Allometric scaling of decompression sickness risk in 5 species of mammals

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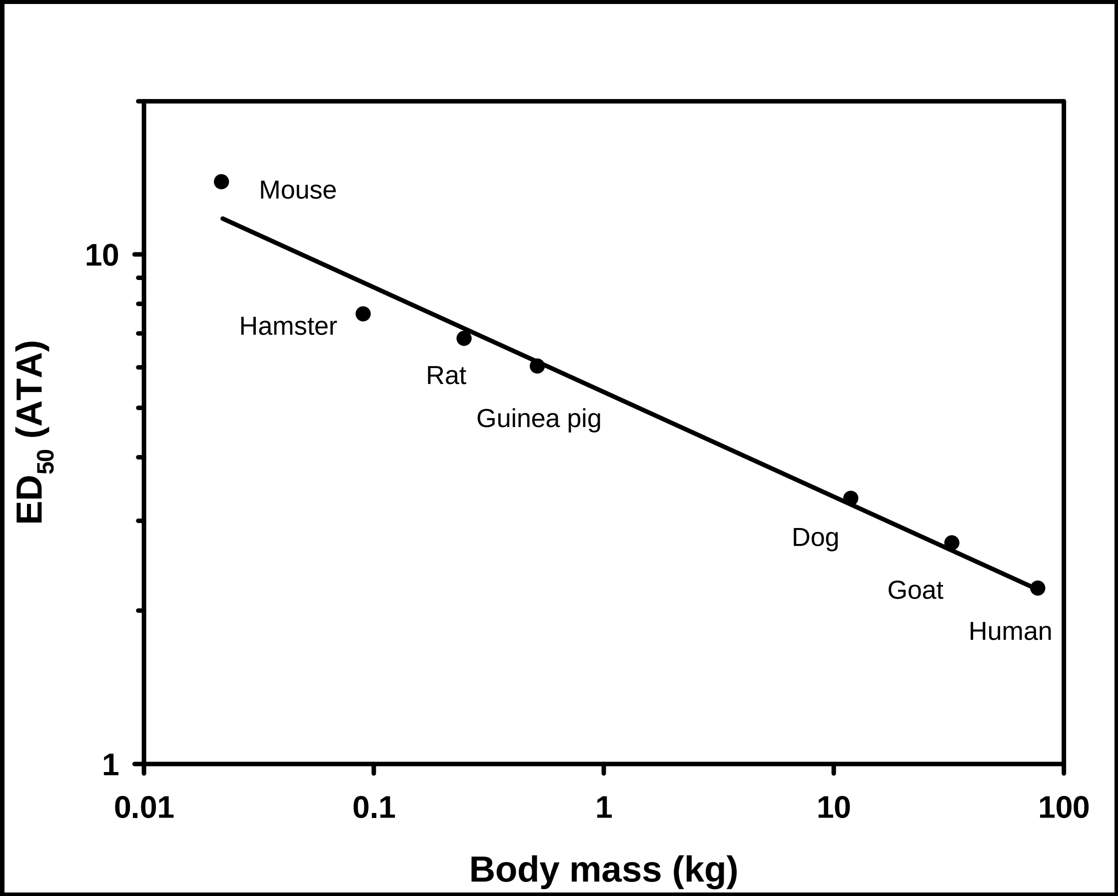
Project goal/Hypothesis

- Does Decompression Sickness Risk differ between mammals (mice, rats, hamsters, dog, pig, human)?
- Can body mass be used to explain the variability?

Background

It is known that decompression sickness (DCS) risk correlates with body mass, but it is not know if susceptibility varies between mammals.



Ref: Berghage et al., Undersea Med 1974

Accounting for differences in ascent rate

Assumption:

-Ascent rate was fast enough so N_2 tension was the same as at saturation depth upon reaching the surface

- Rats/mice/hamster ~ 600 fsw/min
- Dog/pigs ~ 30 fsw/min

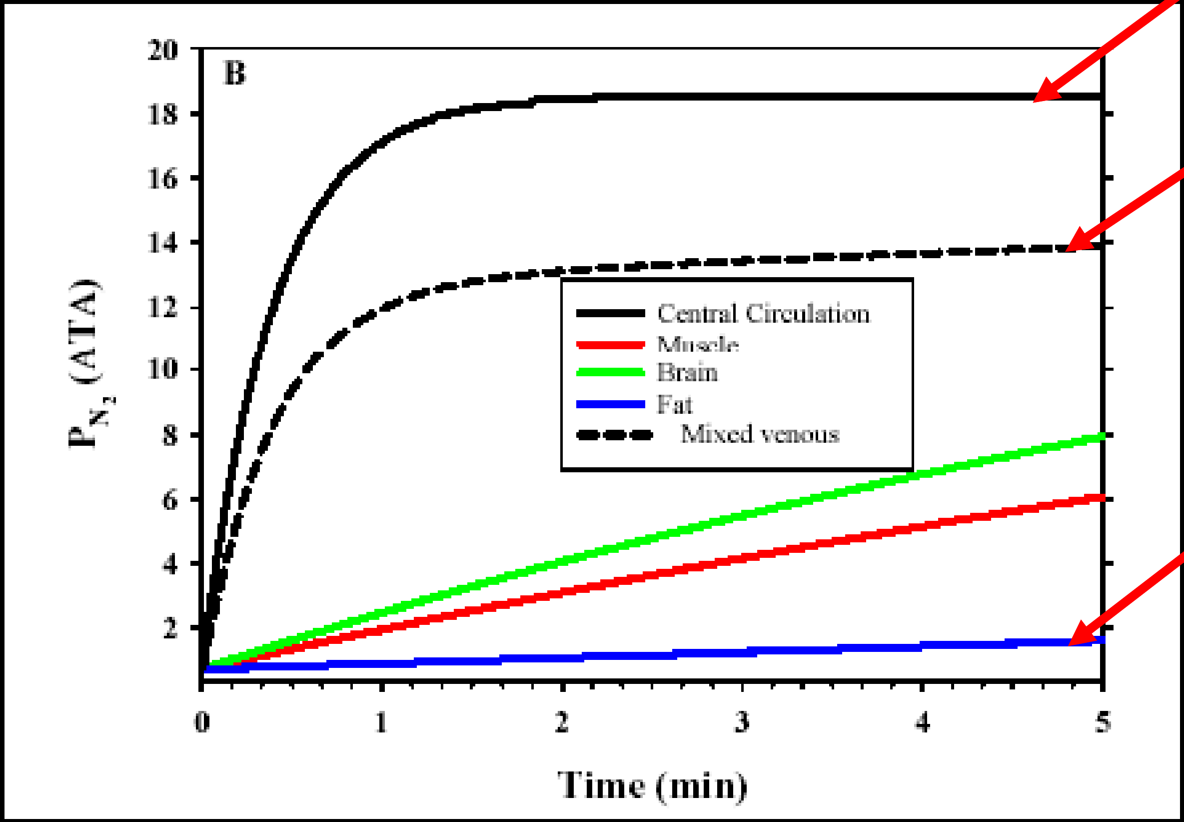
Inert gas exchange:

$$\frac{dPtis}{dt} = \frac{(Ptis - Pamb) \cdot Q \cdot \lambda}{V}$$

Ptis= Tissue inert gas tension
Pamb = Ambient pressure
V=Tissue volume
Q=Blood perfusion
λ=solubility coefficient
τ =tissue time constant

$$\tau = \frac{V \cdot \lambda}{Q}$$

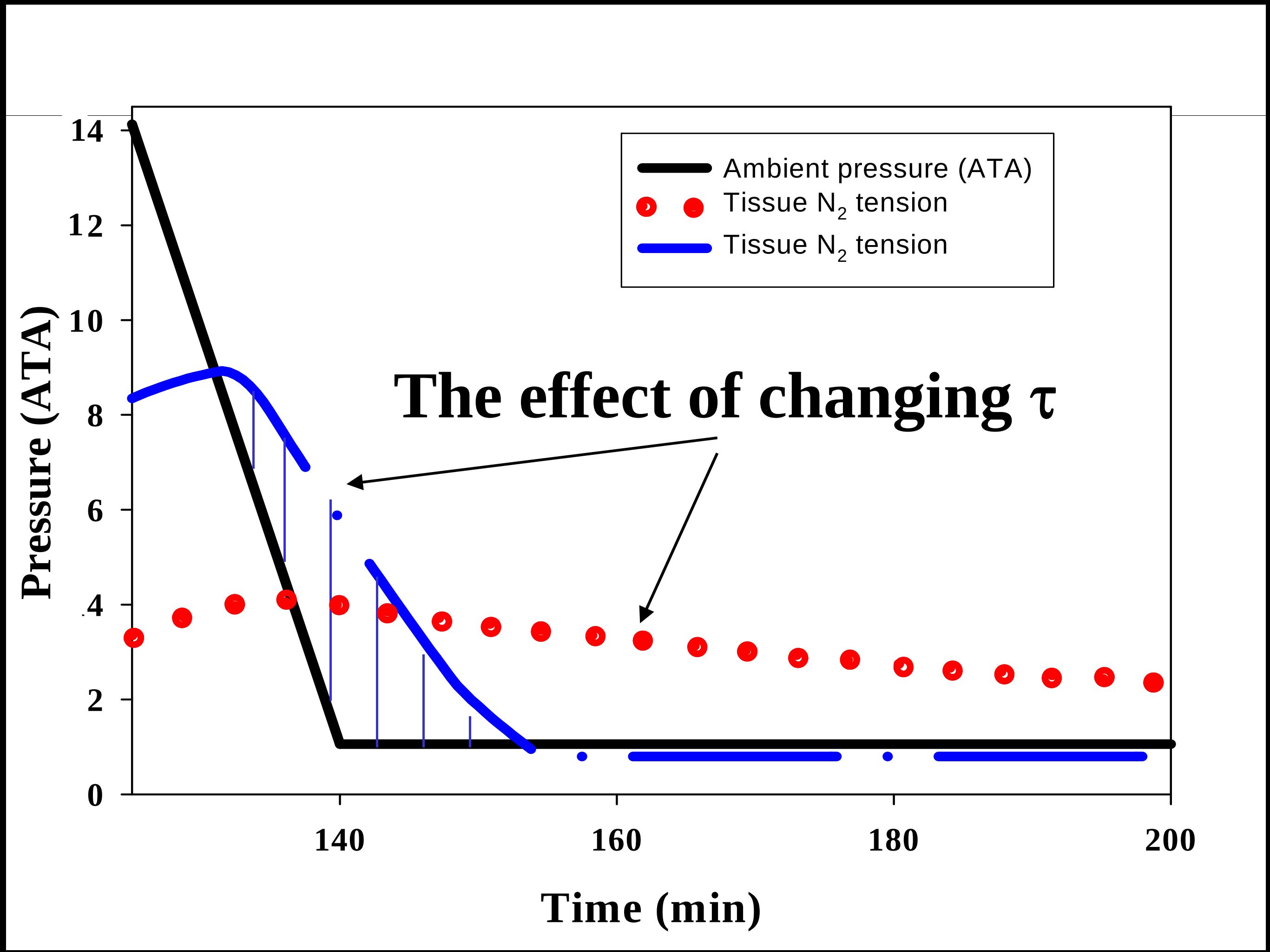
Effect of time at depth in the SCUBA diver meaning of τ



Fast tissue, Short τ

Overall saturation

Slow tissue Long τ



The effect of changing τ
Ambient pressure (ATA)
Tissue N2 tension
Tissue N2 tension
Pressure (ATA)
Time (min)
0
2
.4
6
8
10
12
14
140
160
180
200

Allometric scaling

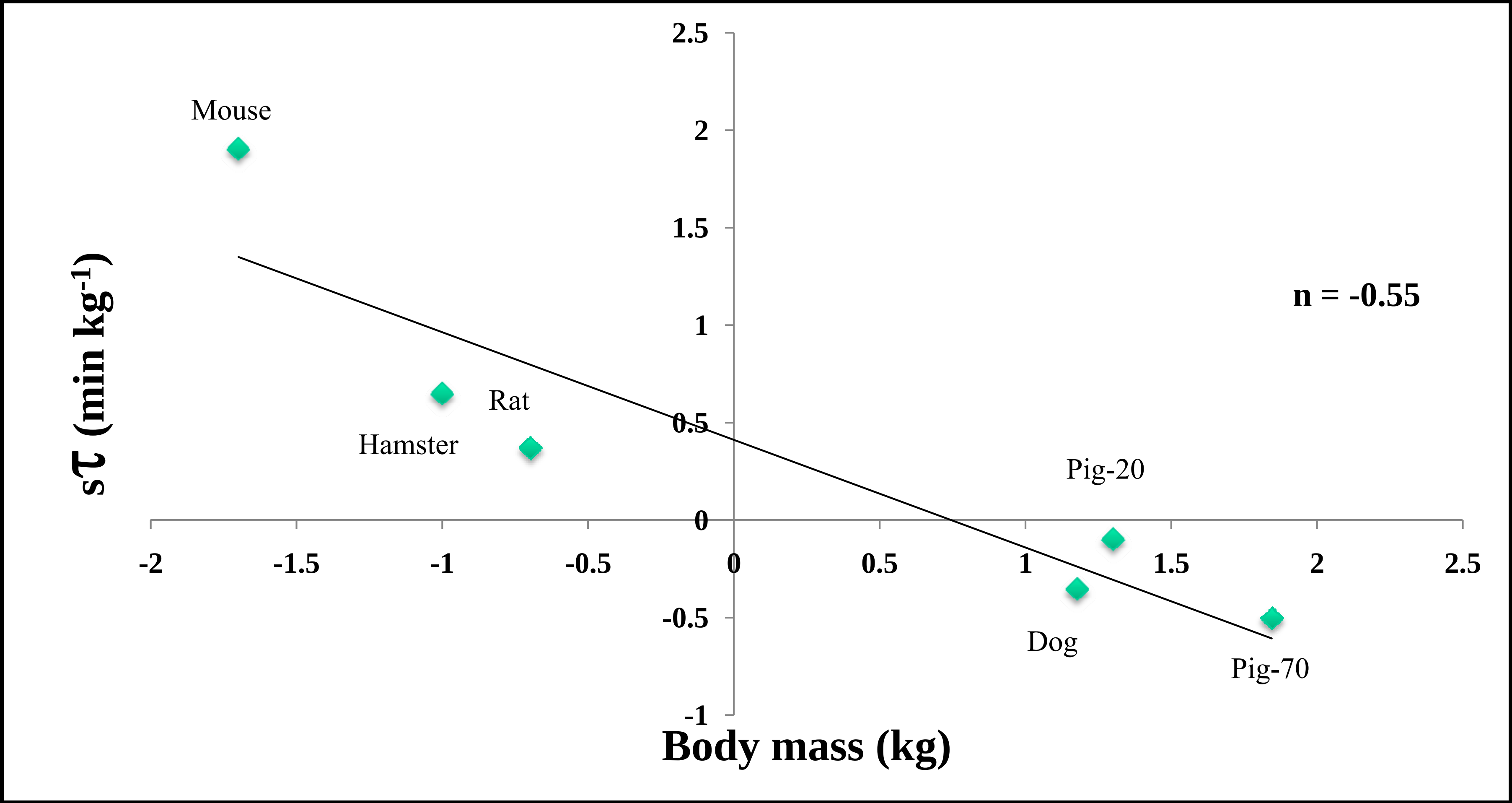
-Cardiac output (Q) scales with body mass as:

$Q = a * M_b^n$

where M_b is body mass and n a mass-exponent

-As Q is related to M_b and inversely related to τ, n should scale with risk between species.

Results
Univariate fit



Results
All species

Model:

$dP_i/dt=(Pamb-Ptis_i-Thr)/s\tau_i$

$s\tau_i = \tau_i / M_b^n$

$r_i = G_i * (Ptis – Pamb – Thr) / Pamb$

$r_{tot} = r_1 + r_2$

Parameter	Estimate ± SE
τ_1	0.27 ± 0.03
G_1	1.19 ± 0.27
n	-0.87 ± 0.04
Thr	0.71 ± 0.07
τ_2	227 ± 30
G_2	0.012 ± 0.002

Conclusion

- Body mass can be used to scale DCS risk in land mammals over a 3 fold difference in body mass.
- In an even balanced data set, there appear to be no differences in susceptibility between species
- Future studies to test different dive types.

Goals/Milestones

FY09 Goal –

☑Gather historical dive data in humans and various animals species.

FY10 Goal

☑ Write a probabilistic model to estimate DCS risk.

☑Run model with animal data sets.

FY11 Goal

☐ Determine whether human DCS risk can be accurately predicted using animal dive data

☐Peer-reviewed journal article

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