli only (MO) on the behaviour of 32 Dutch rabbits observed over 17 months. Increased time spent feeding was observed in the groups fed ad libitum hay (HO, EH, MH) compared to the MO group ($P < 0.05$). A corresponding high level of inactivity was observed in the MO group compared to rabbits receiving hay ($P < 0.05$). In the groups provided with hay a preference to consume hay in a natural grazing posture was observed. The higher activity levels and absence of abnormal behaviours when hay was fed support recommendations that forage should form a significant portion of the diet for domestic rabbits.

1. Introduction

As herbivores, wild rabbits consume relatively large amounts of a high fibre diet of low nutritional quality (Williams and Wells, 1974). This requires them to apportion a large amount of their time budget to grazing. Rabbits spend 30–70% of time outside the burrow grazing, pausing occasionally to groom (Mykytowycz, 1958; Myers and Poole, 1961; Myers and Mykytowycz, 1958; Lockley, 1961). Time spent eating varies with age, sex and social status within the group and has also been shown to increase when food availability falls during drought (Myers and Mykytowycz, 1958; Mykytowycz, 1958). Grazing occurs mainly during late afternoon and throughout the night and daylight hours are spent underground in warrens (Myers and Mykytowycz, 1958; Mykytowycz, 1958; Lockley, 1961, 1962). Caecotrophy is performed while underground (Southern, 1942). Domestic rabbits kept in free range conditions exhibit a similar feeding pattern to their wild counterparts (Vastrade, 1987; Lehmann, 1991). In contrast, many pet rabbits are housed in small hutches with limited exercise opportunities (Mullan and Main, 2006; PDSA, 2011) and a diet consisting largely of concentrates (mono-component nugget or muesli mixes) (PDSA, 2011) which can be consumed rapidly (Lidfors, 1997), with limited or no access to hay or grass (Mullan and Main, 2006; PDSA, 2011).

Stereotypic behaviours are described as behaviours that are relatively invariant, regularly repeated and without an obvious function (Mason, 1991). Stereotypic behaviours reported to occur in laboratory rabbits include excessive grooming, sham chewing (chewing with nothing in mouth), bar biting, licking parts of cage, digging against cage, biting water nipple, sliding nose against bars, head pressing and running repeatedly in a defined pattern (Gunn and Morton, 1995; Lidfors, 1997). An apathetic state of inactivity and boredom has also been reported by Gunn and Morton (1995). Stereotypic behaviours occur most frequently during the night (Gunn and Morton, 1995) when rabbits are naturally at their most active (Mykytowycz, 1958).

Whilst not studied in pet rabbits, the beneficial impact of providing hay to laboratory rabbits has been demonstrated (Lidfors, 1997; Berthelsen and Hansen, 1999). The provision of hay to individually housed laboratory rabbits has proved effective at reducing the expression of abnormal behaviours (Lidfors, 1997; Berthelsen and Hansen, 1999).

Rabbits can consume pelleted feeds rapidly (Lidfors, 1997) and, whilst they may provide adequate nutrition for the maintenance of the rabbit, foraging behaviour is limited. If fed in limited amounts the rapid consumption of the daily ration may leave the rabbit in a state of hunger for a considerable portion of the day (Lidfors, 1997). It has been suggested that stereotypies in pigs and broiler

* Corresponding author. Tel.: +44 1316517457.
E-mail address: Anna.Meredith@ed.ac.uk (A.L. Meredith).
[1] J.P. was employed on a KTP partnership between the Royal (Dick) School of Veterinary Studies and Burgess Pet Care, Victory Mill, Priestman's Lane, Thornton-Le-Dale, Pickering, North Yorkshire YO18 7RU, United Kingdom.
[2] Current address: Askham Bryan College, Askham Bryan, York YO23 3FR, United Kingdom.

http://dx.doi.org/10.1016/j.applanim.2015.05.003
0168-1591/

4 x 8 rabbits kept in pairs
(neutered, vaccinated)
17 months duration

		Crude fibre (%DM)
Hay only *ad lib*	HO	29
Extruded (+hay)	EH	19
Muesli (+hay)	MH	
Muesli only *ad lib*	MO	14




Rabbit study - behaviour

Applied Animal Behaviour Science 169 (2015) 86–92

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

The effect of four different feeding regimes on rabbit behaviour

Jennifer L. Prebble[a,1,2], Fritha M. Langford[b], Darren J. Shaw[a], Anna L. Meredith[a,*]

[a] Royal (Dick) School of Veterinary Studies and the Roslin Institute, University of Edinburgh, Easter Bush Campus, Midlothian EH25 9RG, United Kingdom
[b] Animal and Veterinary Sciences, SRUC, West Mains Road, Edinburgh EH9 3JG, United Kingdom

ARTICLE INFO

Article history:
Received 10 June 2014
Received in revised form 4 May 2015
Accepted 10 May 2015
Available online 22 May 2015

Keywords:
Rabbit
Feeding
Behaviour
Abnormal behaviour
Hay

ABSTRACT

Dietary composition and presentation impacts on the behaviour of animals, and failure to provide a suitable diet can lead to reduced welfare through the development of poor health, the inability to express normal behaviours and the development of abnormal behaviours. This study assessed the effects of two commonly fed pet rabbit diets (extruded nuggets with hay (EH) and muesli with hay (MH)) alongside hay only (HO) and muesli only (MO) on the behaviour of 32 Dutch rabbits observed over 17 months. Increased time spent feeding was observed in the groups fed ad libitum hay (HO, EH, MH) compared to the MO group ($P < 0.05$). A corresponding high level of inactivity was observed in the MO group compared to rabbits receiving hay ($P < 0.05$). In the groups provided with hay a preference to consume hay in a natural grazing posture was observed. The higher activity levels and absence of abnormal behaviours when hay was fed support recommendations that forage should form a significant portion of the diet for domestic rabbits.

1. Introduction

As herbivores, wild rabbits consume relatively large amounts of a high fibre diet of low nutritional quality (Williams and Wells, 1974). This requires them to apportion a large amount of their time budget to grazing. Rabbits spend 30–70% of time outside the burrow grazing, pausing occasionally to groom (Mykytowycz, 1958; Myers and Poole, 1961; Myers and Mykytowycz, 1958; Lockley, 1961). Time spent eating varies with age, sex and social status within the group and has also been shown to increase when food availability falls during drought (Myers and Mykytowycz, 1958; Mykytowycz, 1958). Grazing occurs mainly during late afternoon and throughout the night and daylight hours are spent underground in warrens (Myers and Mykytowycz, 1958; Mykytowycz, 1958; Lockley, 1961, 1962). Caecotrophy is performed while underground (Southern, 1942). Domestic rabbits kept in free range conditions exhibit a similar feeding pattern to their wild counterparts (Vastrade, 1987; Lehmann, 1991). In contrast, many pet rabbits are housed in small hutches with limited exercise opportunities (Mullan and Main, 2006; PDSA, 2011) and a diet consisting largely of concentrates (mono-component nugget or muesli mixes) (PDSA, 2011) which can be consumed rapidly (Lidfors, 1997), with limited or no access to hay or grass (Mullan and Main, 2006; PDSA, 2011).

Stereotypic behaviours are described as behaviours that are relatively invariant, regularly repeated and without an obvious function (Mason, 1991). Stereotypic behaviours reported to occur in laboratory rabbits include excessive grooming, sham chewing (chewing with nothing in mouth), bar biting, licking parts of cage, digging against cage, biting water nipple, sliding nose against bars, head pressing and running repeatedly in a defined pattern (Gunn and Morton, 1995; Lidfors, 1997). An apathetic state of inactivity and boredom has also been reported by Gunn and Morton (1995). Stereotypic behaviours occur most frequently during the night (Gunn and Morton, 1995) when rabbits are naturally at their most active (Mykytowycz, 1958).

Whilst not studied in pet rabbits, the beneficial impact of providing hay to laboratory rabbits has been demonstrated (Lidfors, 1997; Berthelsen and Hansen, 1999). The provision of hay to individually housed laboratory rabbits has proved effective at reducing the expression of abnormal behaviours (Lidfors, 1997; Berthelsen and Hansen, 1999).

Rabbits can consume pelleted feeds rapidly (Lidfors, 1997) and, whilst they may provide adequate nutrition for the maintenance of the rabbit, foraging behaviour is limited. If fed in limited amounts the rapid consumption of the daily ration may leave the rabbit in a state of hunger for a considerable portion of the day (Lidfors, 1997). It has been suggested that stereotypies in pigs and broiler

* Corresponding author. Tel.: +44 1316517457.
E-mail address: Anna.Meredith@ed.ac.uk (A.L. Meredith).
[1] J.P. was employed on a KTP partnership between the Royal (Dick) School of Veterinary Studies and Burgess Pet Care, Victory Mill, Priestman's Lane, Thornton-Le-Dale, Pickering, North Yorkshire YO18 7RU, United Kingdom.
[2] Current address: Askham Bryan College, Askham Bryan, York YO23 3FR, United Kingdom.

http://dx.doi.org/10.1016/j.applanim.2015.05.003
0168-1591/

8-10 h eating
10 h 'inactive'

as described for wild rabbits

2 h eating
15-18 h
'inactive'

as described for lab rabbits

Possible contributions to husbandry and welfare

- freely shareable, reasonable dataset on nutrient composition of feeds
  - not a blind compilation of all data that exists
  - complete nutrient sets (no data gaps)
  - reasonable categories (emphasis on practical relevance rather than academic accuracy)

- reliable datasets on natural diets … and natural activity

- developing feeding regimes that meet physiological requirements and represent adequate physical and cognitive challenges

Possible contributions to husbandry and welfare

- developing feeding regimes that meet physiological requirements and represent adequate physical and cognitive challenges

Possible contributions to husbandry and welfare

- developing feeding regimes that meet physiological requirements and represent adequate physical and cognitive challenges

Possible contributions to husbandry and welfare

- developing feeding regimes that meet physiological requirements and represent adequate physical and cognitive challenges

Possible contributions to husbandry and welfare

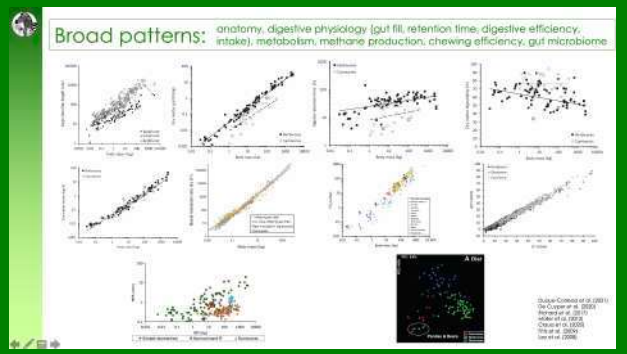
- freely shareable, reasonable dataset on nutrient composition of feeds
  - not a blind compilation of all data that exists
  - complete nutrient sets (no data gaps)
  - reasonable categories (emphasis on practical relevance rather than academic accuracy)

- reliable datasets on natural diets … and natural activity

- developing feeding regimes that meet physiological requirements and represent adequate physical and cognitive challenges

The future of comparative nutrition?

Contributions to understanding animals

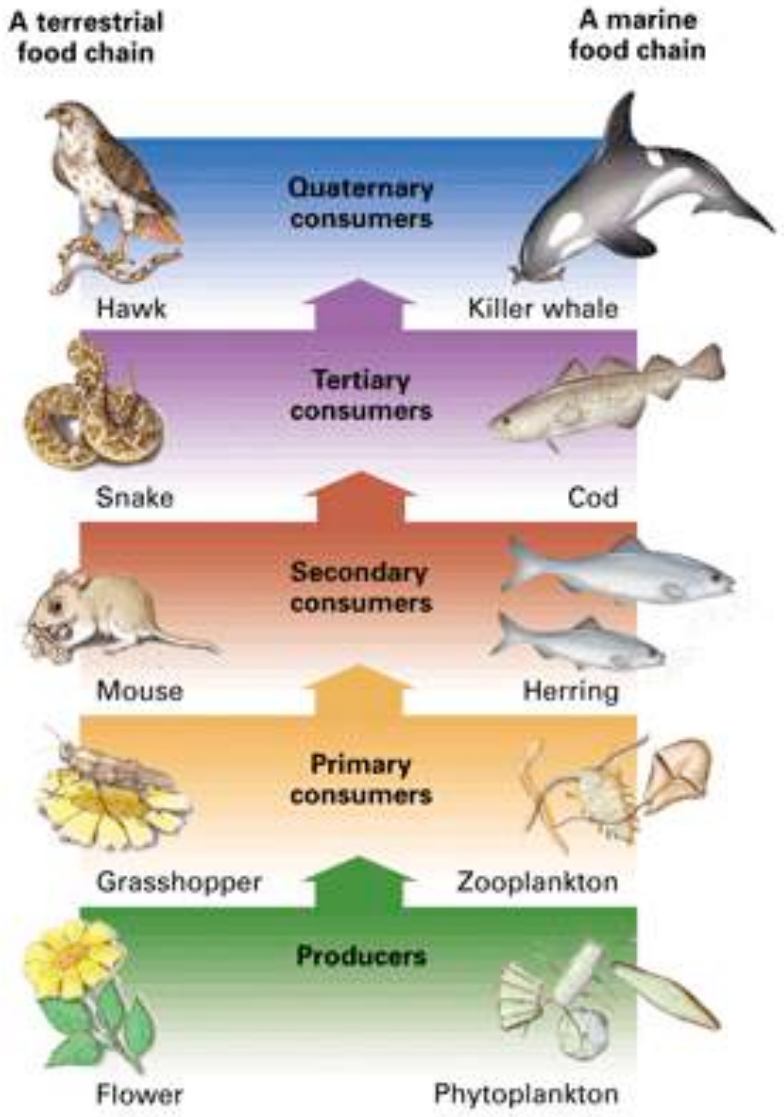


Faunivory – Omnivory – Herbivory

…

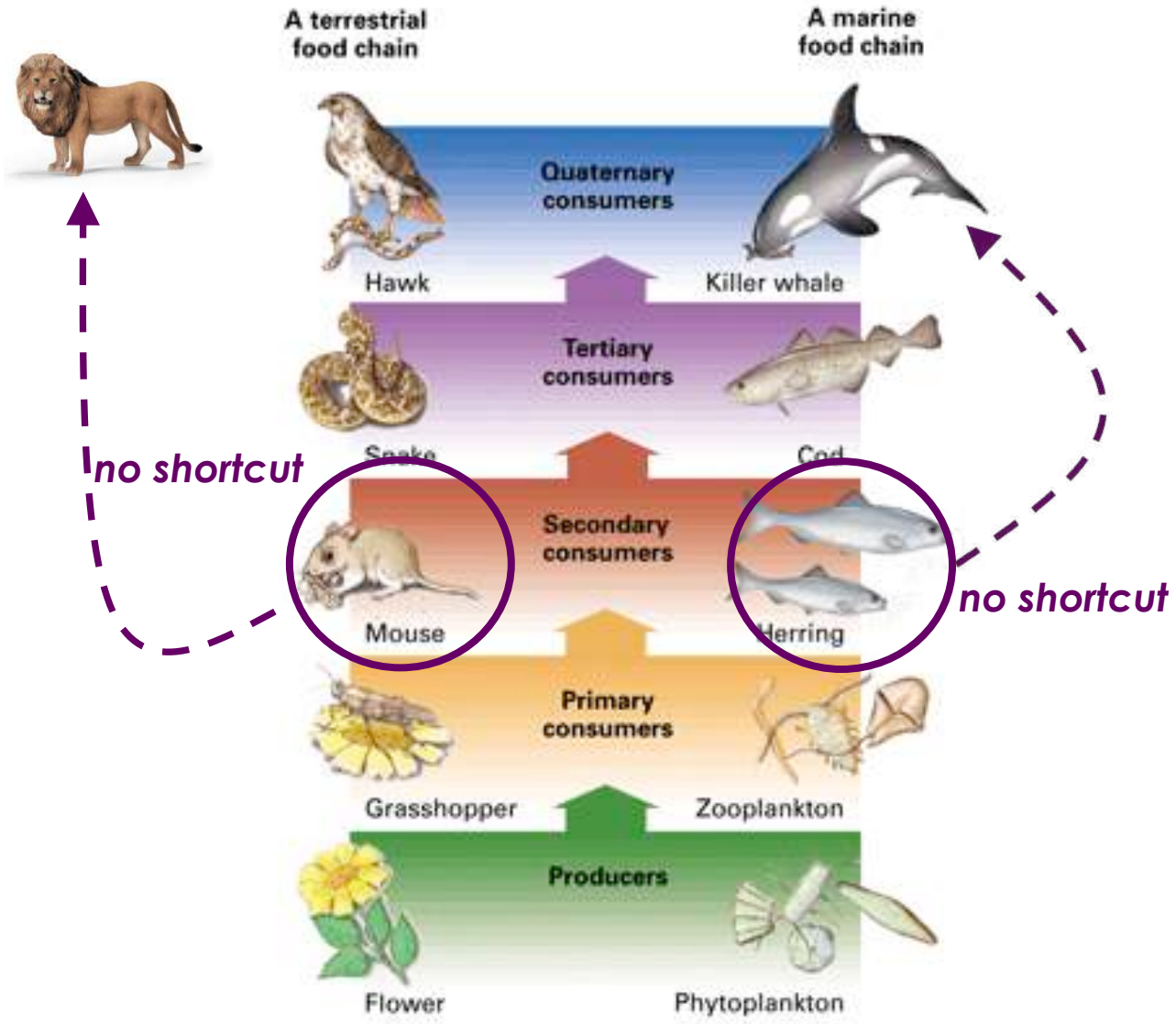
and microbe farming

Food chains … & *shortcuts*



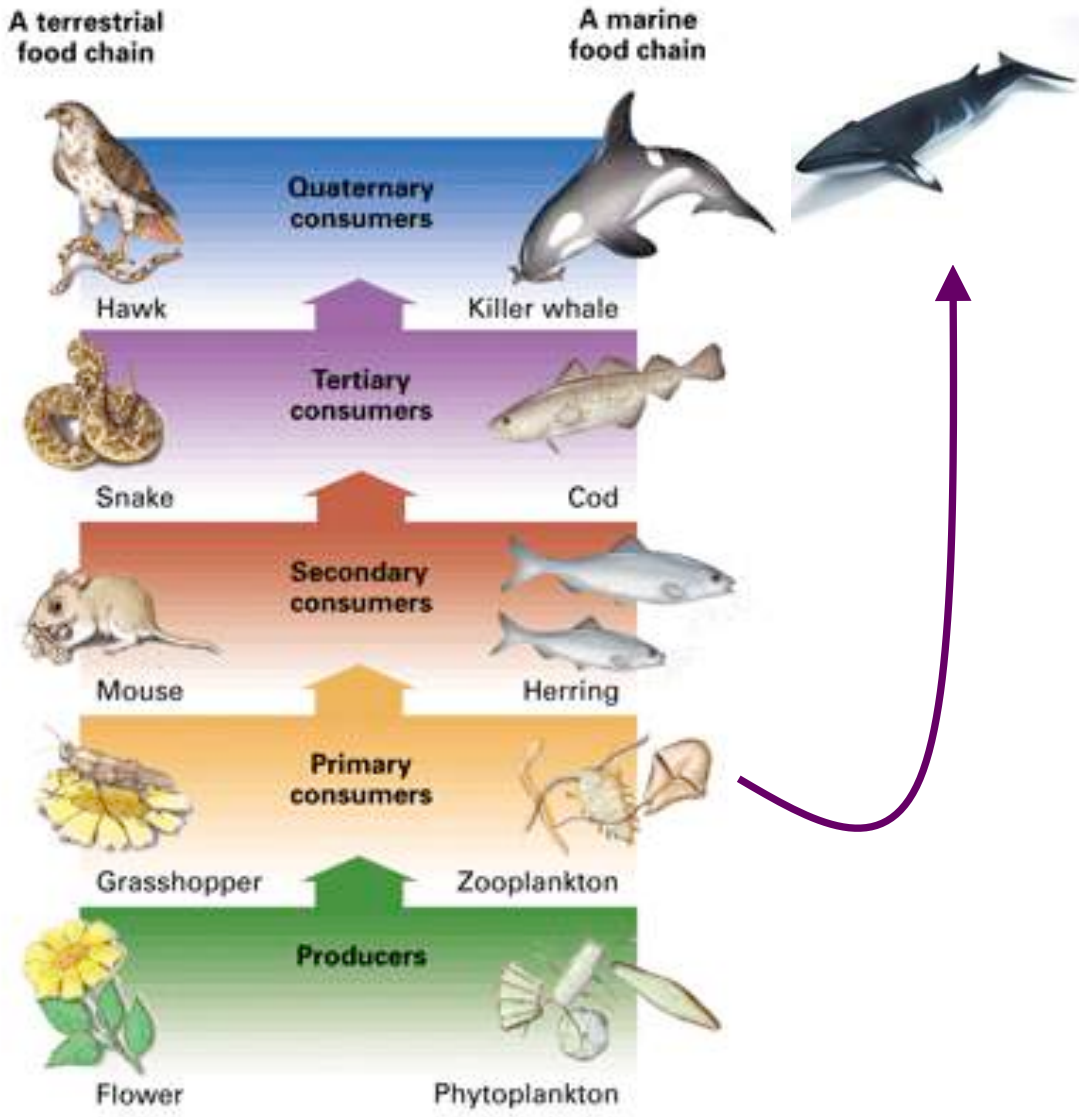
http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Food chains … & *shortcuts*



http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

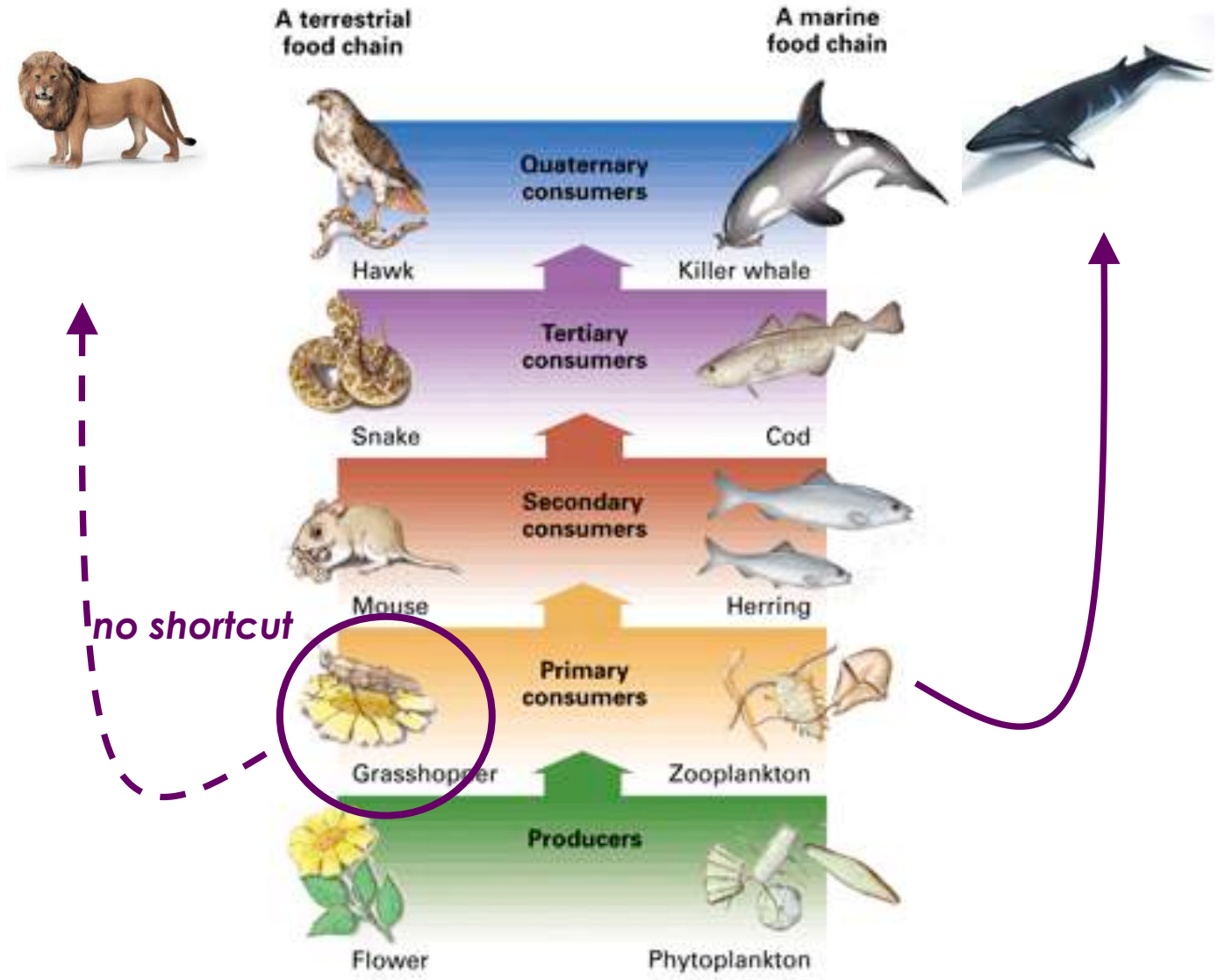
Food chains … & *shortcuts*



http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Easy-to-harvest packages of tiny invertebrates – krill clouds

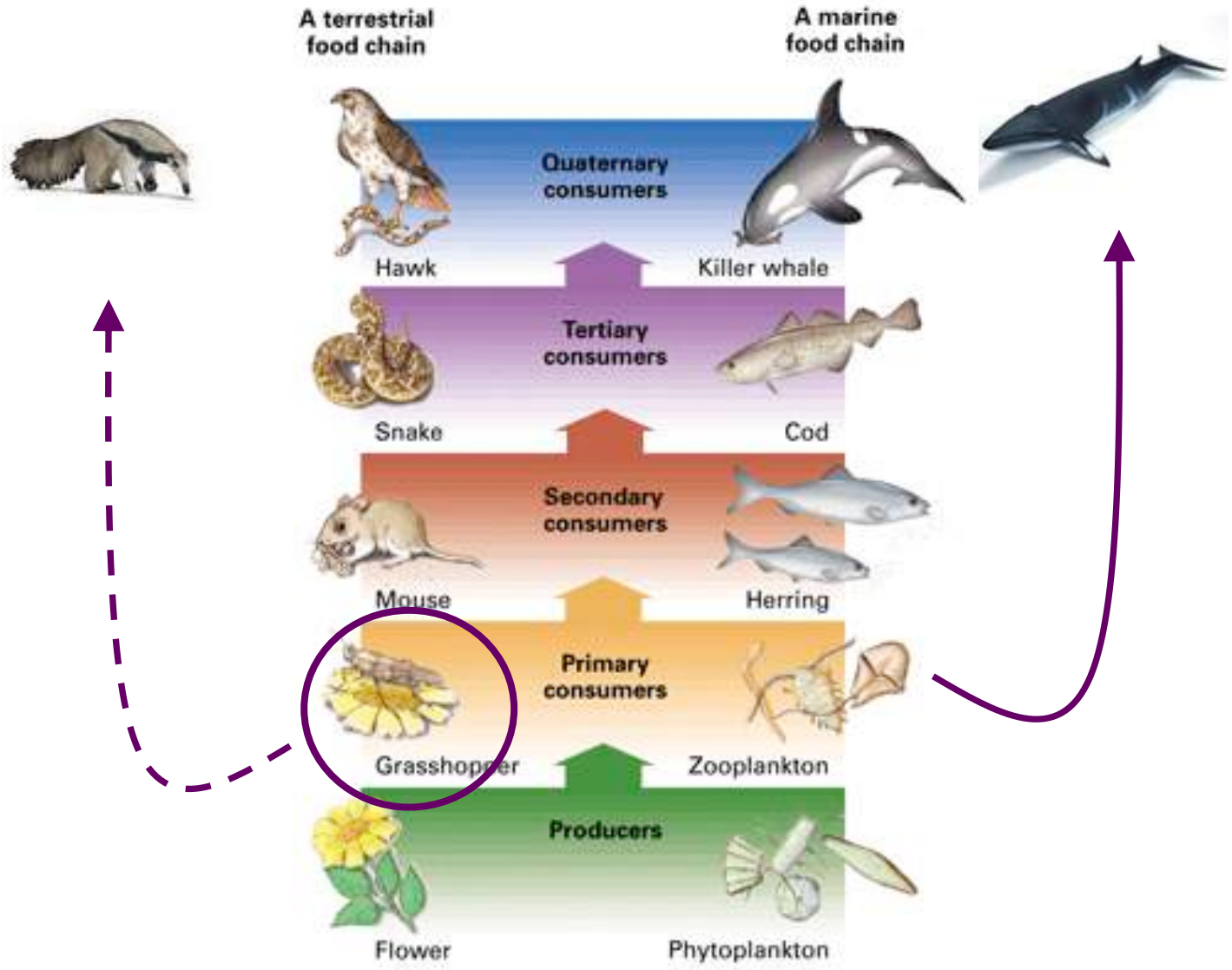
Food chains … & *shortcuts*



http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

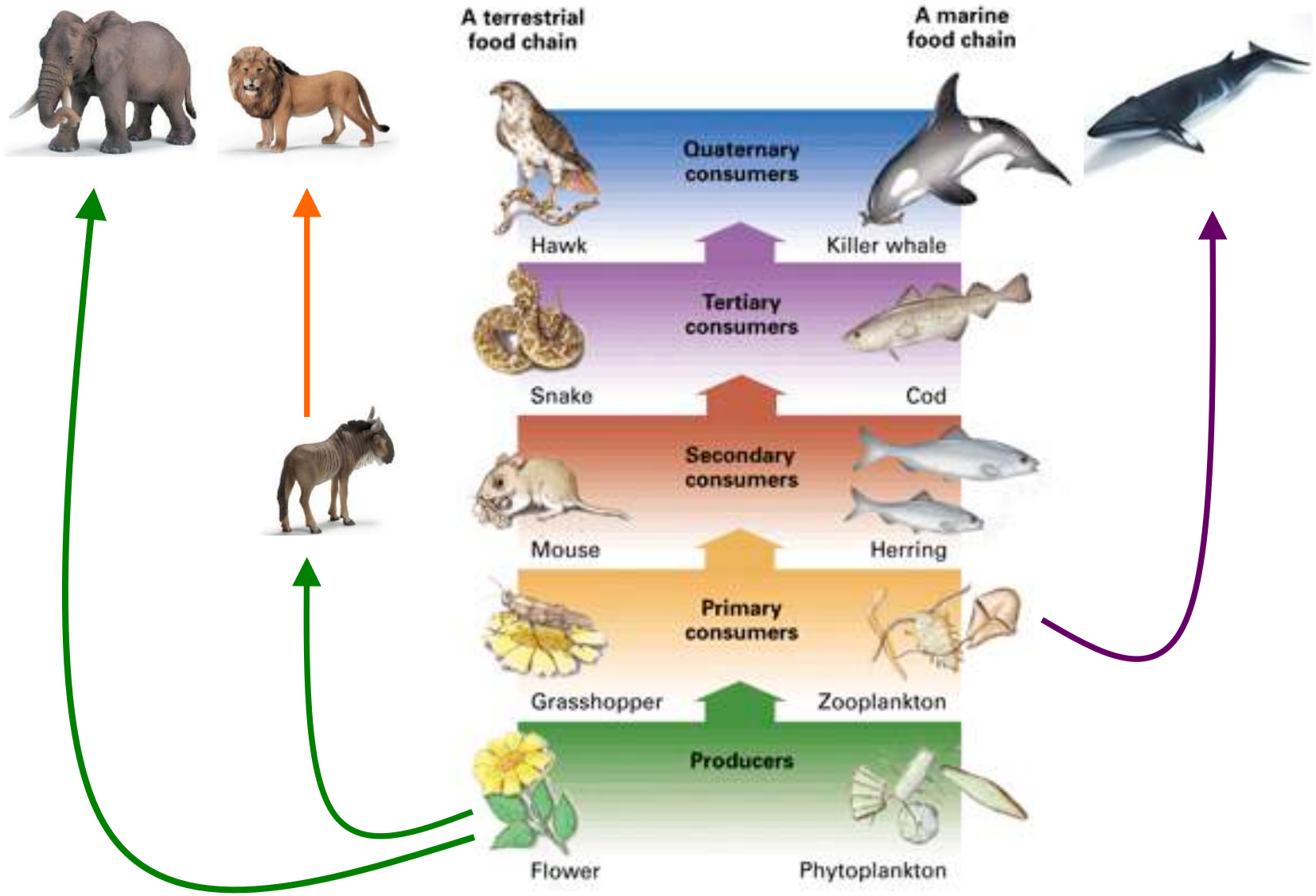
No easy-to-harvest packages of tiny vertebrates

Food chains … & *shortcuts*



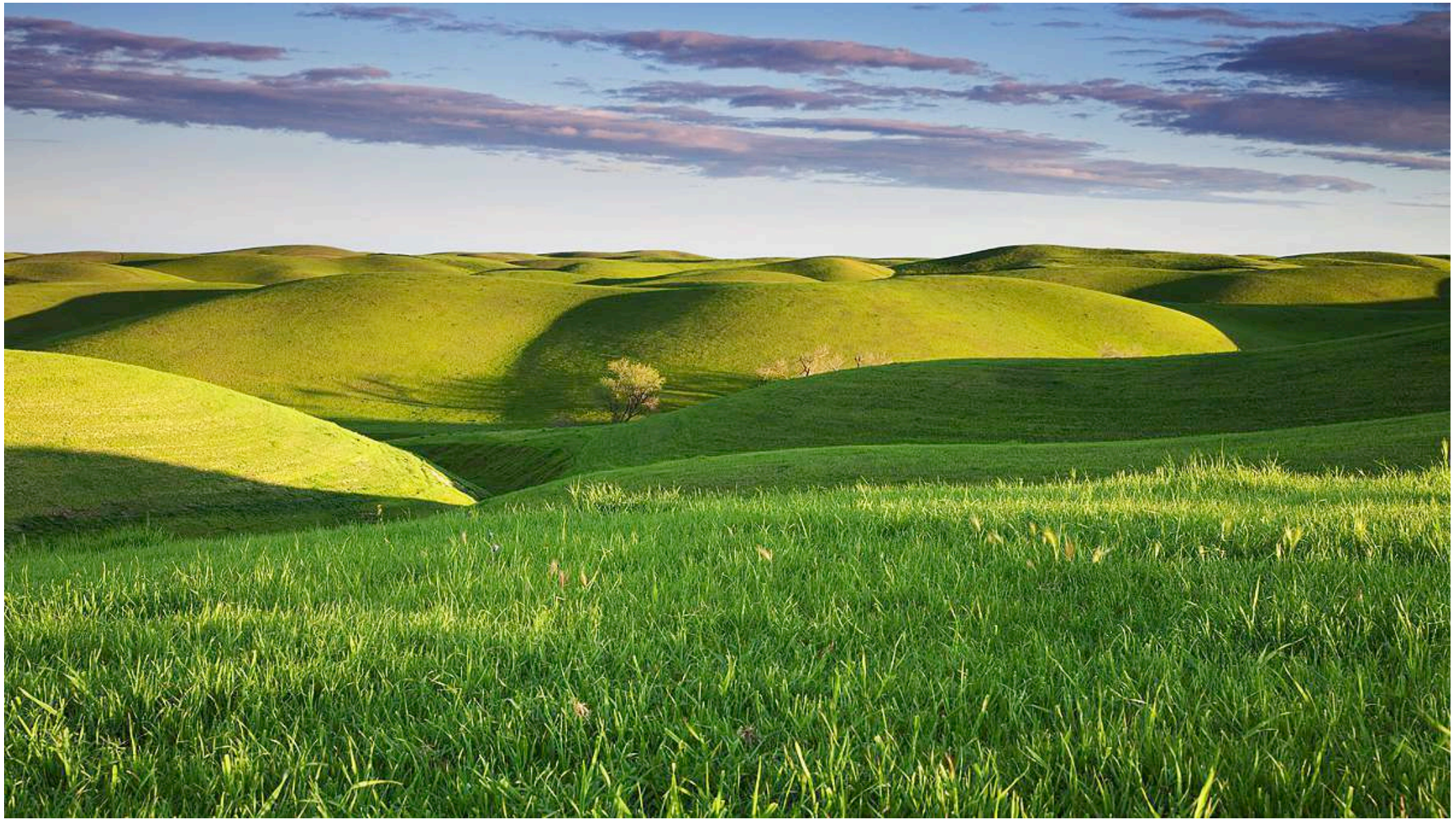
http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Food chains … & *shortcuts*



http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Ubiquitous dense large packages of plant food in terrestrial systems

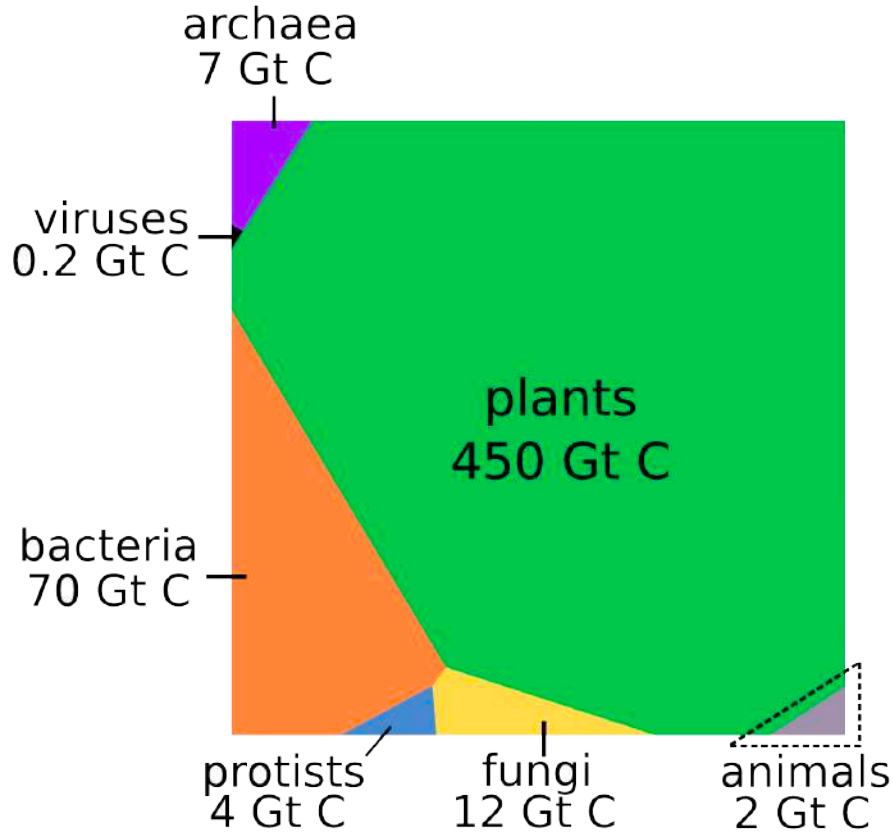


Food chains … & *shortcuts*

The biomass distribution on Earth

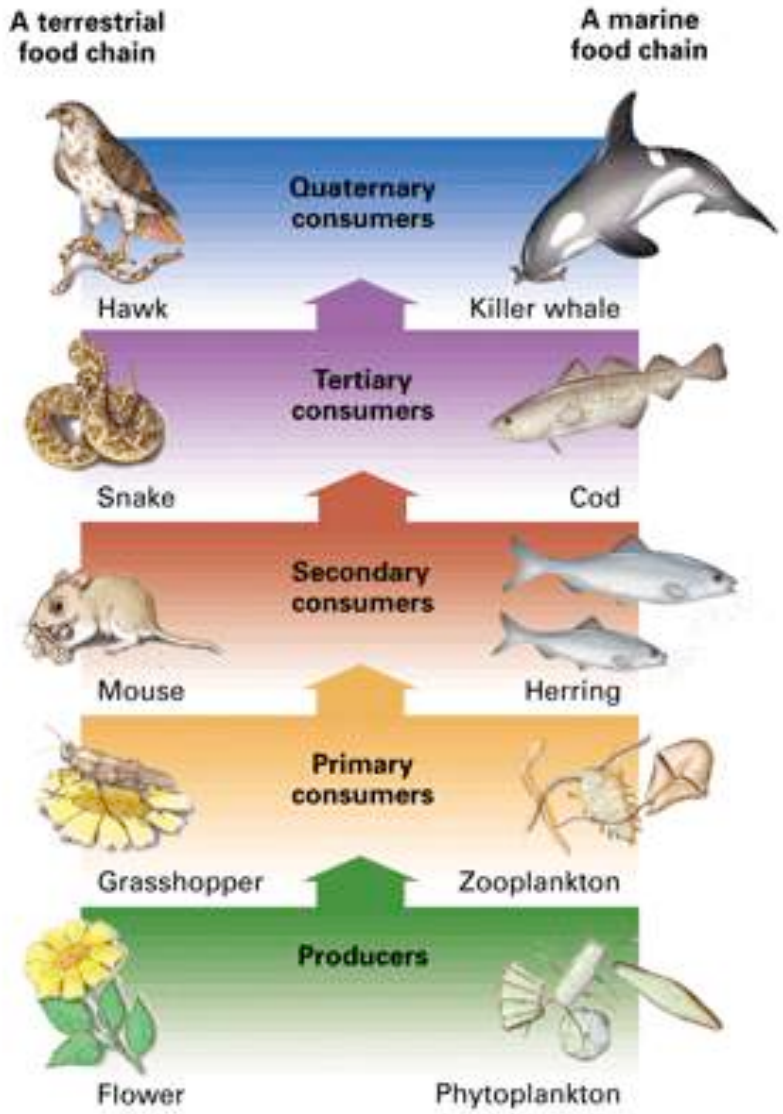
Yinon M. Bar-On[a], Rob Phillips[b,c], and Ron Milo[a,1]

6506–6511 | PNAS | June 19, 2018 | vol. 115



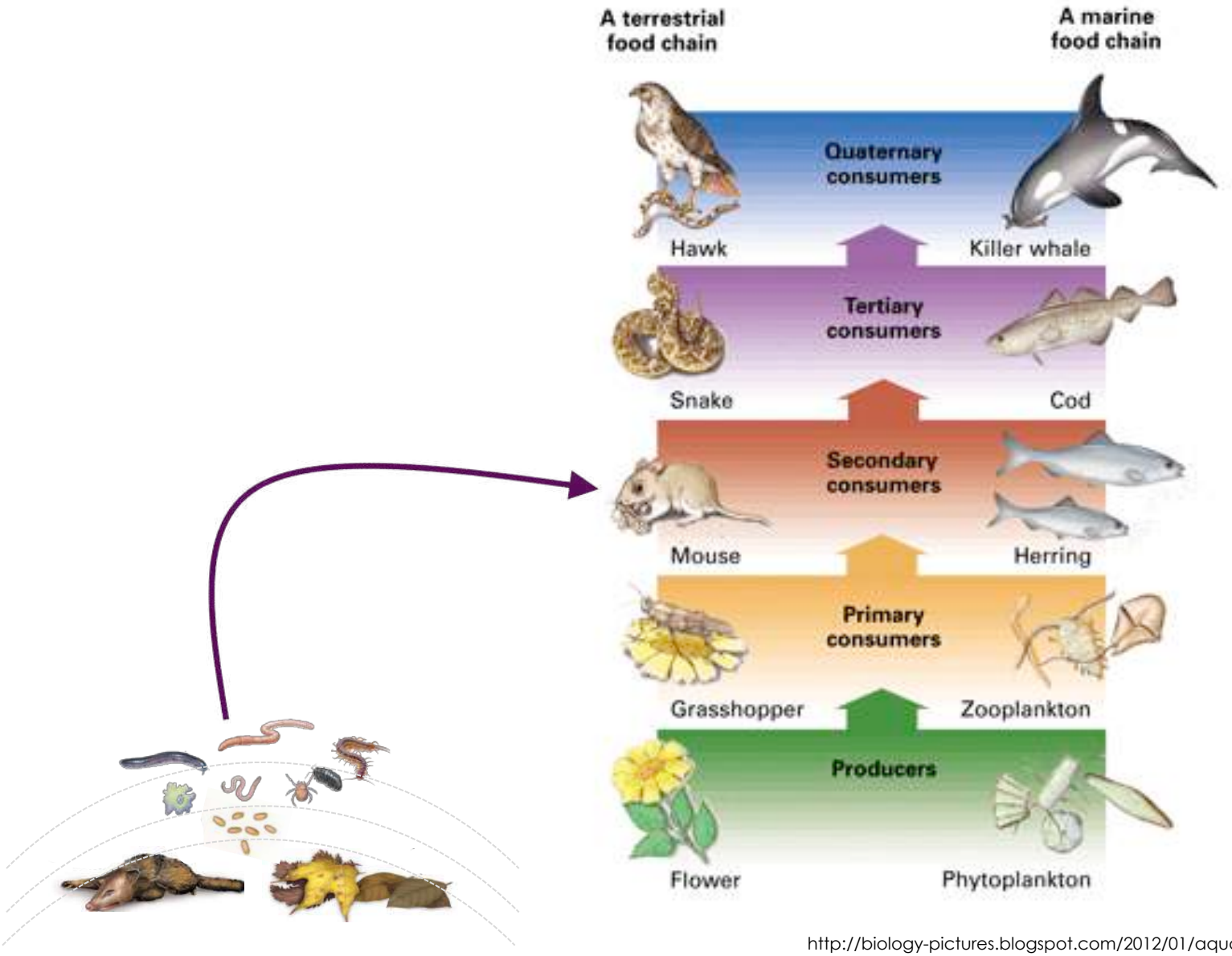
Food chains … & *shortcuts*

no shortcut



http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Food chains … & *shortcuts*



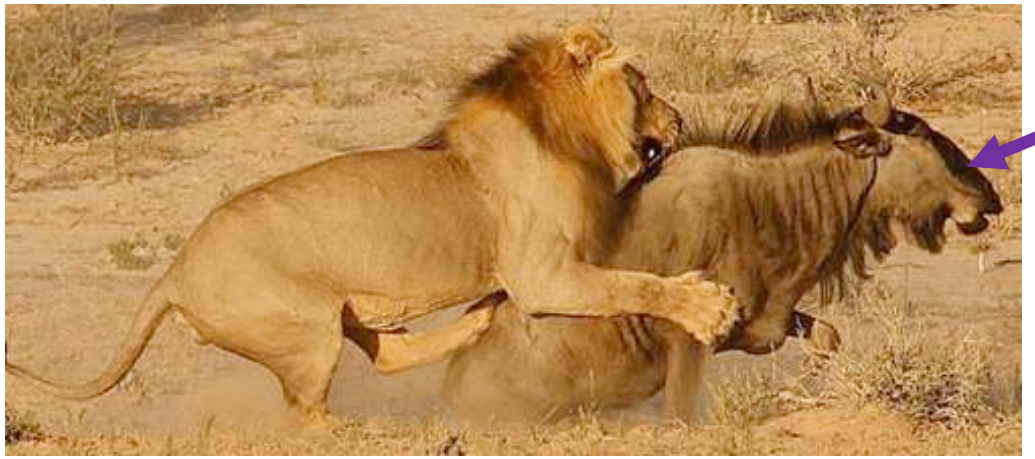
http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

Microbes in the digestive tract

Microbes in the digestive tract

… "*provide a service*":

- they 'ferment' carbohydrates and produce volatile fatty acids
- they may detoxify certain substances
- they produce vitamins
- they fixate atmospheric nitrogen (termites, fish, small mammals?)
- they '*produce microbial protein*'



a 'protein producer'?

Microbes in the digestive tract

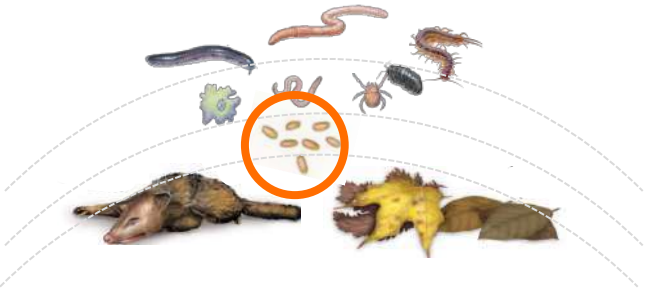
… "*provide a service*":

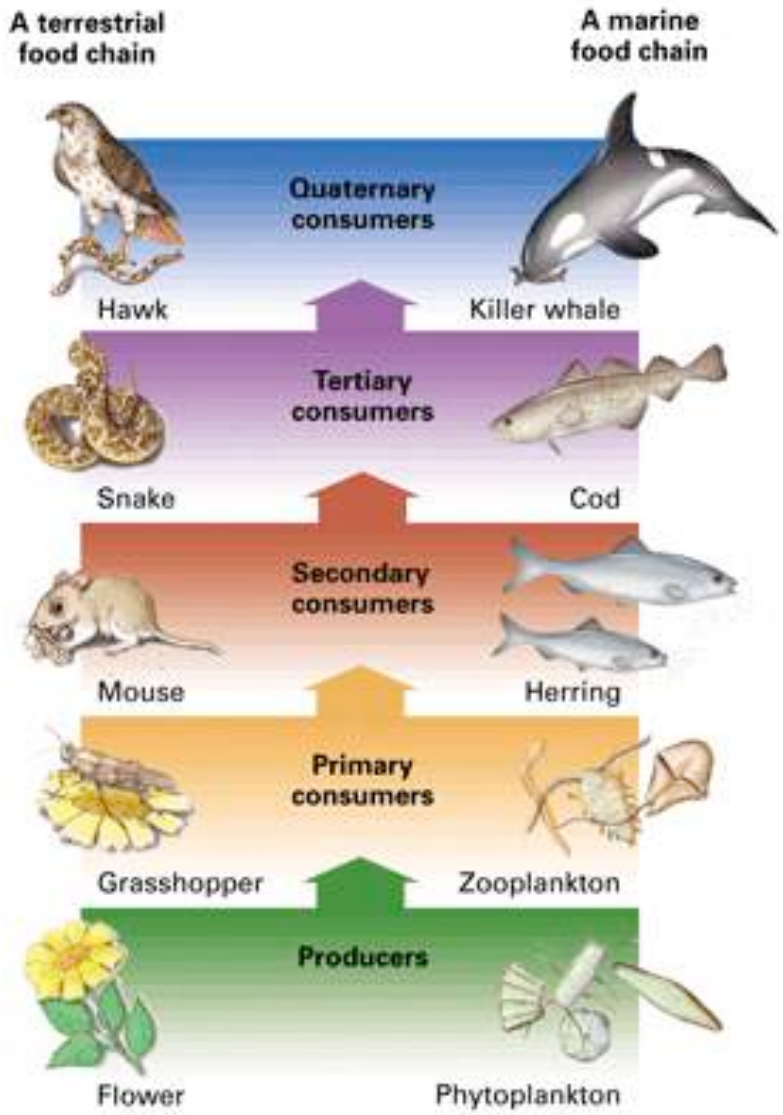
- they 'ferment' carbohydrates and produce volatile fatty acids
- they may detoxify certain substances
- they produce vitamins
- they fixate atmospheric nitrogen (termites, fish, small mammals?)
- they '*produce microbial protein*'

= microbes are (potential) prey in a trophic chain

Food chains … & *shortcuts*

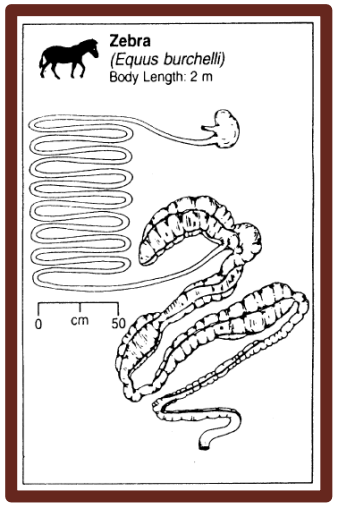
but there is microbe farming

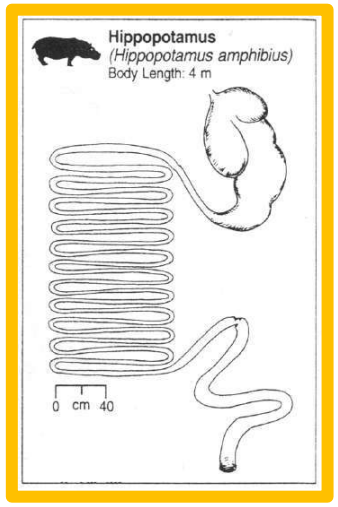




http://biology-pictures.blogspot.com/2012/01/aquatic-and-terrestrial-food-chains.html

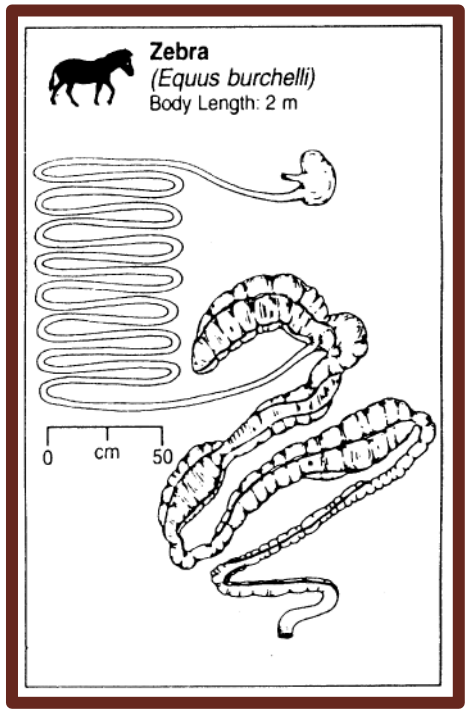
Farming: contain, nurture, harvest

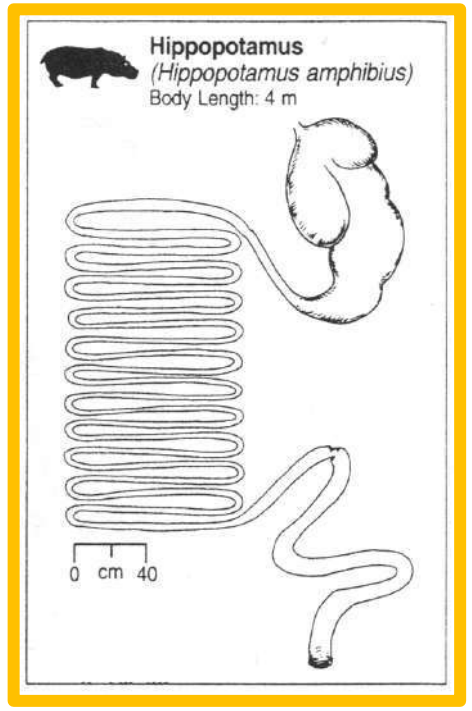




Stevens & Hume (1995)

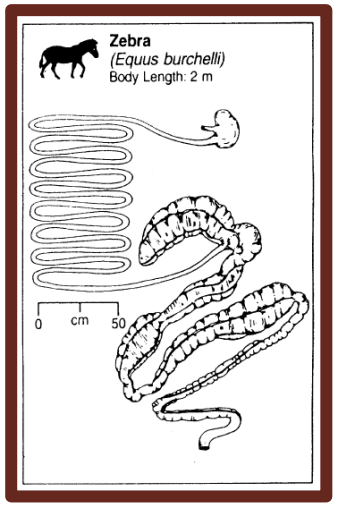
Hindgut and Foregut fermenters

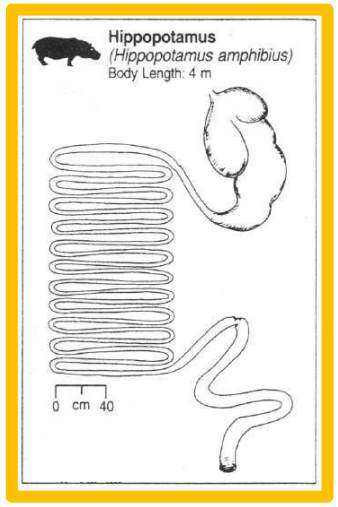




(Stevens & Hume 1995)

Farming: contain, nurture, harvest



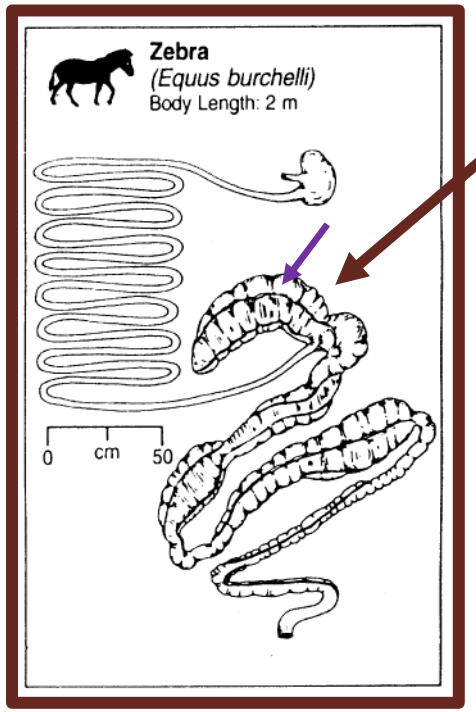


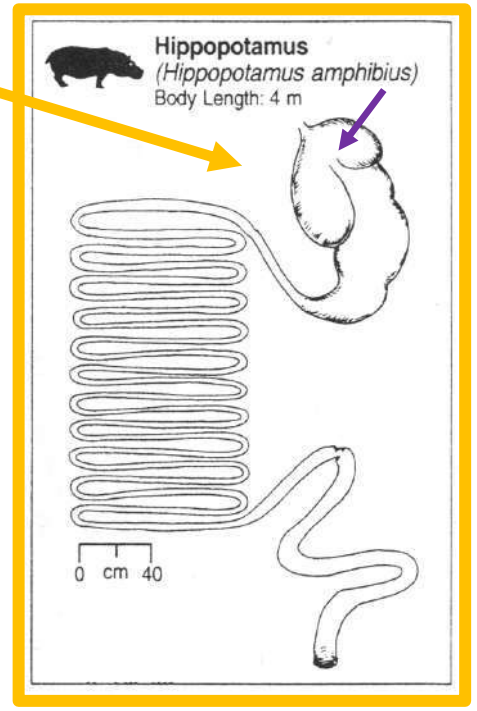
Stevens & Hume (1995)

Hindgut and Foregut fermenters

Microbes live and grow by fermenting the **diet** (**rest**) …
… and produce volatile fatty acids

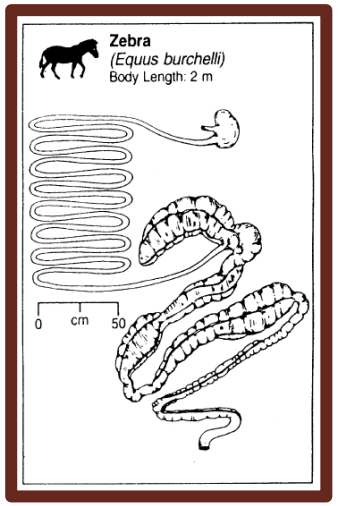
… and are supplied with **urea** via **blood** / **saliva**

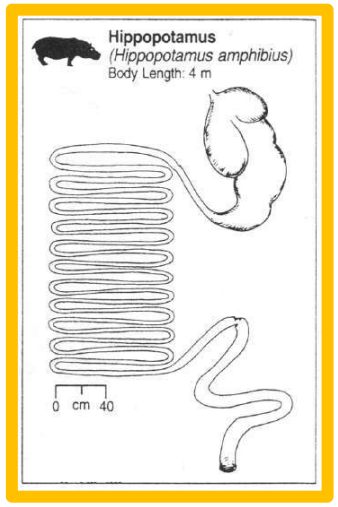




(Stevens & Hume 1995)

Farming: contain, nurture, harvest





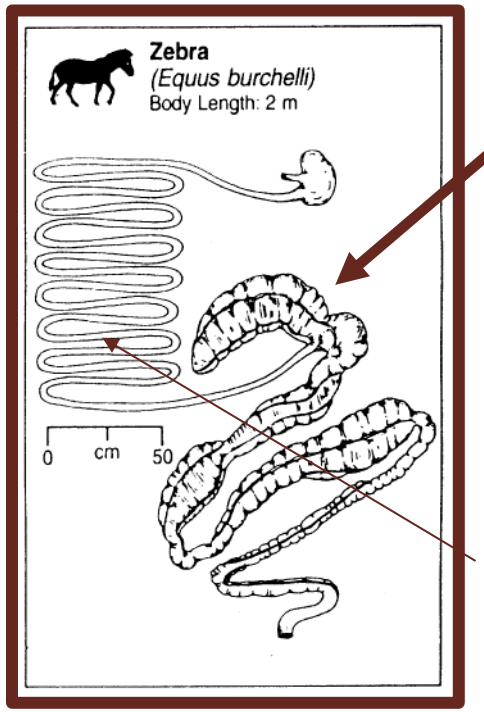
+ supplemental (endogenous) nitrogen

?

Stevens & Hume (1995)

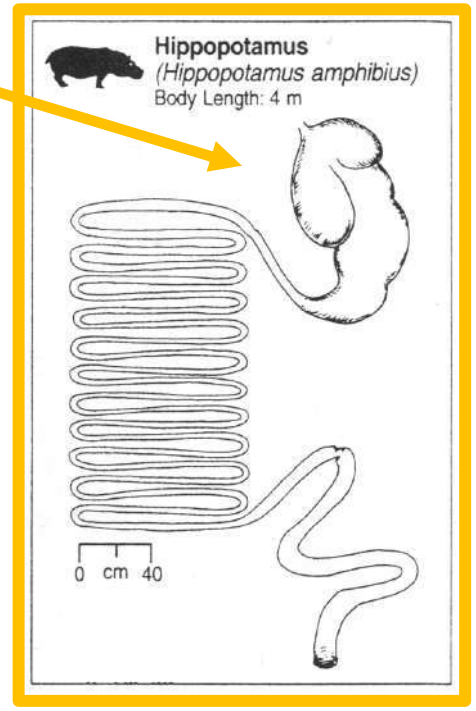
Hindgut and Foregut fermenters

Microbes ferment the
diet (**rest**) ...



... ***after*** small intestine

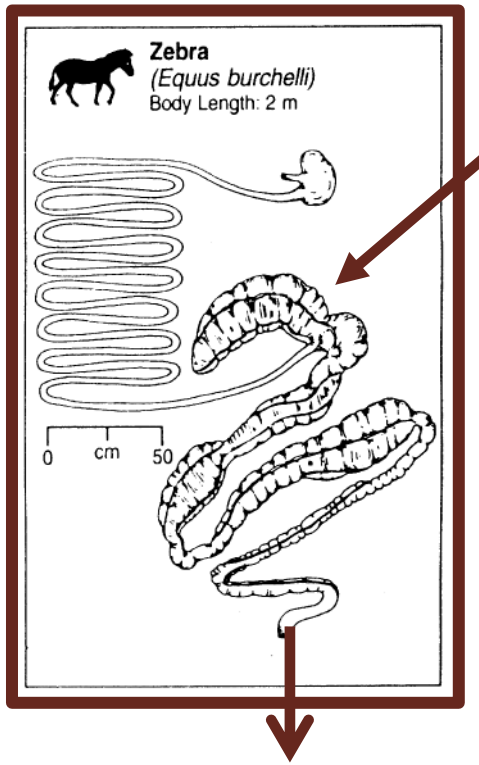
enzymatic digestion of diet



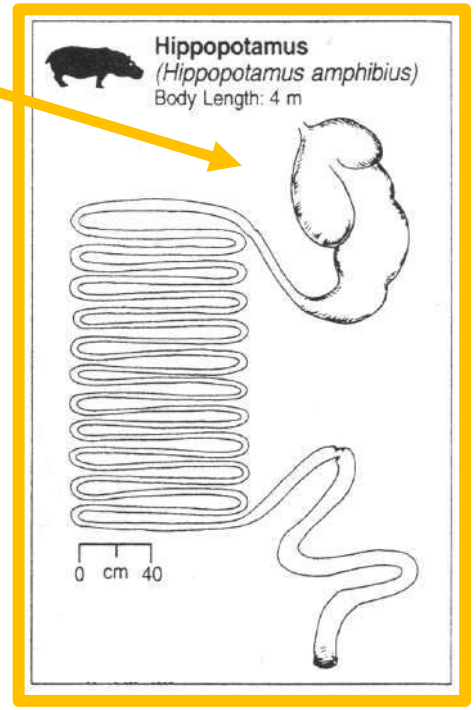
(Stevens & Hume 1995)

Hindgut and Foregut fermenters

Microbes ferment the
diet (**rest**) …



… and are excreted

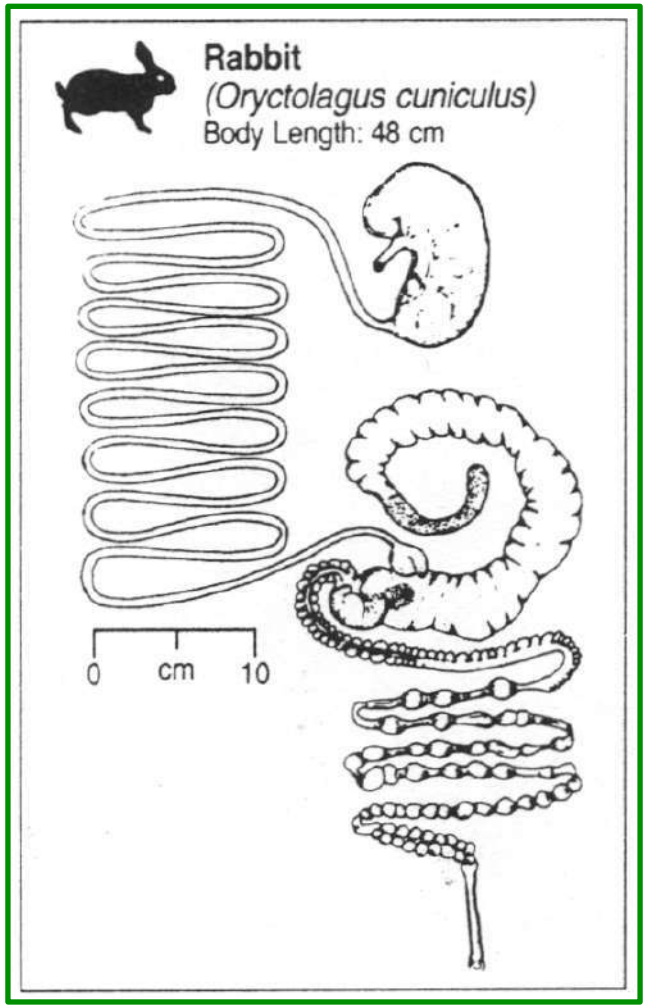


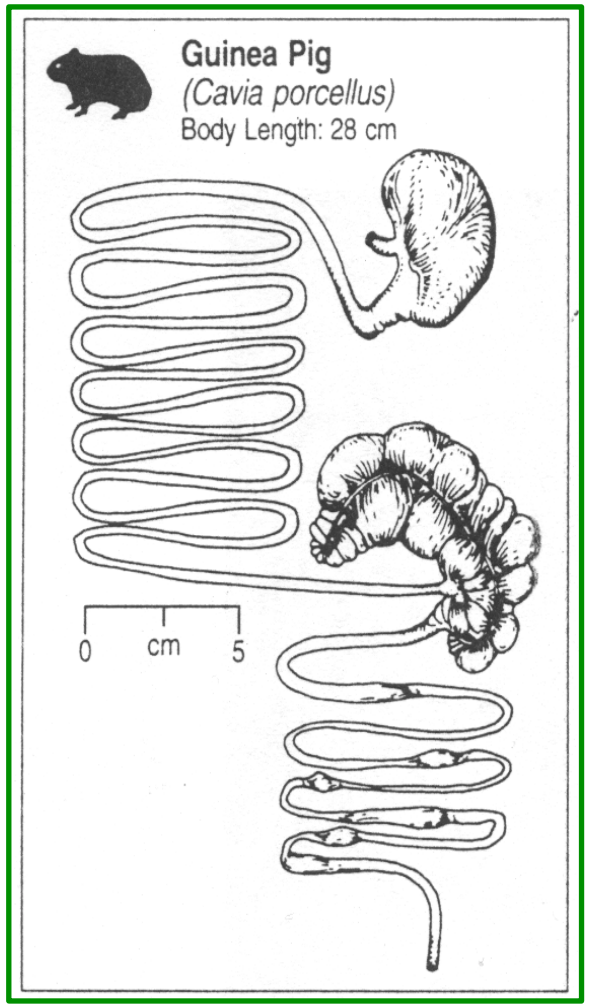
(Stevens & Hume 1995)

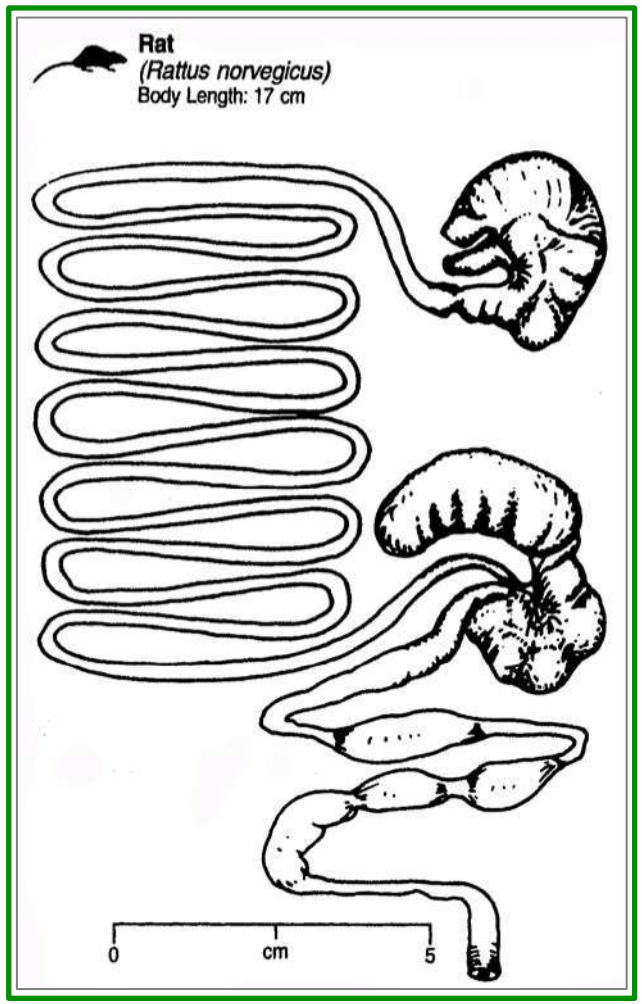
Extraction not possible ?

Extraction not possible ?

Small hindgut fermenters







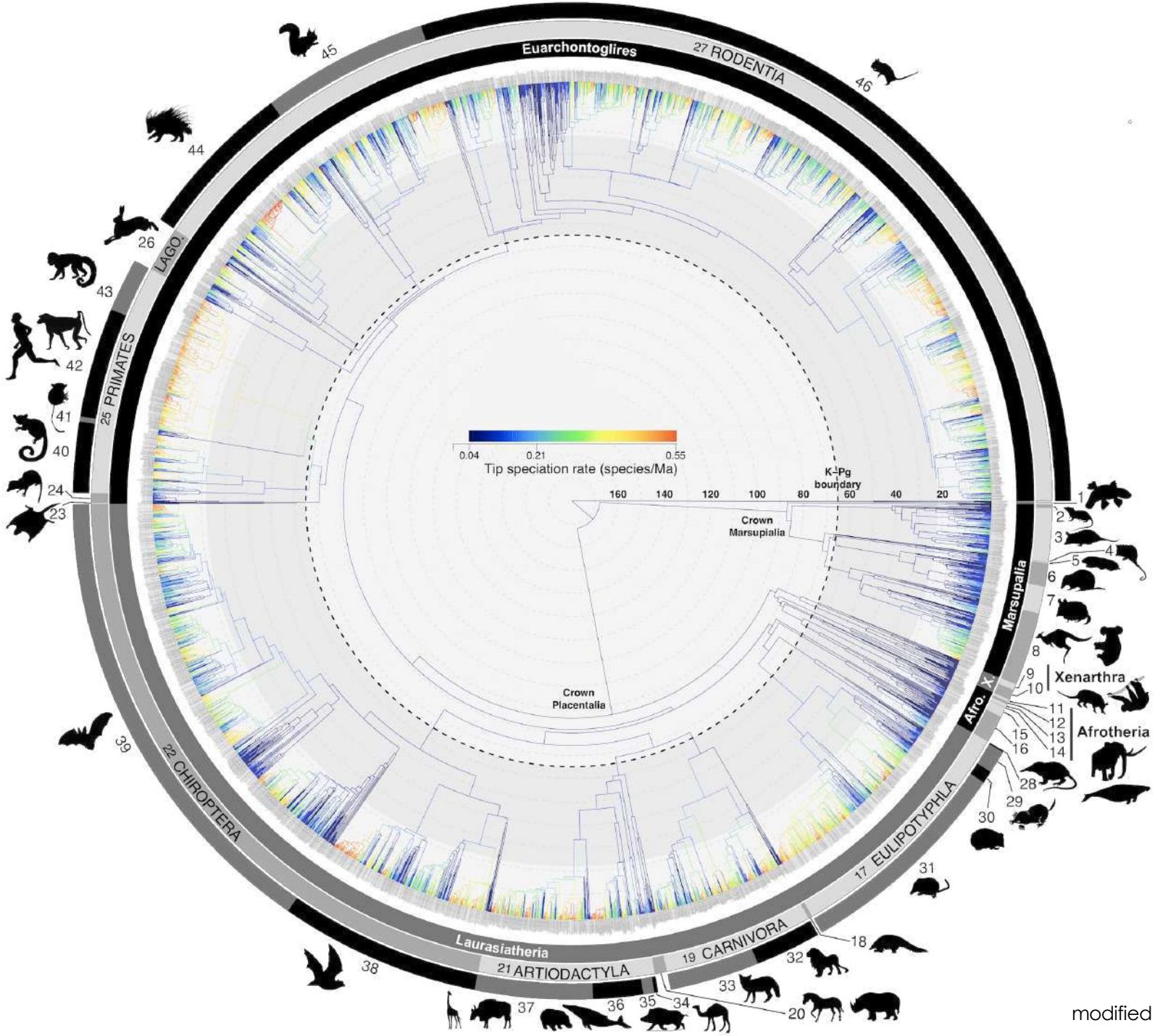
Stevens & Hume (1995)

Separating microbes from indigestible material

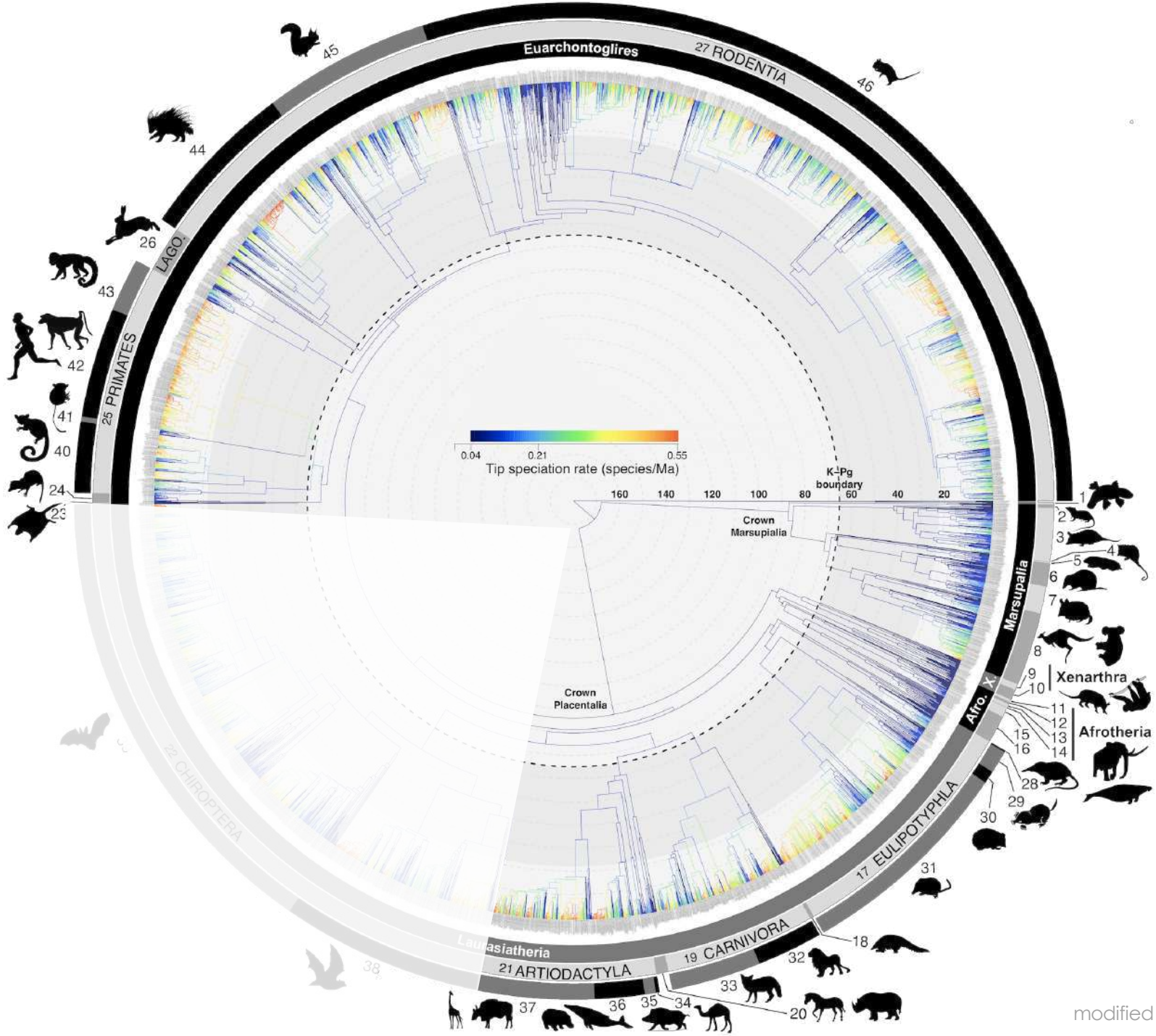
"Colonic separation mechanism"

more microbial matter, measurable as protein

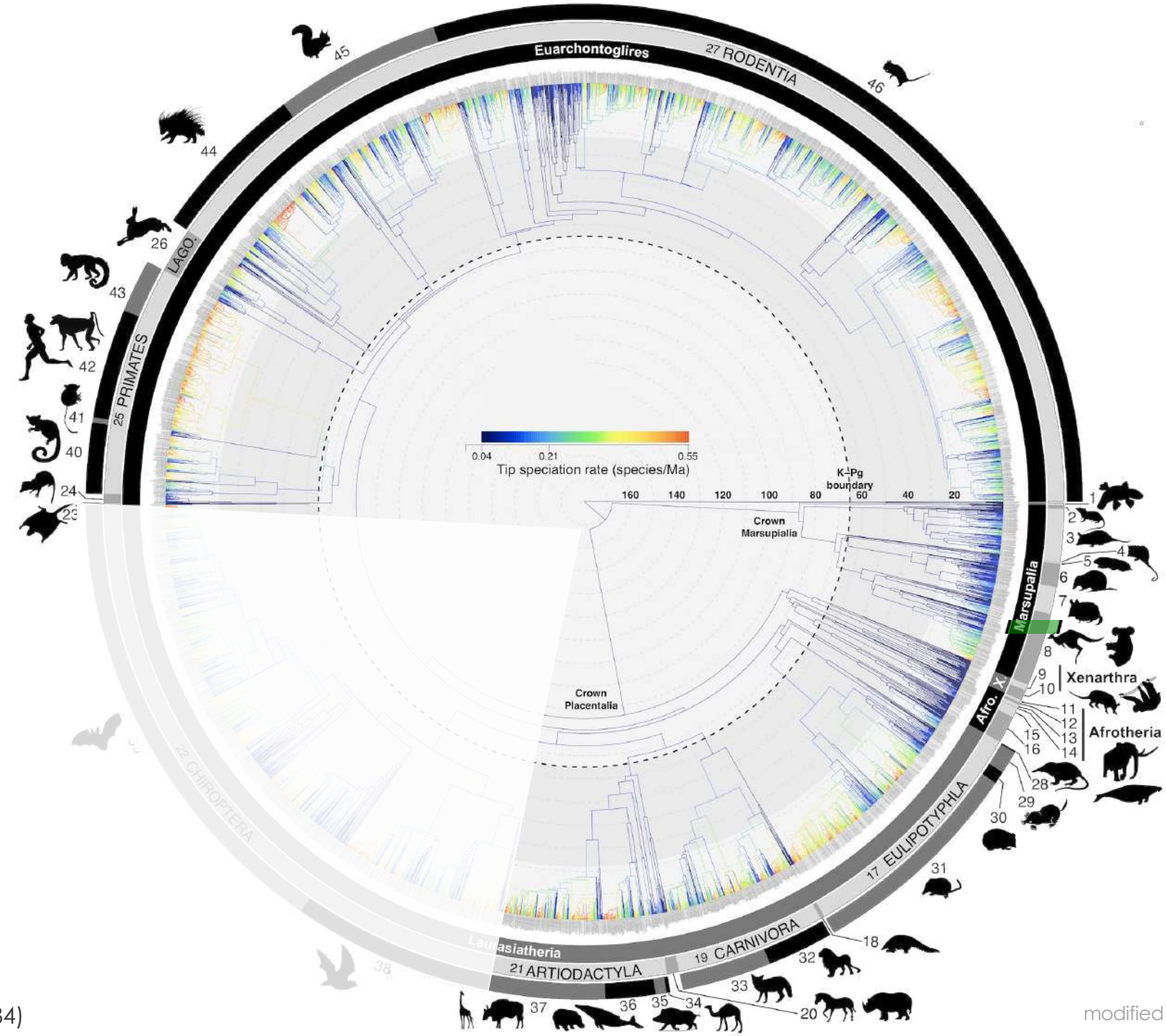
more indigestible material, especially fibre



modified from Upham et al. (2019)

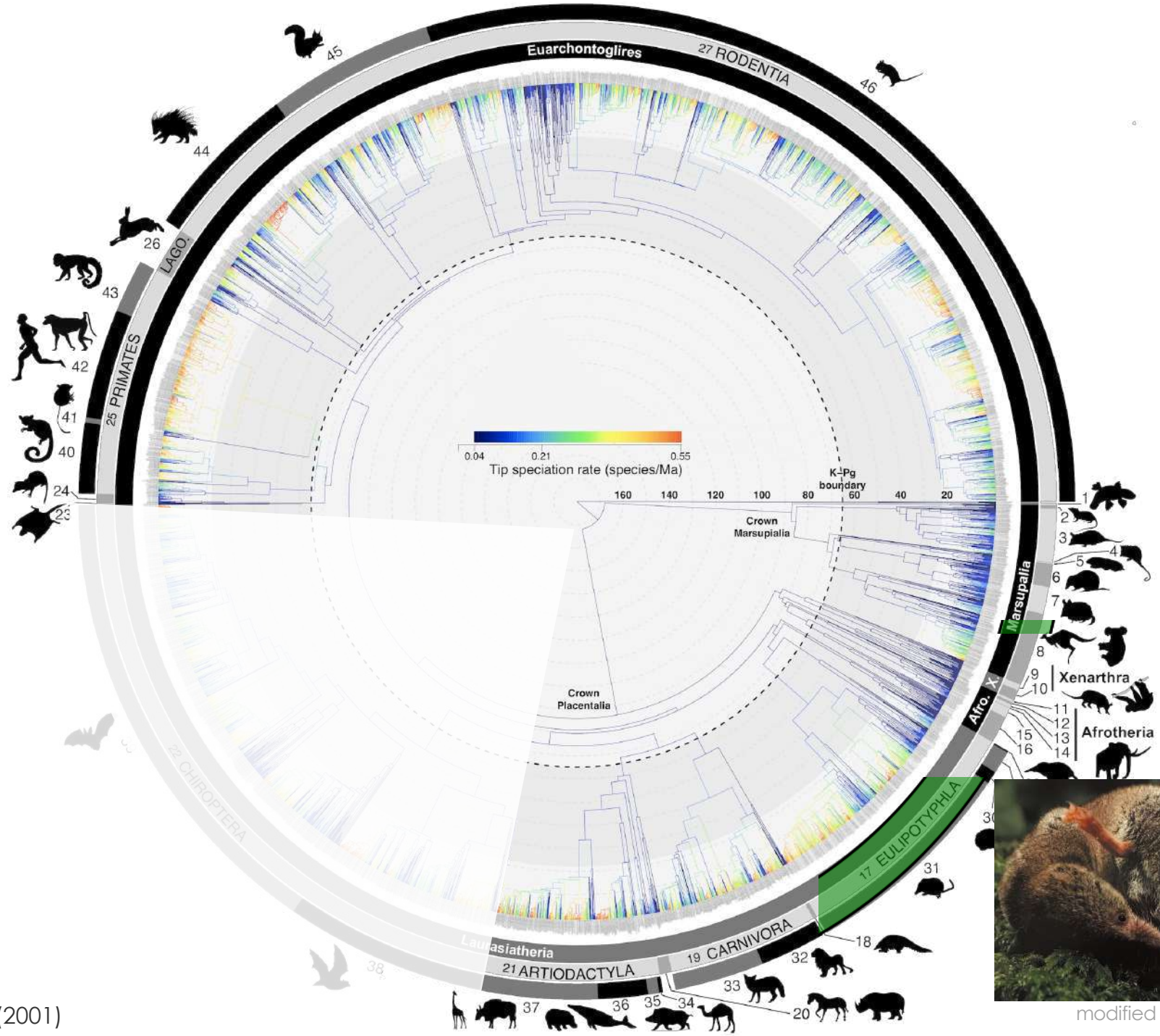


modified from Upham et al. (2019)



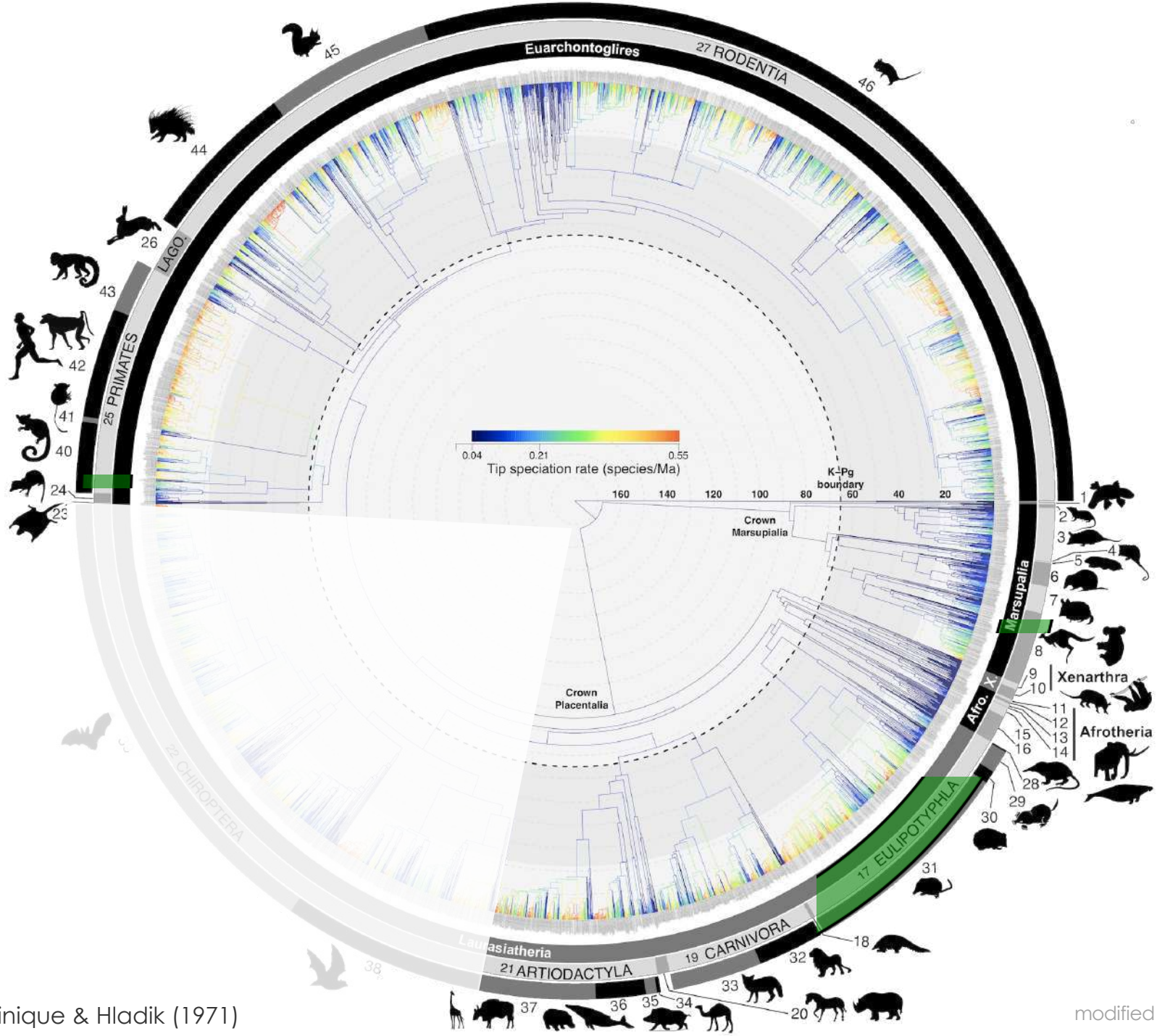
Chilcott (1984)

modified from Upham et al. (2019)



Macdonald (2001)

modified from Upham et al. (2019)

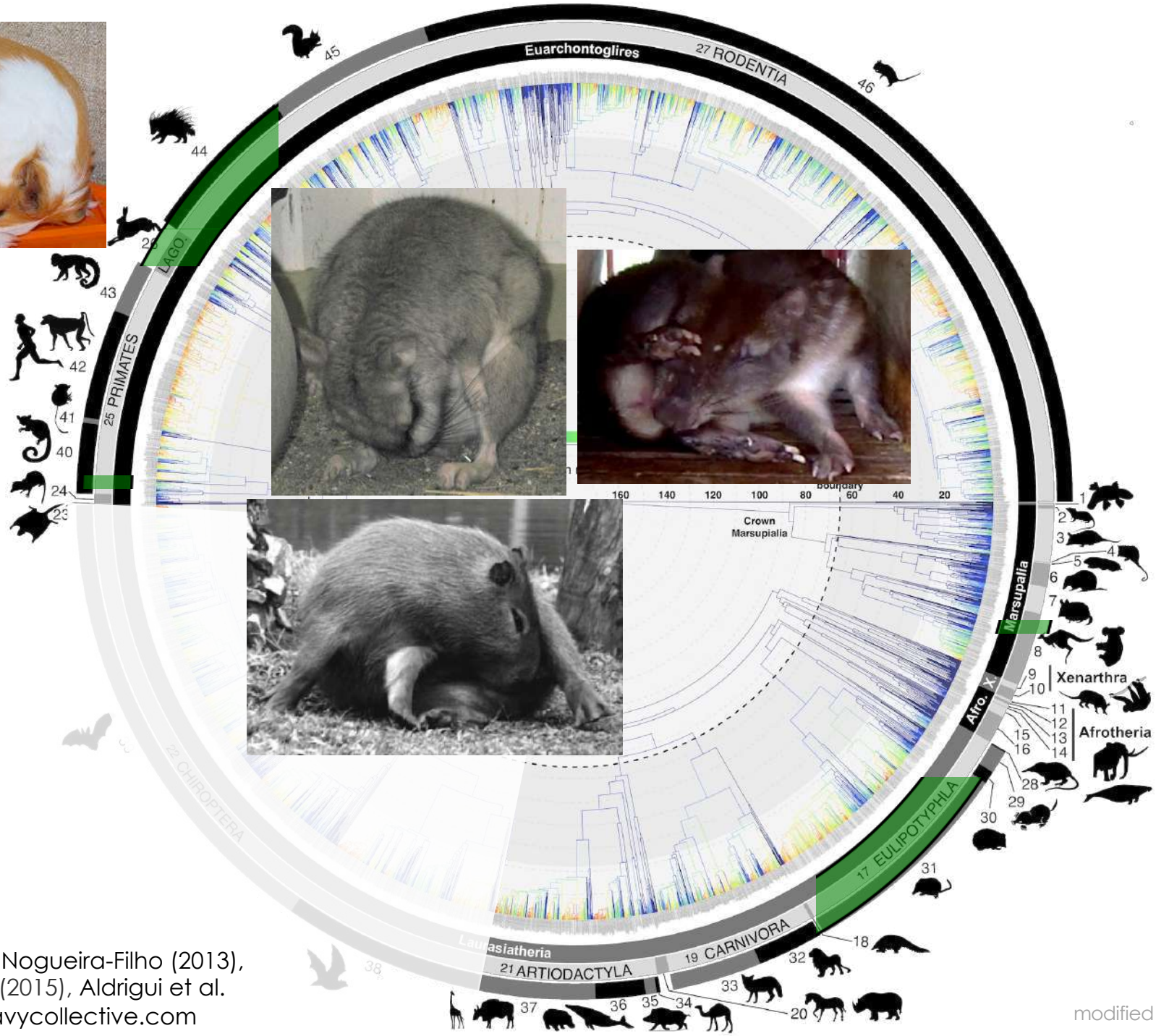


Charles-Dominique & Hladik (1971)

modified from Upham et al. (2019)

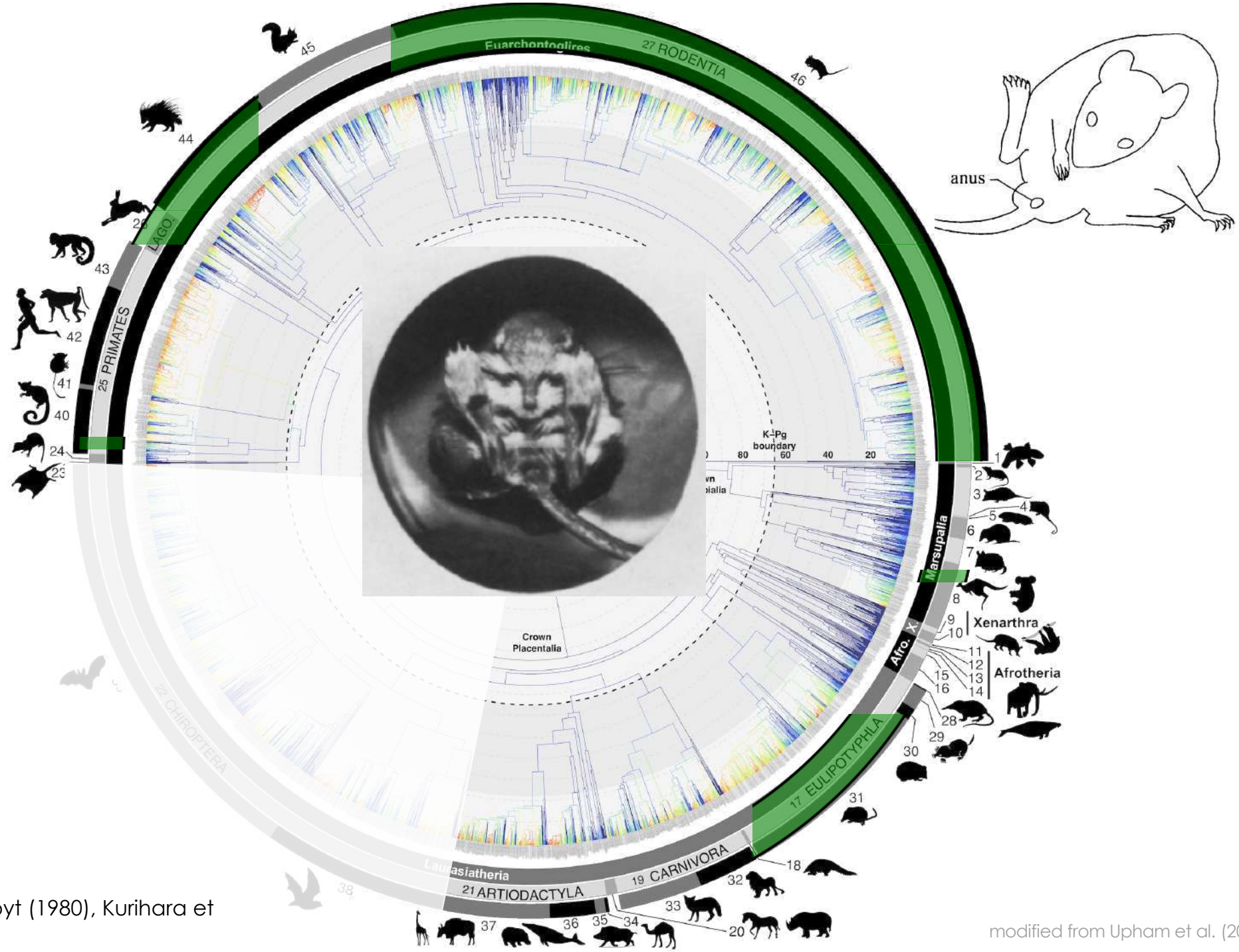
Tschudin (photo), Varner et al. (2016), raising-rabbits.com, wildscrrenexchange.org

modified from Upham et al. (2019)



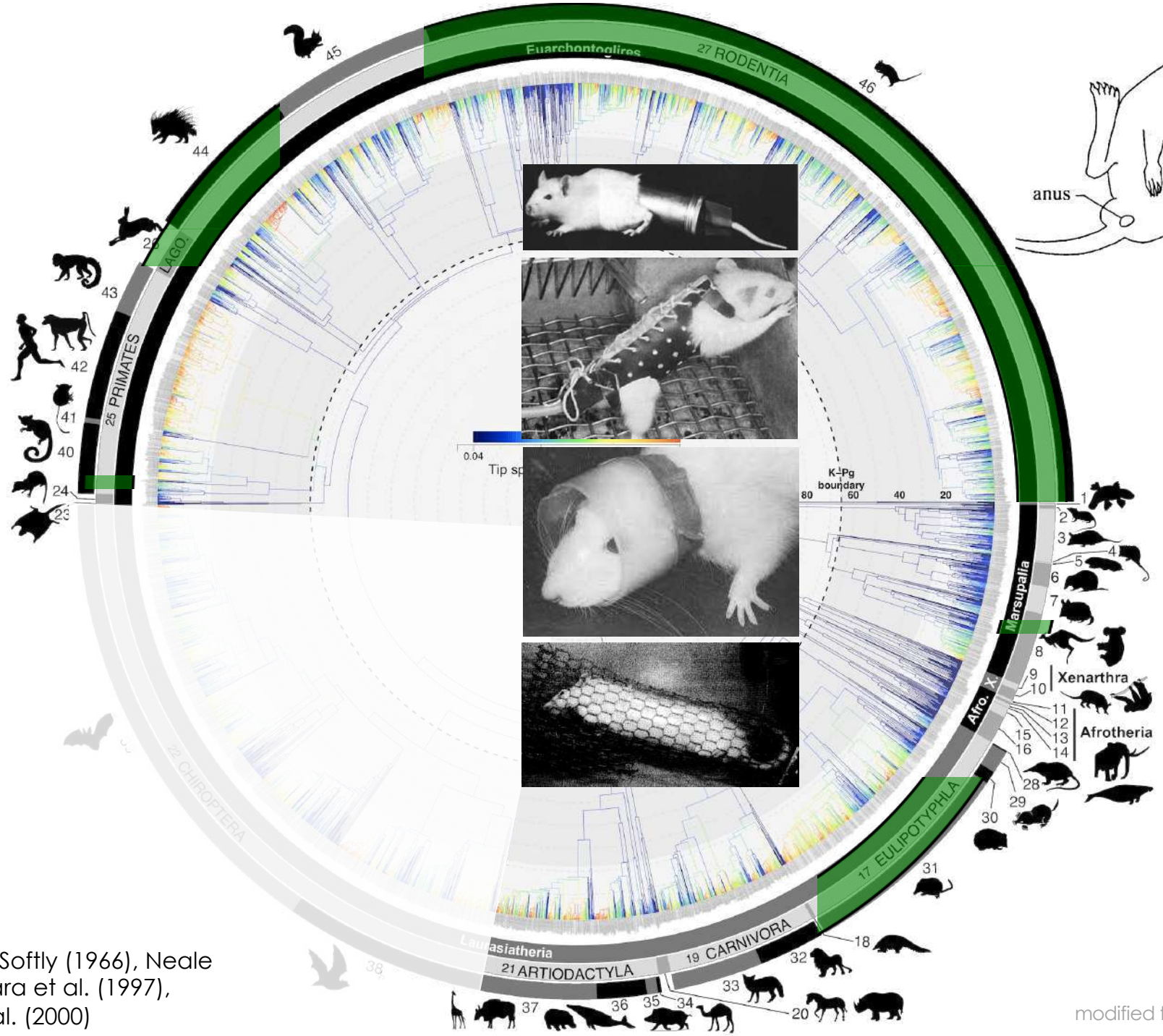
Mendes and Nogueira-Filho (2013), Hagen et al. (2015), Aldrigui et al. (2018), calicavycollective.com

modified from Upham et al. (2019)



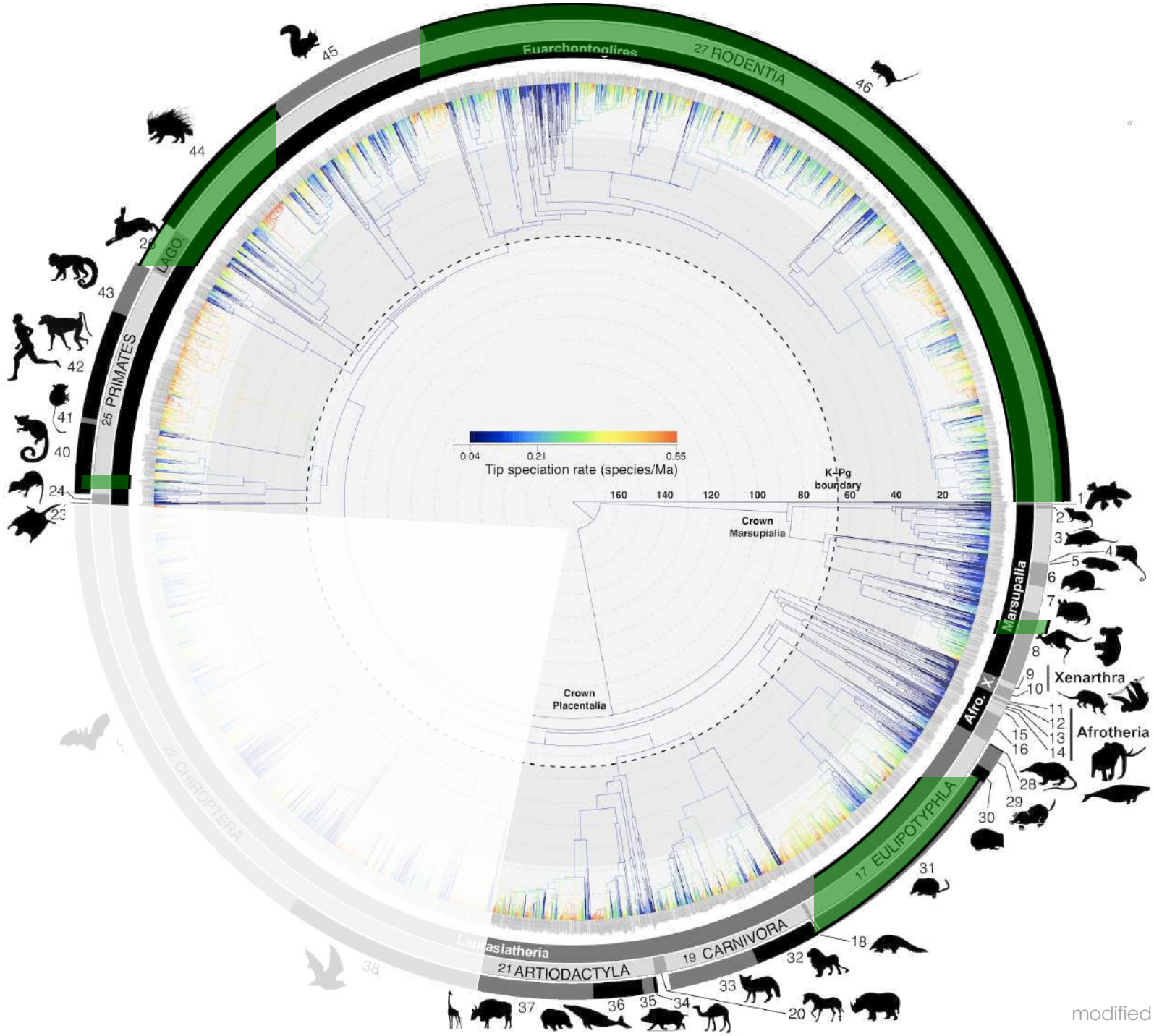
Kenagy & Hoyt (1980), Kurihara et al. (1997)

modified from Upham et al. (2019)



Armstrong & Softly (1966), Neale (1994), Kurihara et al. (1997), Sukemori et al. (2000)

modified from Upham et al. (2019)

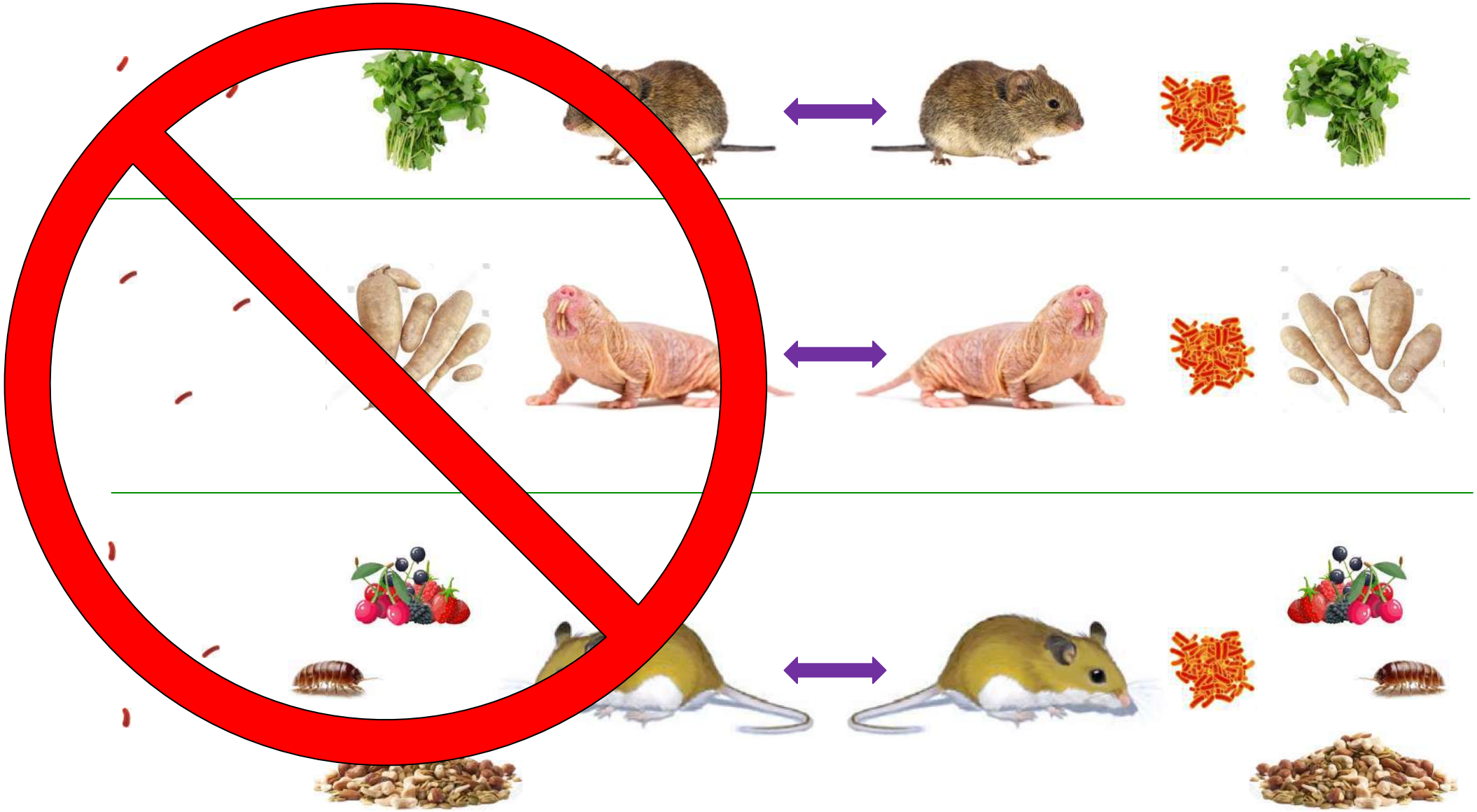


modified from Upham et al. (2019)

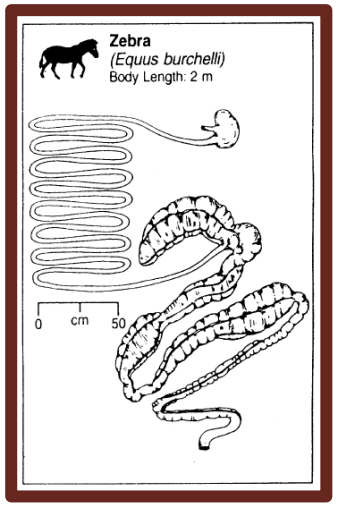
Limited menus: an ecological challenge

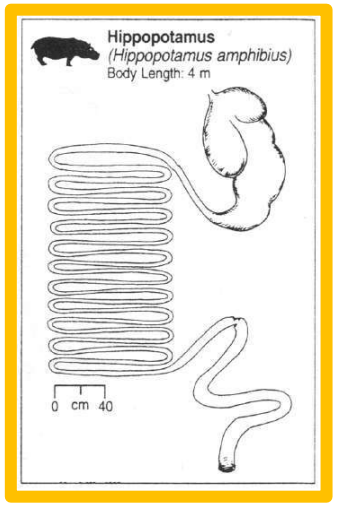
Expanded menus: an ecological opportunity

(without alternative)



Farming: contain, nurture, harvest



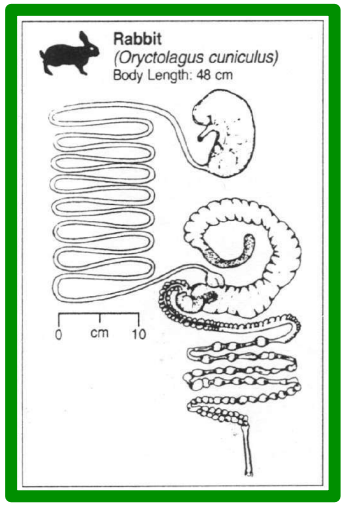


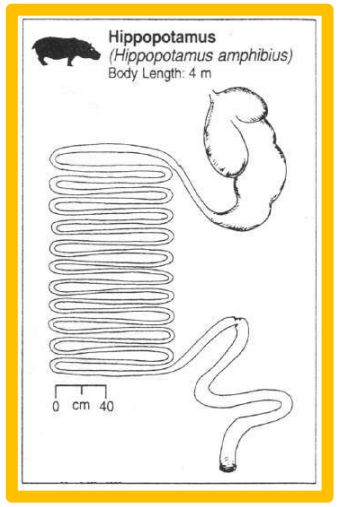
+ supplemental (endogenous) nitrogen

not possible ?

Stevens & Hume (1995)

Farming: contain, nurture, harvest



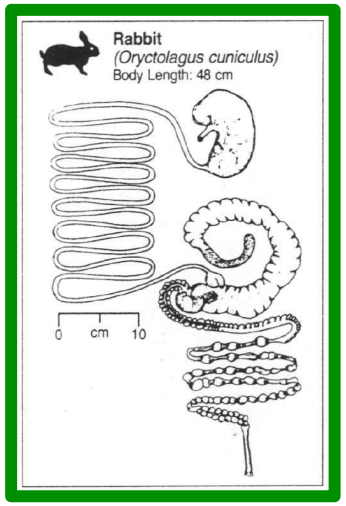


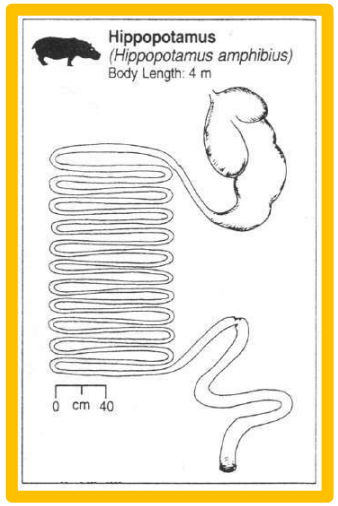
+ supplemental (endogenous) nitrogen

colonic separation & coprophagy

Stevens & Hume (1995)

Farming: contain, nurture, harvest





+ supplemental (endogenous) nitrogen

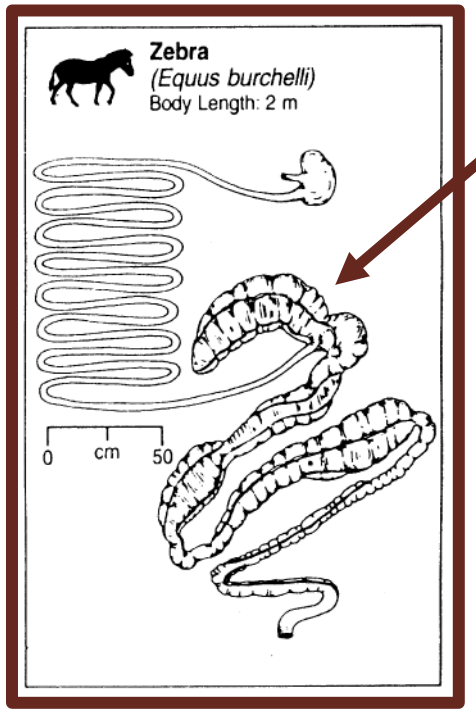
feasible at small body size

(and few extant small species do *not* do it)

Stevens & Hume (1995)

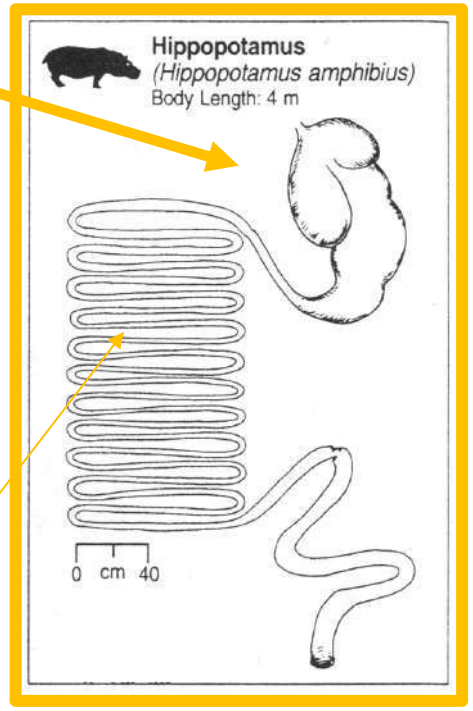
Hindgut and Foregut fermenters

Microbes ferment the
diet (**rest**) ...



... ***prior*** to small intestine

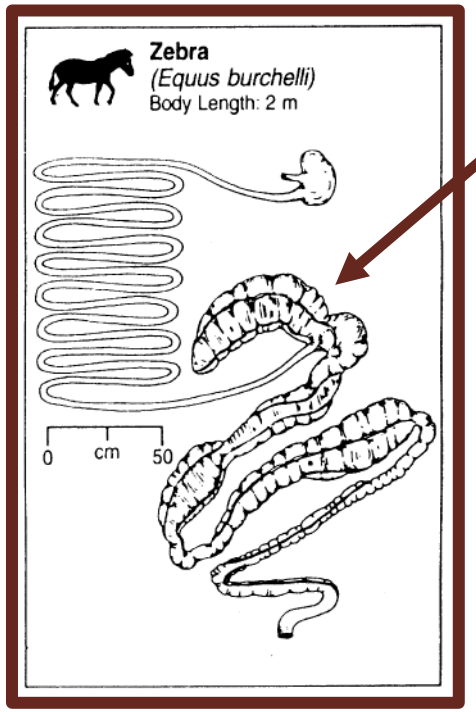
enzymatic digestion of processed material



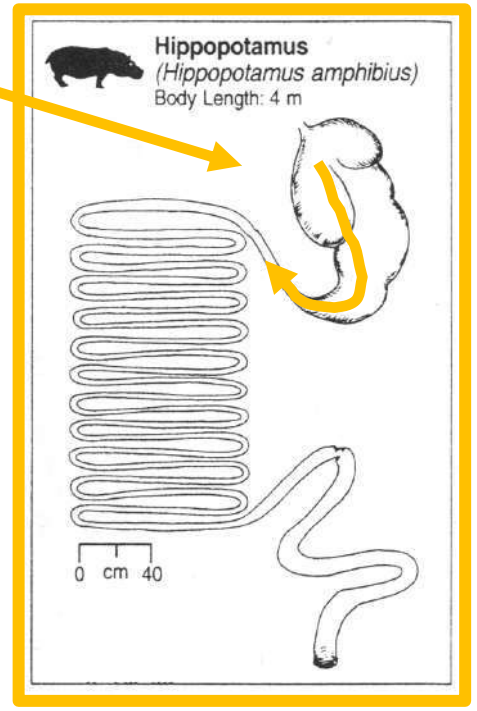
(Stevens & Hume 1995)

Hindgut and Foregut fermenters

Microbes ferment the
diet (**rest**) ...

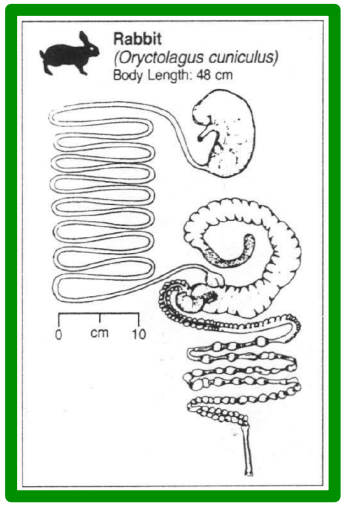


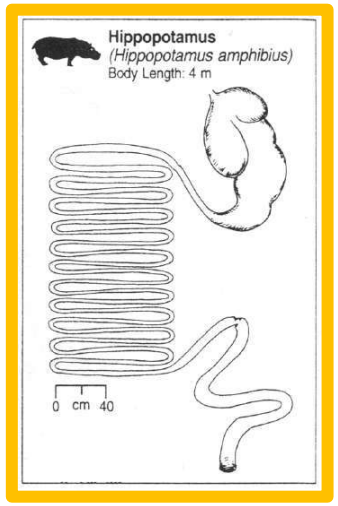
... flow out and are digested



(Stevens & Hume 1995)

Farming: contain, nurture, harvest



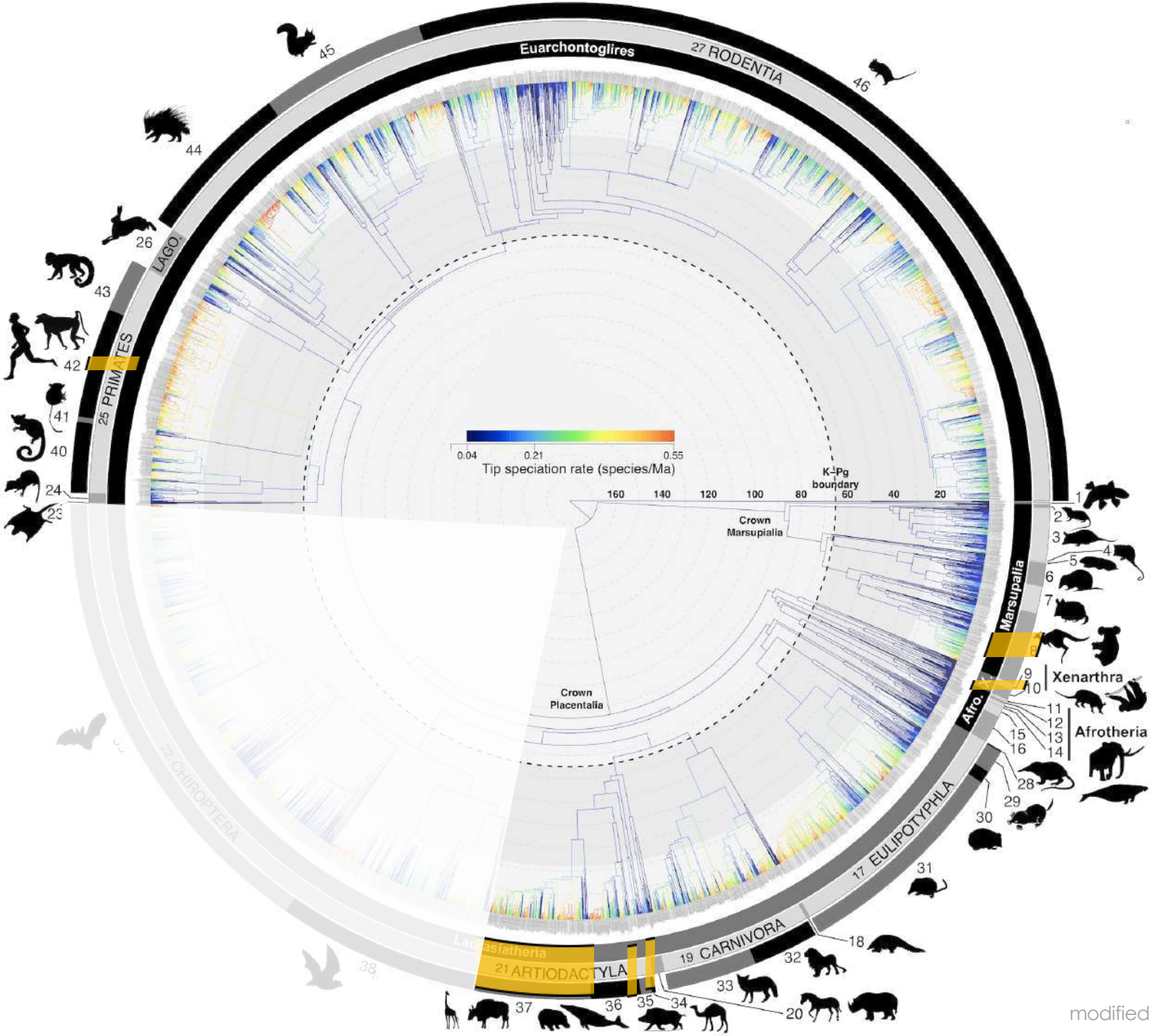


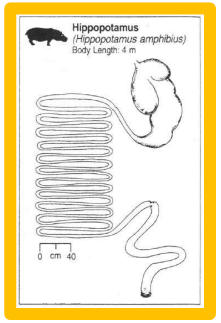
+ supplemental (endogenous) nitrogen

feasible at small body size
(and few extant small species do *not* do it)

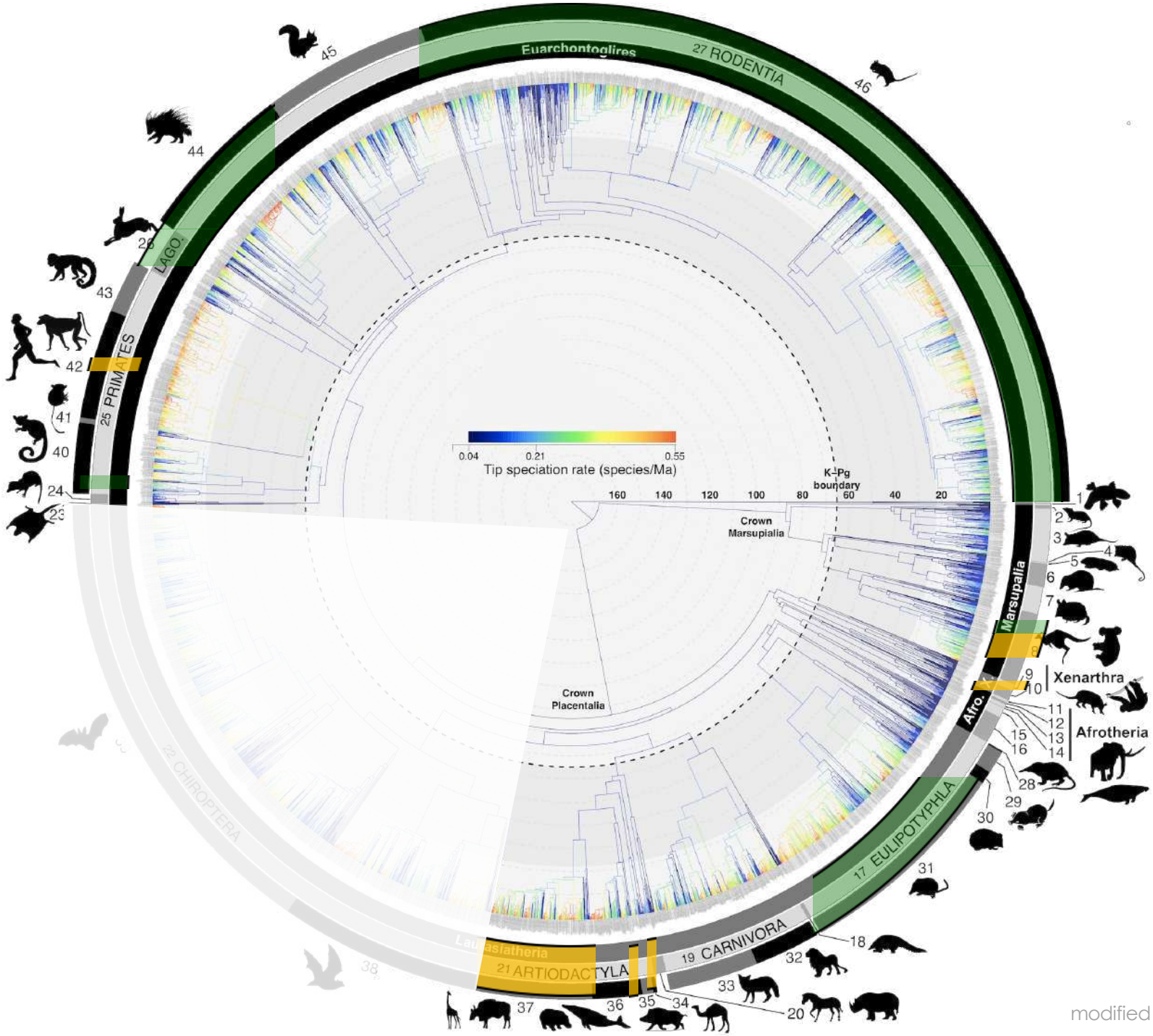
no effort required ?

Stevens & Hume (1995)

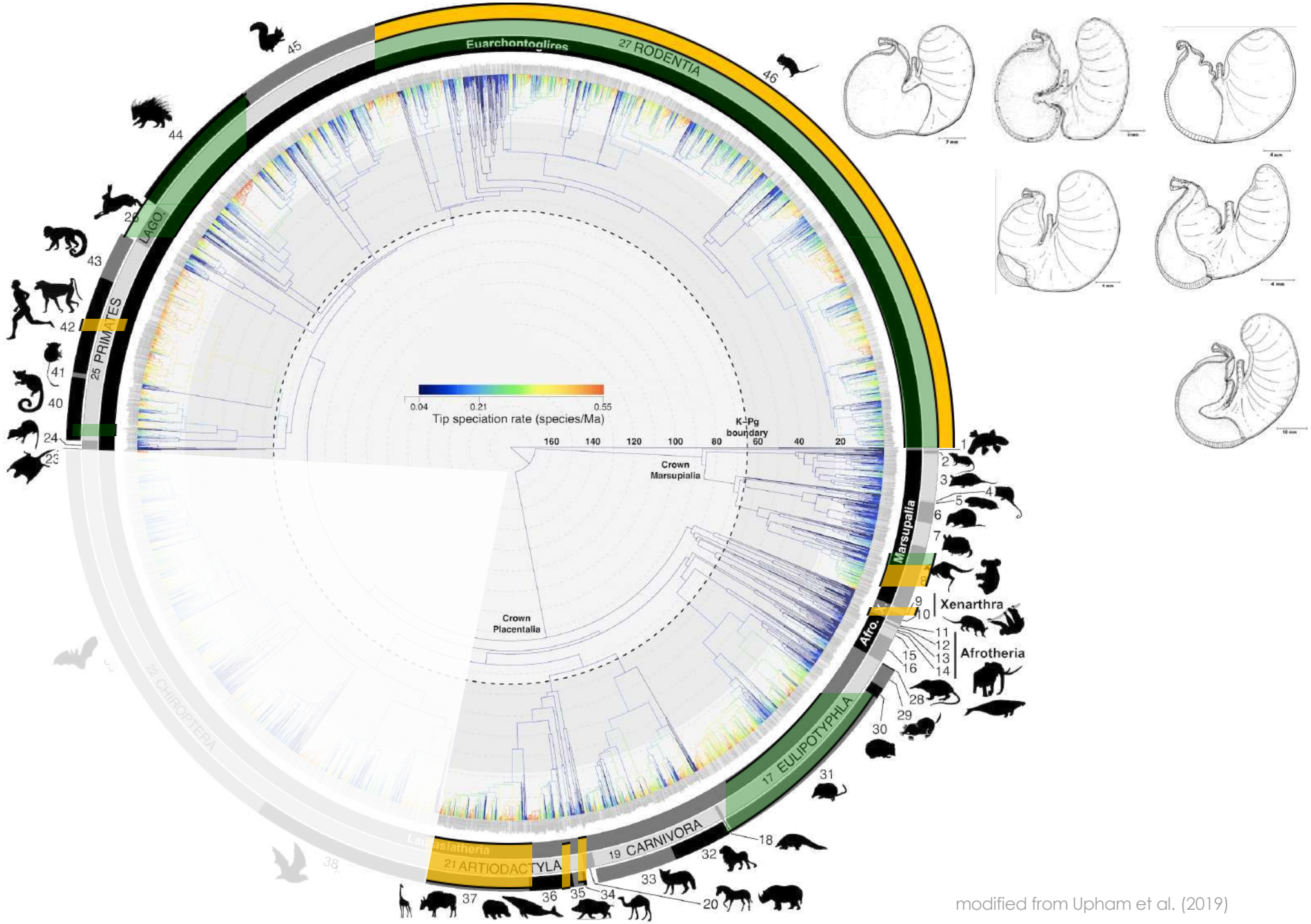




modified from Upham et al. (2019)



modified from Upham et al. (2019)



modified from Upham et al. (2019)

How do you increase the yield of a growing system ?

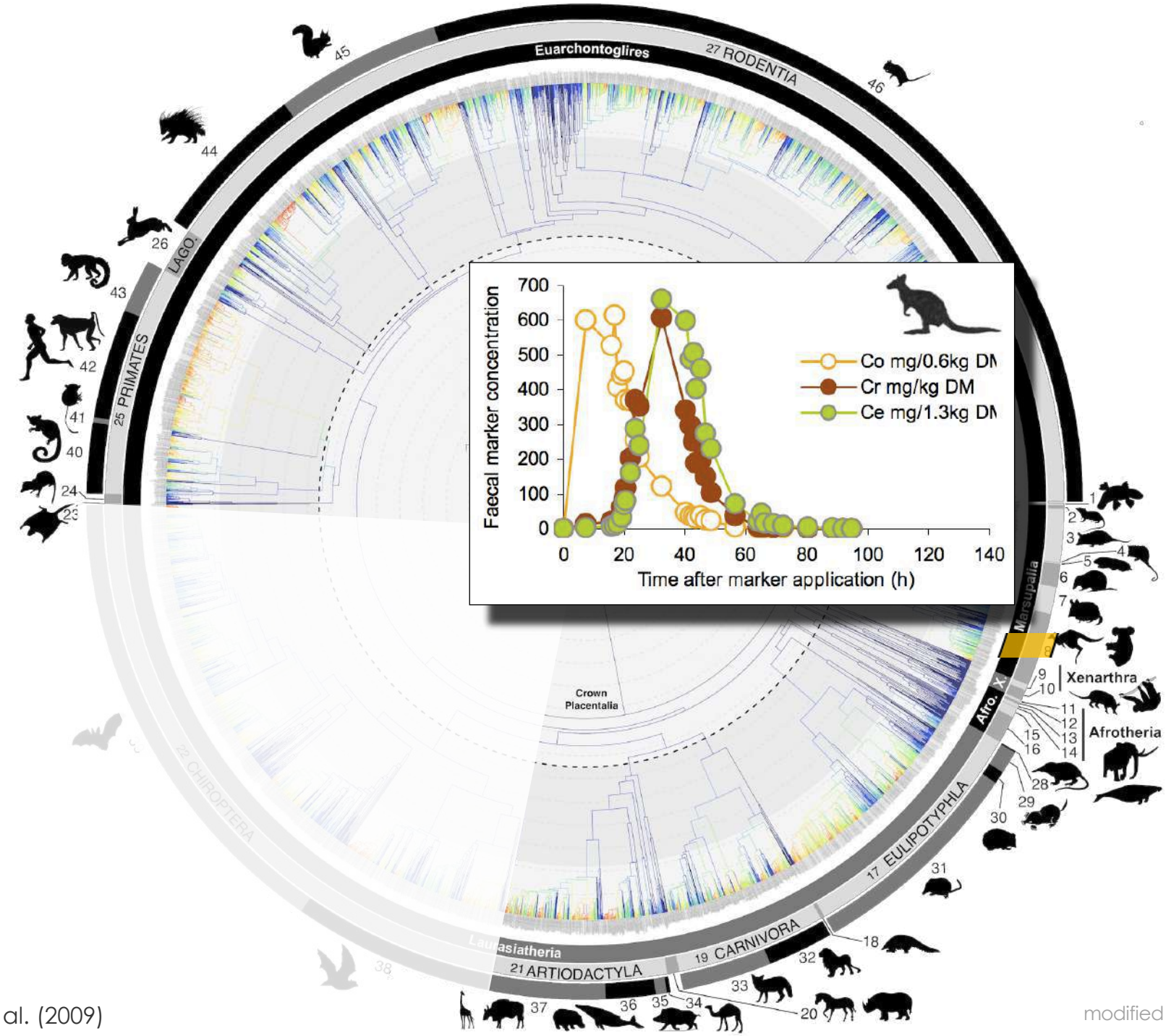
How do you increase the yield of a growing system ?

How do you increase the yield of a growing system ?

frequent harvest to keep the population in the growth stage

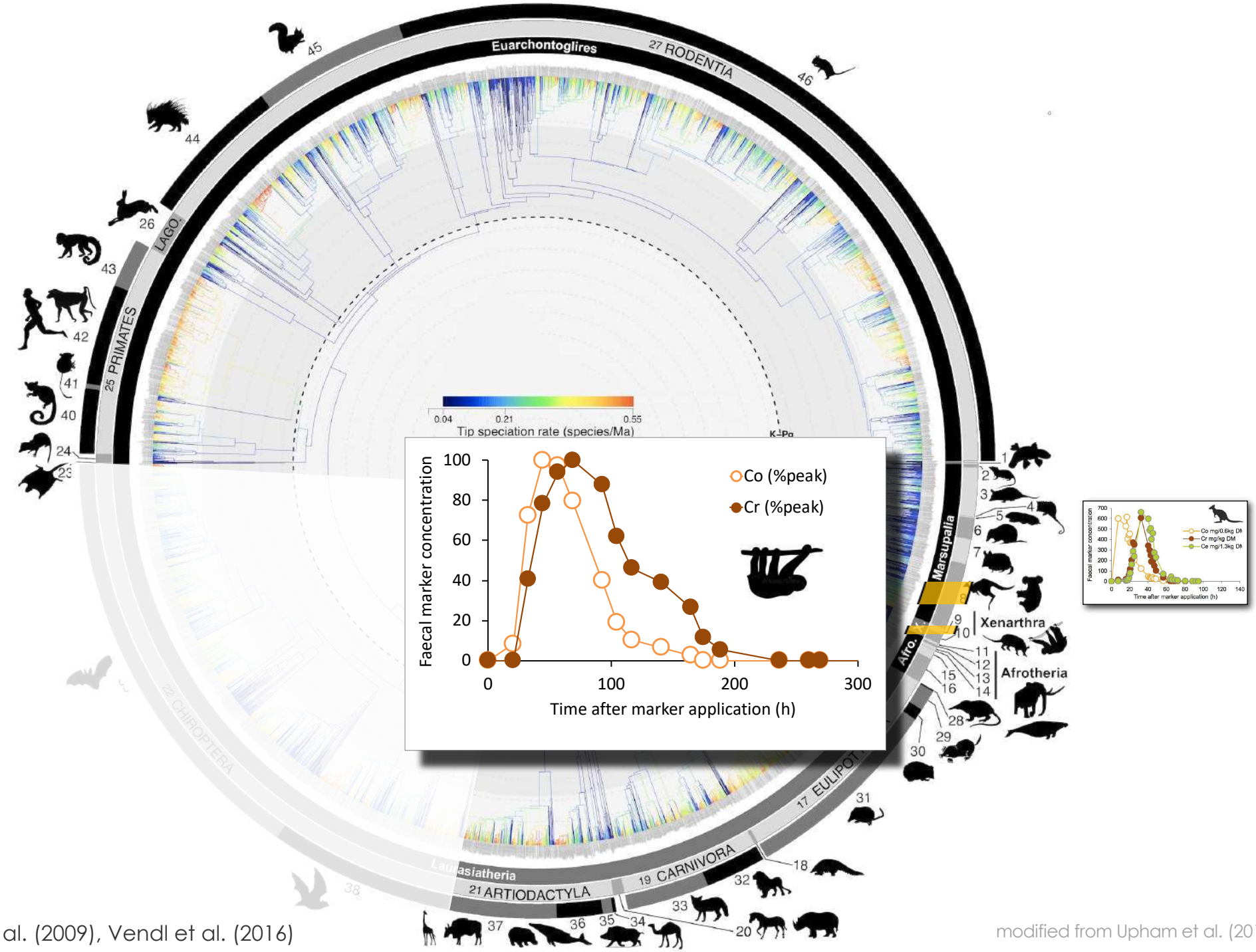
How do you harvest microbes ?

by flushing them out of the fermenter
while retaining the substrate



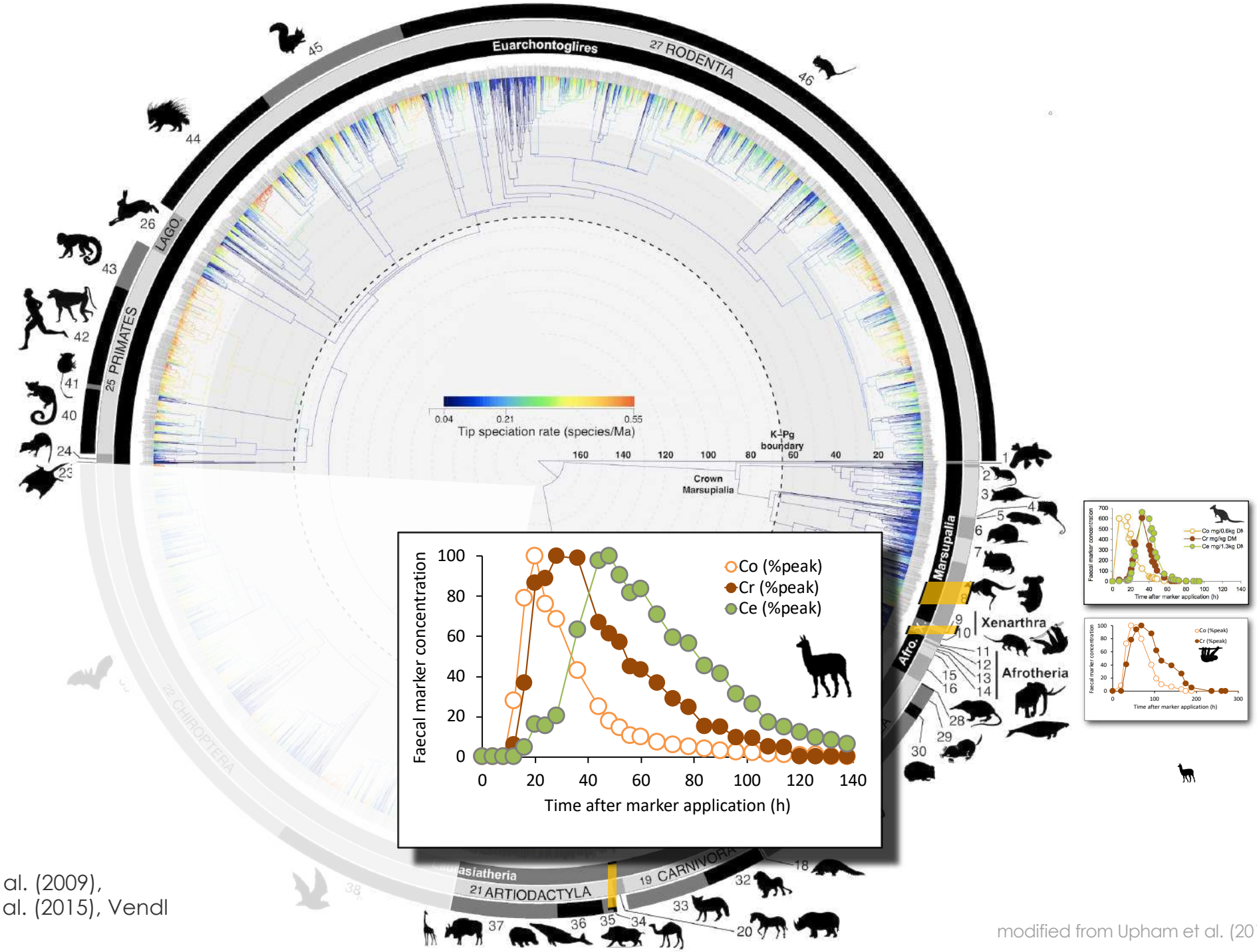
Schwarm et al. (2009)

modified from Upham et al. (2019)



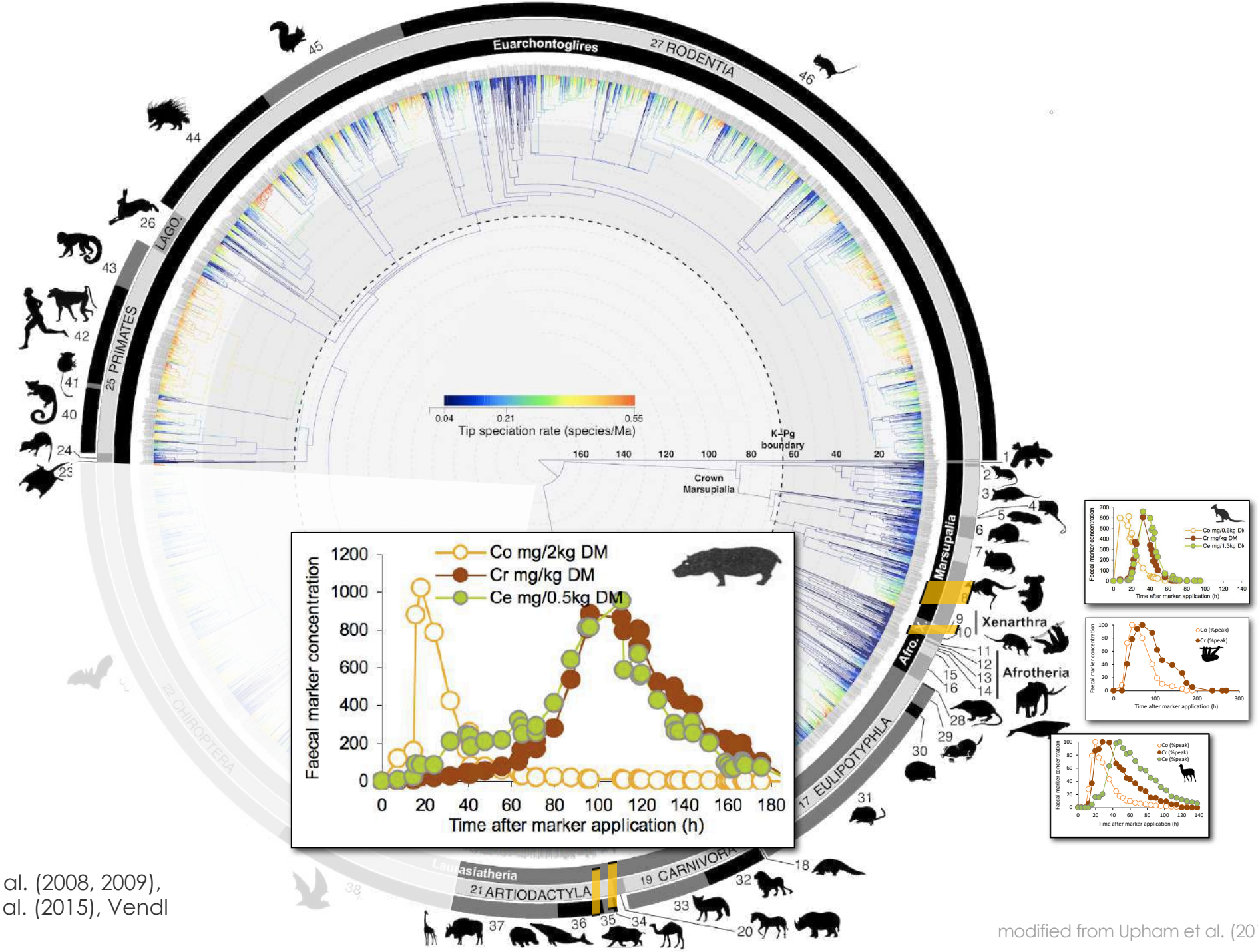
Schwarm et al. (2009), Vendl et al. (2016)

modified from Upham et al. (2019)



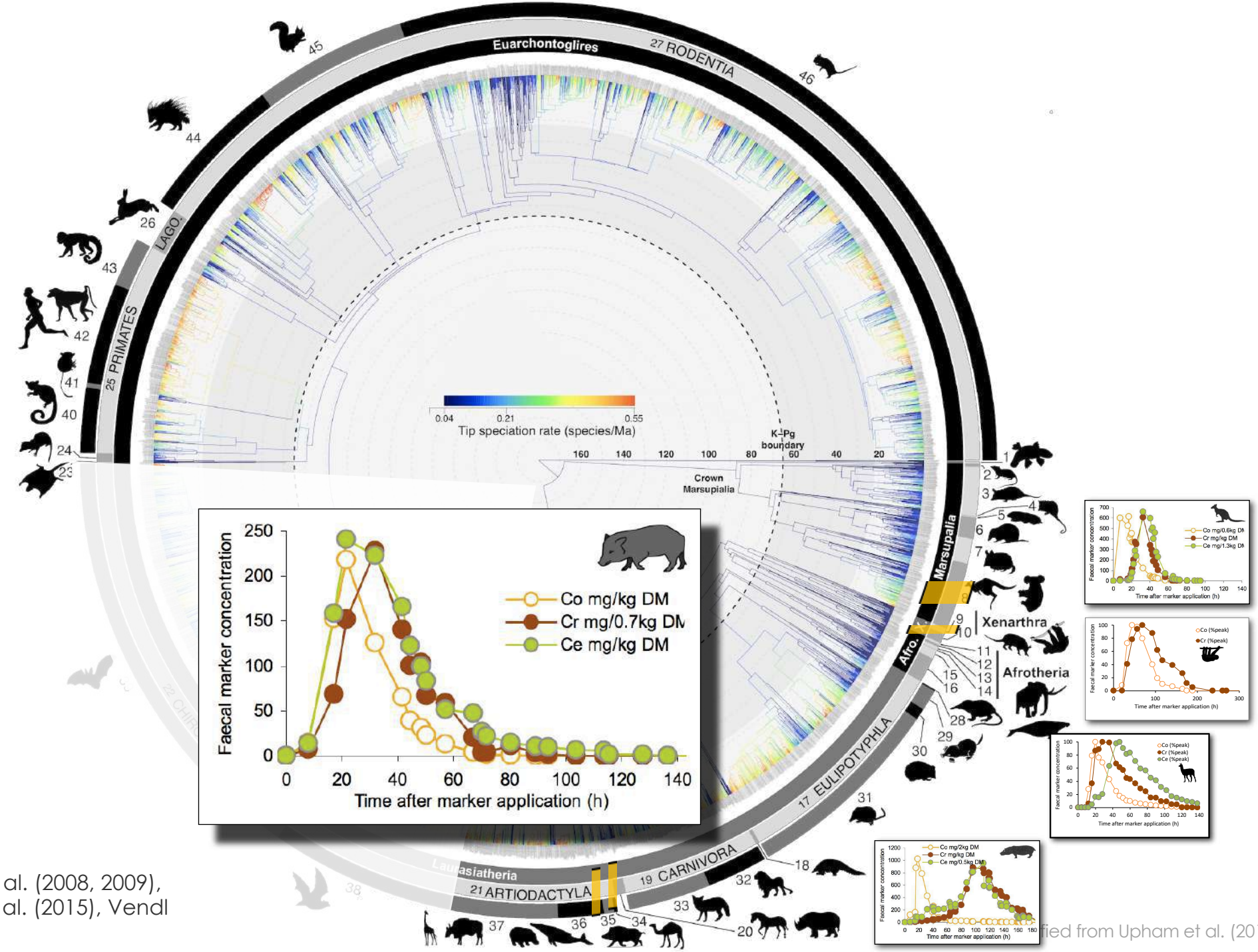
Schwarm et al. (2009), Dittmann et al. (2015), Vendl et al. (2016)

modified from Upham et al. (2019)



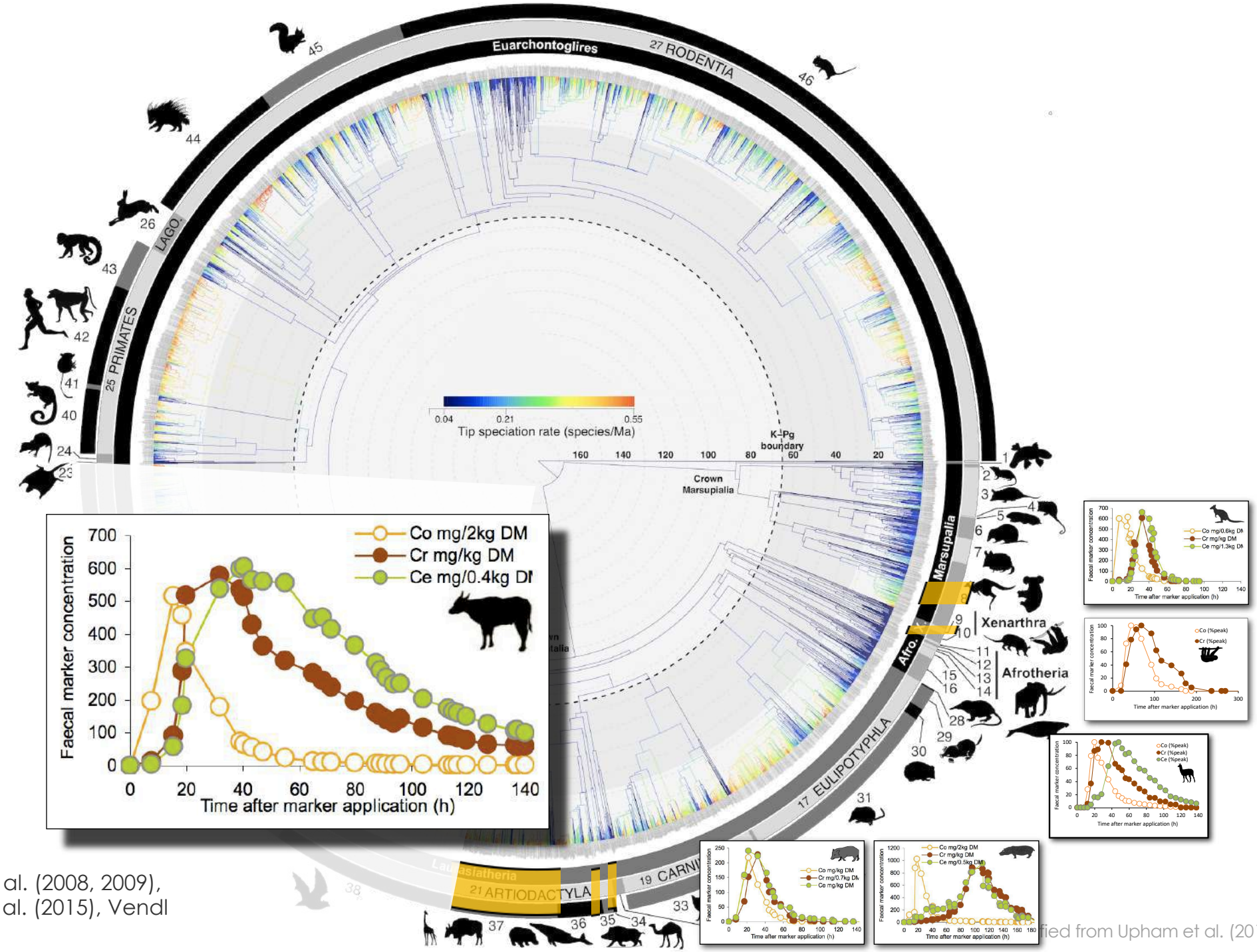
Schwarm et al. (2008, 2009), Dittmann et al. (2015), Vendl et al. (2016)

modified from Upham et al. (2019)



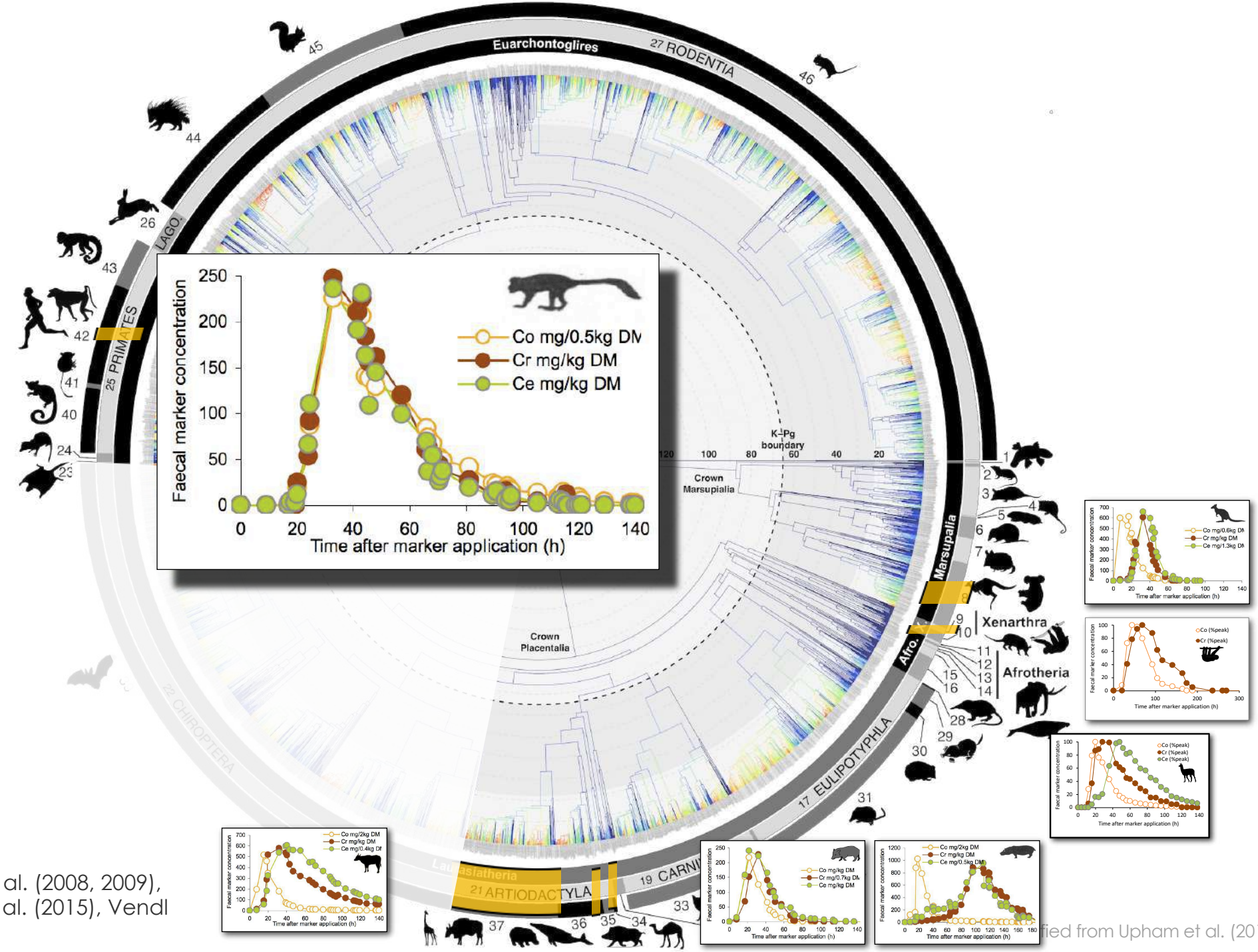
Schwarm et al. (2008, 2009), Dittmann et al. (2015), Vendl et al. (2016)

Modified from Upham et al. (2019)



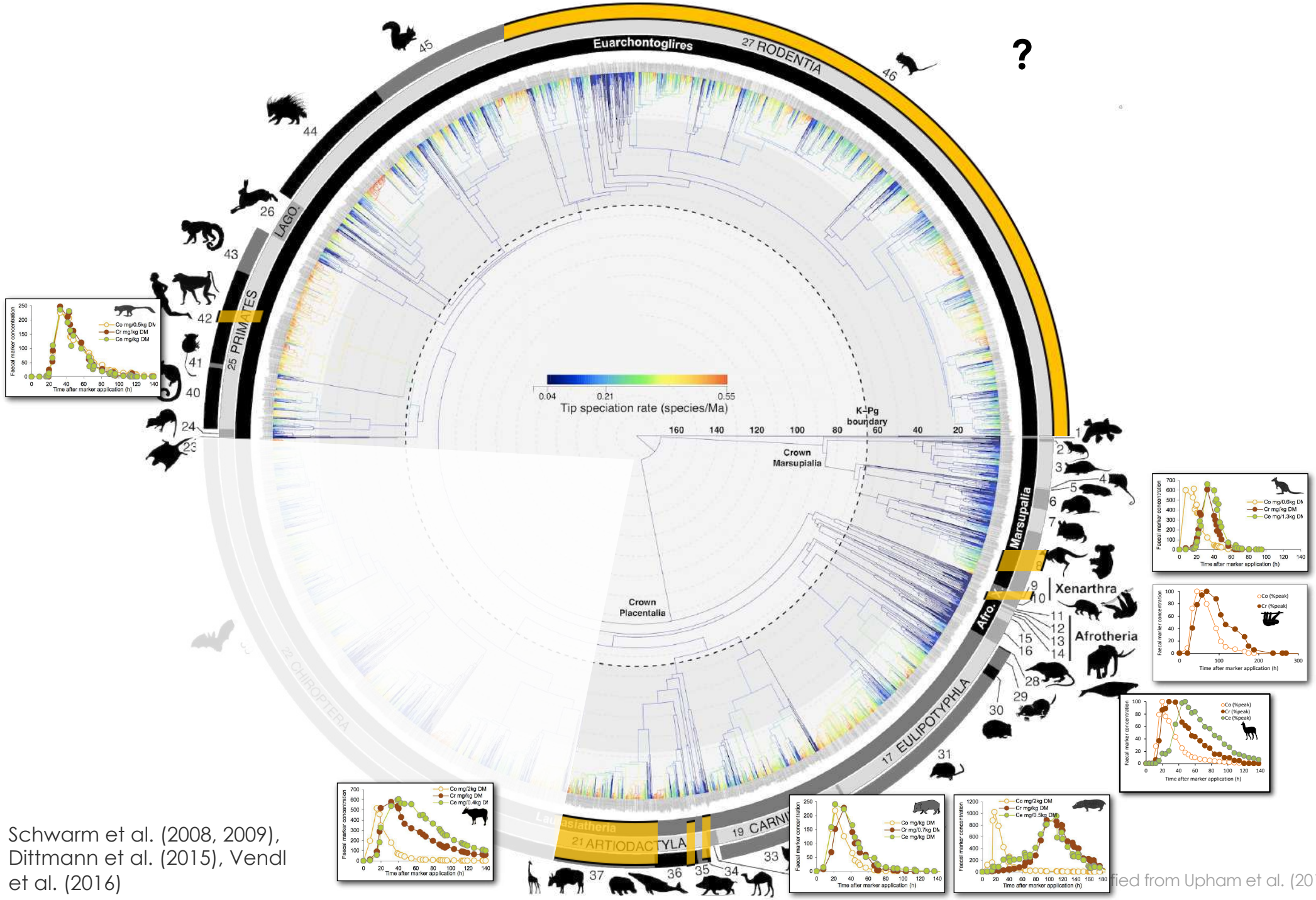
Schwarm et al. (2008, 2009), Dittmann et al. (2015), Vendl et al. (2016)

Modified from Upham et al. (2019)



Schwarm et al. (2008, 2009), Dittmann et al. (2015), Vendl et al. (2016)

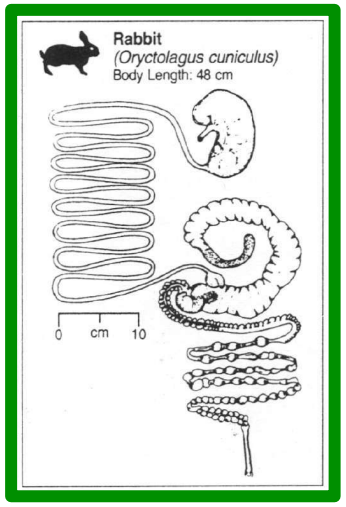
Modified from Upham et al. (2019)

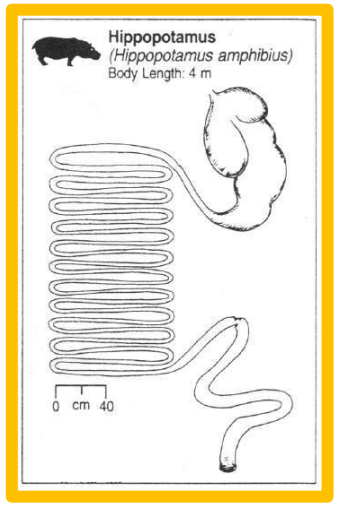


Schwarm et al. (2008, 2009), Dittmann et al. (2015), Vendl et al. (2016)

Modified from Upham et al. (2019)

Farming: contain, nurture, harvest





+ supplemental (endogenous) nitrogen

feasible at small body size
(and few extant small species do *not* do it)

optimize via flushing (saliva)

Stevens & Hume (1995)

Open areas

- convergence in animals that use microbes (growth enhancement, harvest mechanisms, enzymes: lysozyme, ribonucleases, uricase) ?
- microbe use across the animal kingdom ?
- constraints in the use of microbes as food ?
- treatment of microbes to overcome constraints ?

The future of comparative nutrition?

Contributions to understanding animals

-

the speed of reproduction

Evolutionary Ecology Research, 2019, **20:** 385–401

Within-niche pace of life acceleration as a fundamental evolutionary principle: a mammal pilot test case

Marcus Clauss[1], Dennis W.H. Müller[2] and Daryl Codron[3]

By what means do cattle achieve faster intrauterine growth than horses?

280 days

340 days

By what means do some animals achieve faster intrauterine growth?

280 days

340 days

390 days

440 days

By what means do some animals achieve faster intrauterine growth?

280 days

340 days

390 days

440 days

42 days

230 days

365 days

660 days

By what means do some animals achieve faster intrauterine growth?

280 days

340 days

390 days

440 days

42 days

230 days

365 days

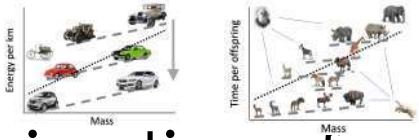
660 days

there is not even a theory about underlying physiological mechanisms

Summary

Scientific practice: language conveys content – and attitude

Craving for rules should not outweigh critical evaluation; logistics of data generation; reliance on databases; comparative evaluation under an evolutionary context



Applied comparative nutrition: clear objectives for improving husbandry and welfare

Basic comparative nutrition: endless interesting questions (constrained by experimental ethics)

thank you for your invitation and your attention