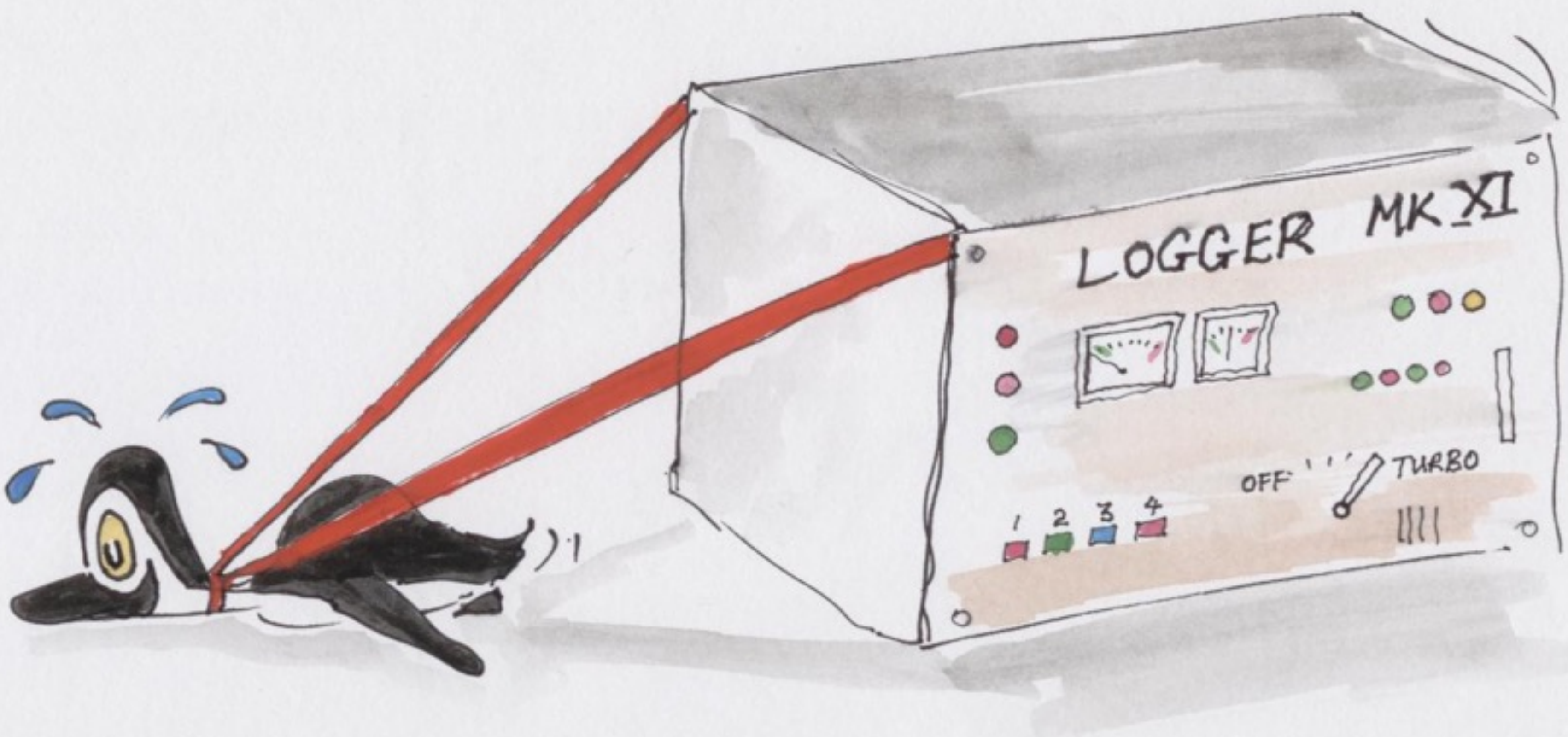
# Tags on birds - how much are our guidelines flights of fancy?

Rory Wilson
Swansea University

Photo: colourbox.com

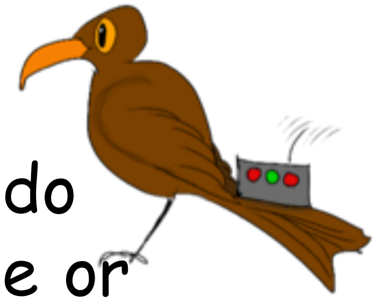
# How much do we bother birds while supposedly studying them? The case for animal-attached tags.

There is no question that animal-attached tags can tell us incredible things.




What is the price? (answer ≠ $2500)
Who pays it?

# Time to talk of some of the things that bother birds



Compromising capacity – affecting capacity to do something (e.g. affecting power or performance or heat loss [thermal windows due to glue] etc.)

Physical – direct physical detriment (e.g. tag rubbing, feather loss etc.).

'Mental' – affecting time budgets, vigilance etc.

HOW DO WE DECIDE WHAT IS ACCEPTABLE?

# Actually, trial and error

https://en.wikipedia.org/wiki/Pigeon_photography

Given that birds seem almost infinitely variable, surely we can do better then that? What do we really quantify when we consider tag effects on birds?

Photo: colourbox.com

Introducing

The magnificent 5% (3%) rule

Which necessitates that we weigh the bird and weigh the tag!

Is this ok?

This is a nice metric (it is quantified).

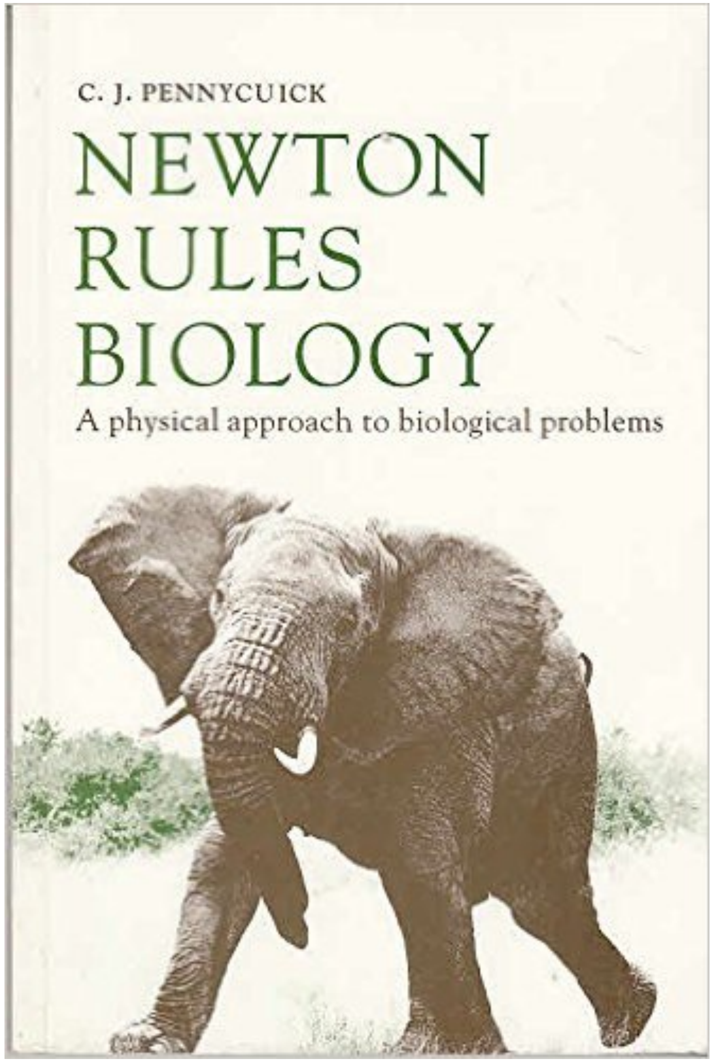
How much variation in 'device effect' does it hide?

Excuse me. We intend to put some luggage on your 747. It weighs less than 3% of the plane. Happy?

Photo: colourbox.com

The answer is, no pilot in their right mind would accept that

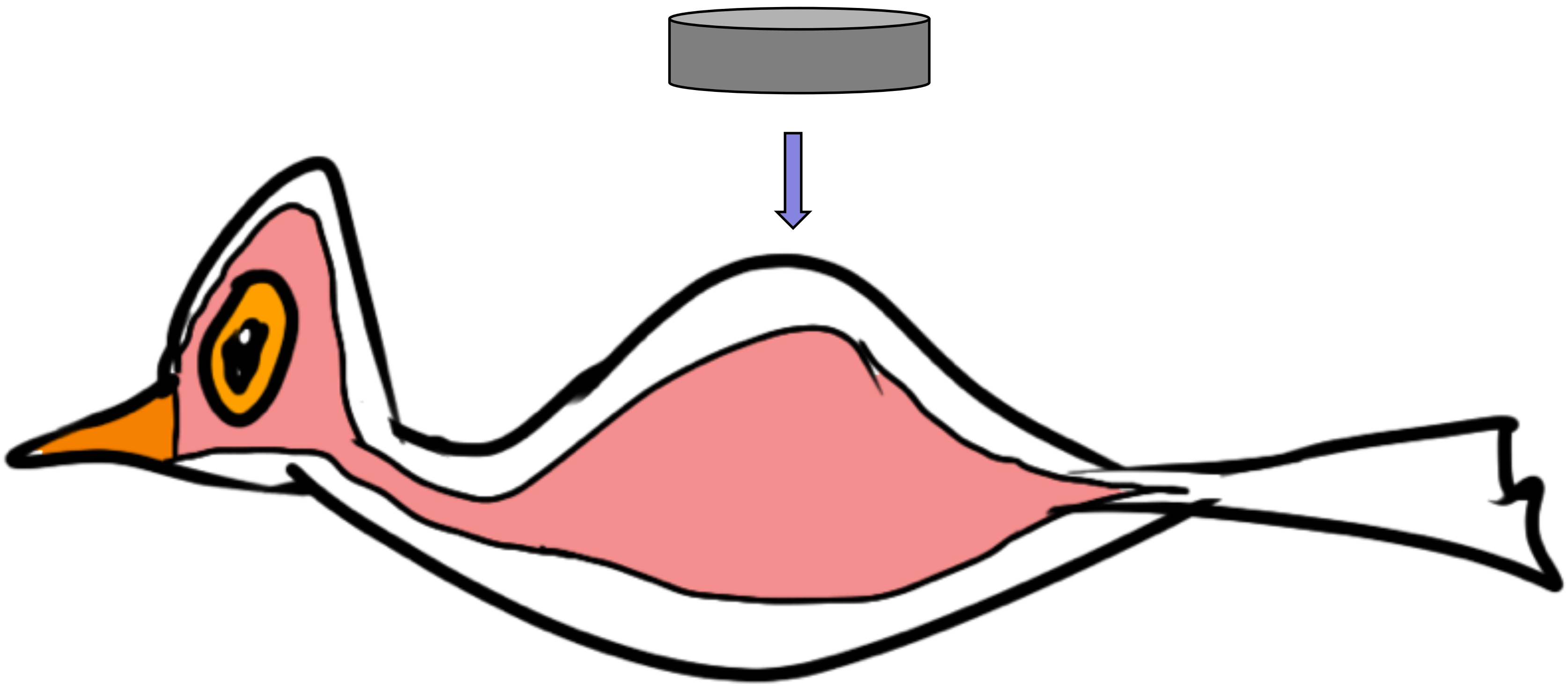
# We really can do better than that; Examples of a predictive framework…… (and why we should have paid attention in school physics lessons)

So what of compromising capacity and physical detriment?

Question 1 - How much pressure do tags exert on the dorsal feather surface of birds?

Answer; Weigh the tag (x kg) and work out the surface area of the base (y $m^2$).



Pressure = Force/Area so Pressure = x/y $kg/m^2$

Why is this important?

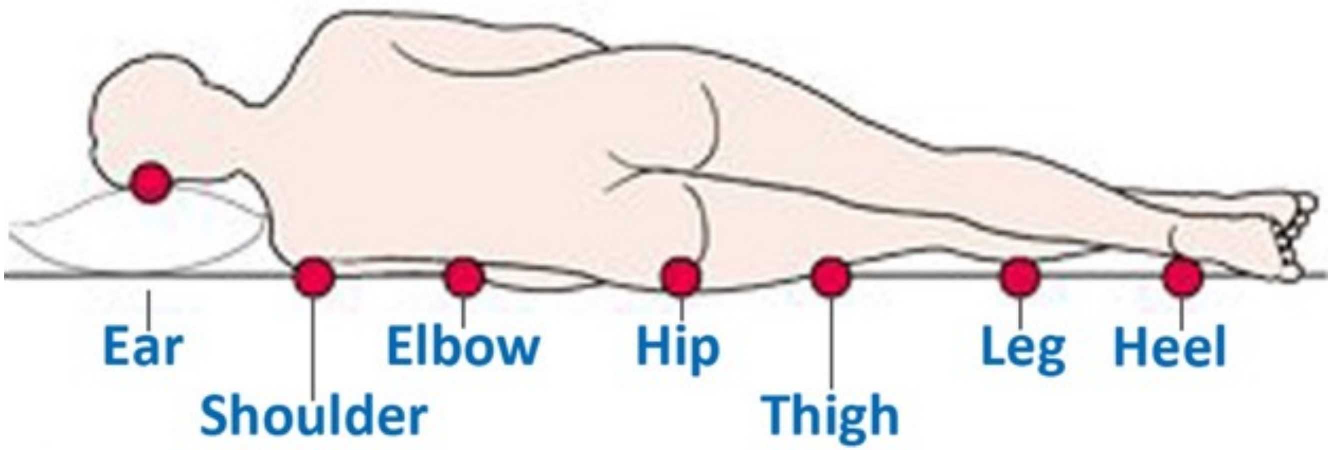



Illustration: http://www.facilitywebsource.com/page/pressure-ulcers.html

Birds have thin skin

Photo: colourbox.com

But appreciating that pressure = F/A enables workers to work out pressures caused by projections (e.g. on harnesses, and harnesses themselves) according to design and how they are ‘fit’.

Remember that irregularities in tags (and their attachments systems, like harnesses), can cause high pressure points.

And that the effects of pressure (and abrasion) will be modified by wing flap rate and extent….

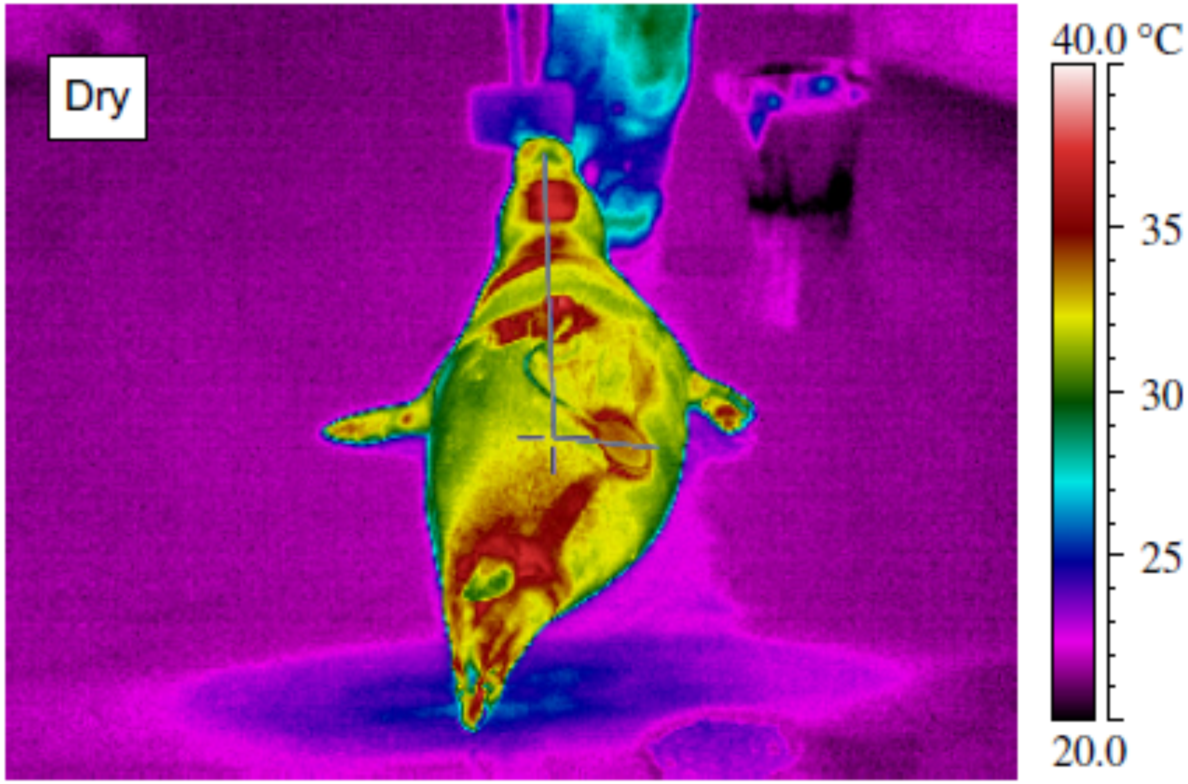
Is this ok then? Never mind skin. Has anyone ever looked what happens to bird feathers as a function of pressure?

Higher pressure reduces the air layer which will reduce feather insulation which will increase heat loss.

Photo: colourbox.com

# The effect of instrument attachment on the surface temperature of juvenile grey seals (*Halichoerus grypus*) as measured by infrared thermography

Dominic J. McCafferty[a,*], John Currie[b], Carol E. Sparling[c]



Question 2 – How much heat does a compressed feather layer loose then?

The (lost) heat flow;

$$q = h \cdot A \cdot \Delta T$$

$q$ = heat flow in input or lost heat flow , J/s = W
$h$ = heat transfer coefficient, $W/(m^2K)$ (depends on feather thickness)
$A$ = heat transfer surface area, $m^2$
$\Delta T$= difference in temperature between the solid surface and surrounding fluid area, K

What is the predicted increase in heat loss then? (remember also % time in water and % time in air and the conductivity of the habitat)

This problem will be more important for birds living in colder environments.

So we should be noting the temperature of the habitat at the time the bird is tagged.

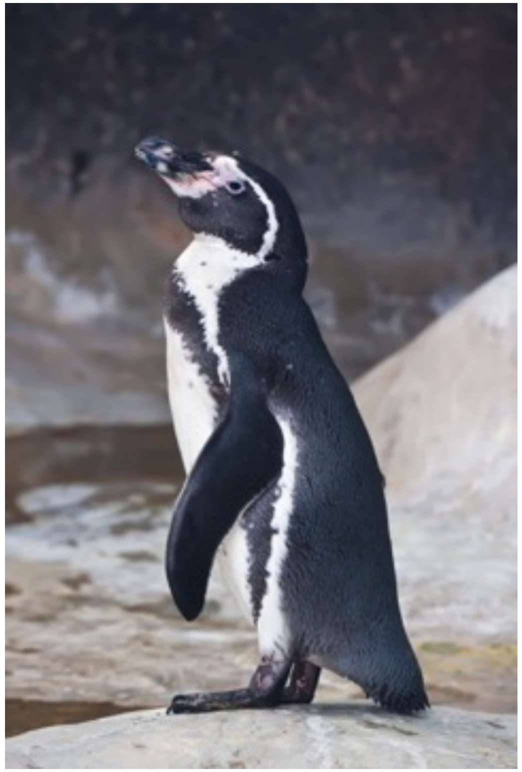


Photo: colourbox.com

Question 3 – How much heat does a compressed feather layer lose <u>per bird</u> then?

We know the surface area of the bottom of the tag

We now need the formula for calculating the surface area of the bird (as a function of mass)

J. exp. Biol. (1978), 76, 185–189
With 1 figure

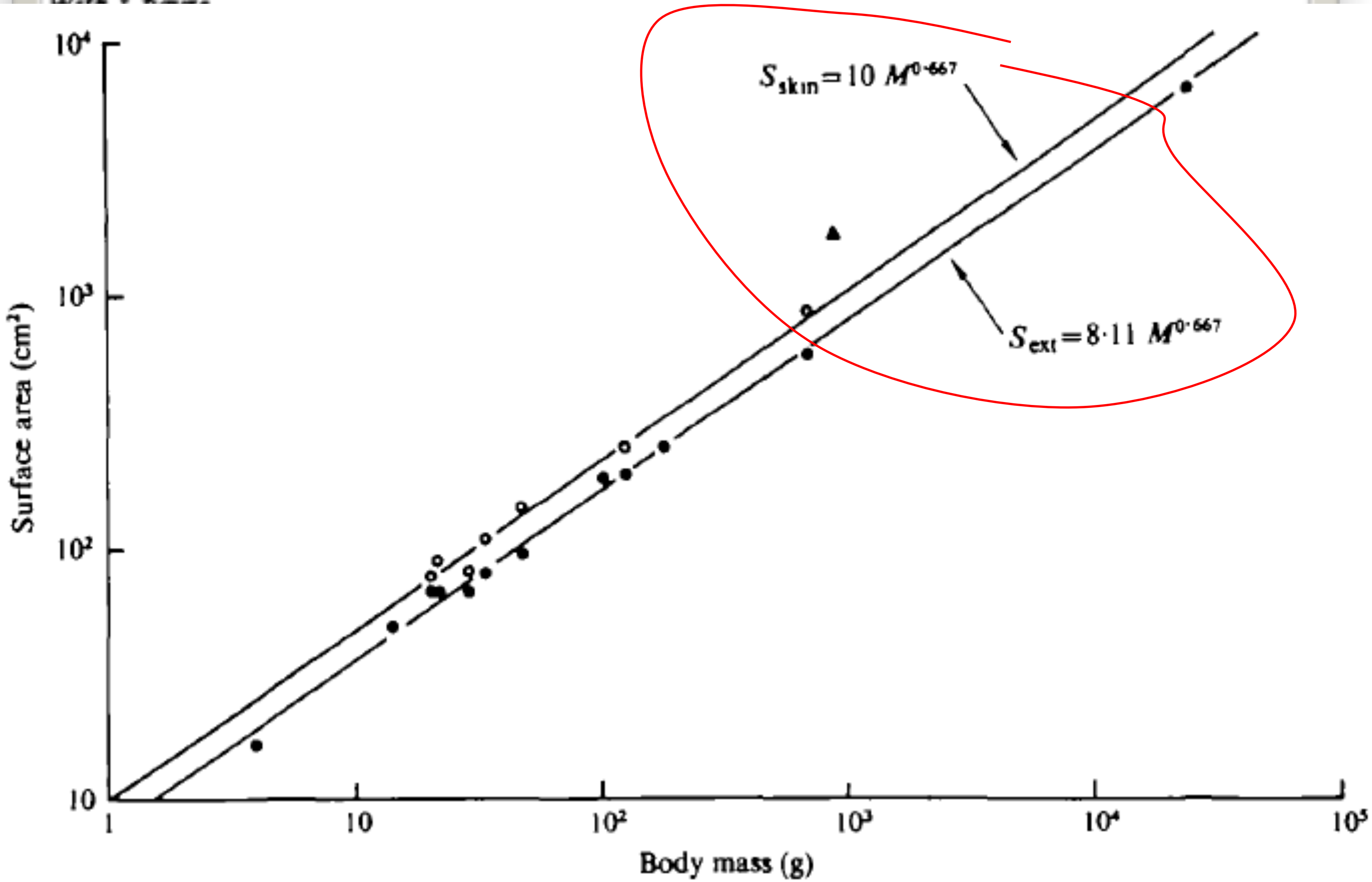



Fig. 1. The relation of the external surface area of the plumage ($S_{ext}$) and the skin surface area beneath the plumage ($S_{skin}$) to body mass. Filled circles represent data from Table 1 to which the line describing $S_{ext}$ was fitted. Triangle shows Veghte's (1975) value for $S_{ext}$ in Ravens, which was not used in calculations. Unfilled circles show values for $S_{skin}$ measured in this study. Values for $S_{skin}$ and $S_{ext}$ are virtually identical in *Turdus migratorius* and are plotted as a single half-filled circle.

So, <u>fraction of bird with compromised insulation</u>

$= A/8.11 \times M^{0.667}$

(nice metric)

# Question 4 – What is the energy lost by the whole bird then?

The Journal of Experimental Biology 208, 1621-1625
Published by The Company of Biologists 2005
doi:10.1242/jeb.01553

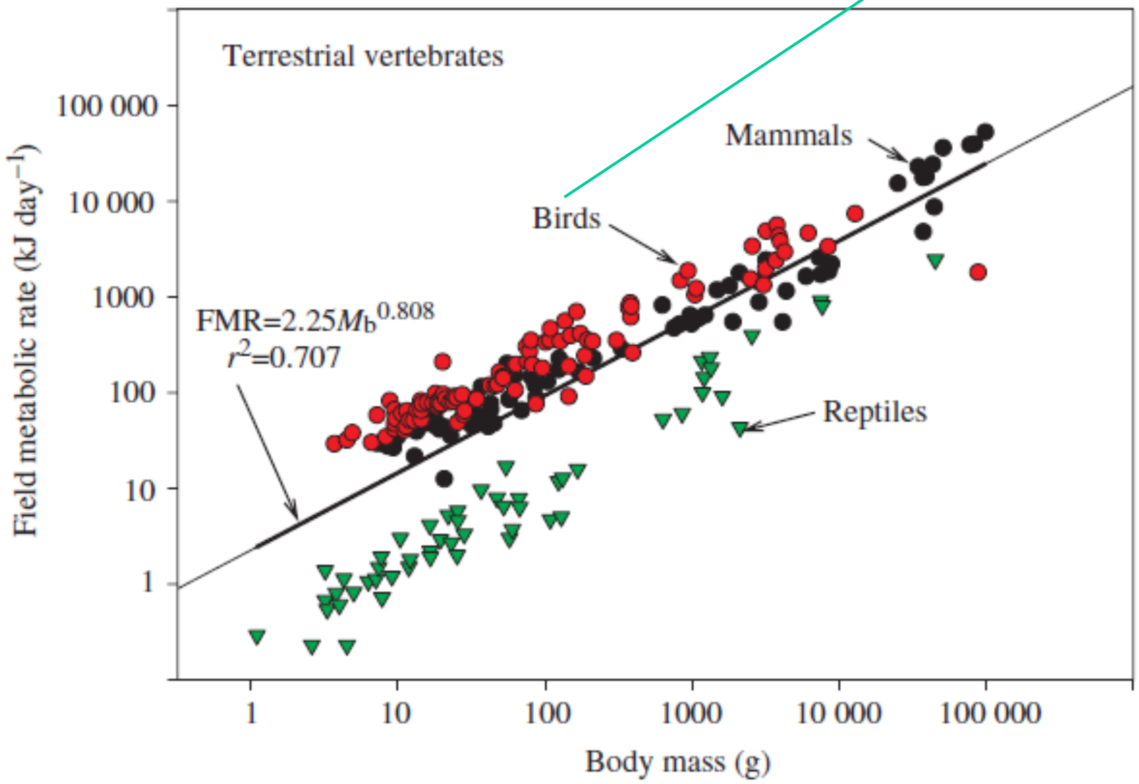


**Review**

## Field metabolic rate and body size

Kenneth A. Nagy

$$FMR=10.5M_b^{0.681}$$



If 70% of the FMR is produced (and lost) as heat [heat produced = heat lost] then normal heat loss per unit surface area of bird can be calculated by combining Nagy's equation with that of Walsberg and King.

And <u>this</u> can be used to calculate the expected energy lost as heat due to the tag!

Things to note; Increasing the tag bottom surface area (e.g. for solar panels) will decrease the pressure proportionately but increase the area for heat transfer...

Birds in colder places will be more affected

Question 5 – What factors increase **the drag** acting on a flying (or swimming) bird?

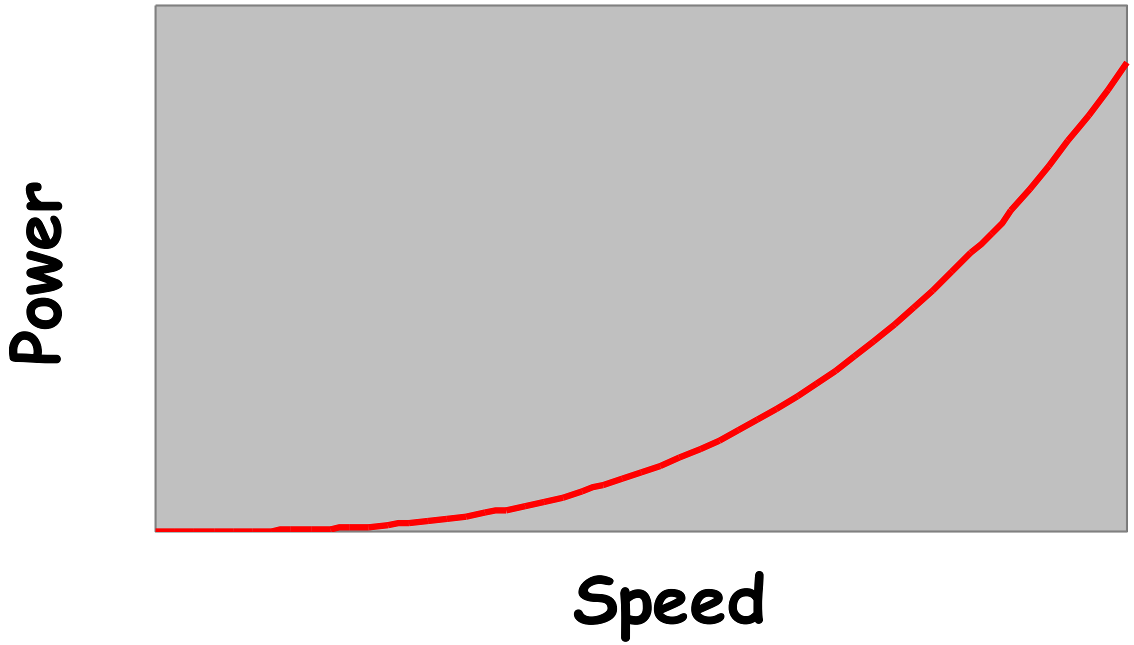
$$F_d = \frac{1}{2}(\rho v^2 A C_d)$$

How does drag affect energetics?

The power required to overcome drag;

$$F_d v = P = \frac{1}{2}(\rho v^3 A C_d)$$

# Some frightening truths about drag




Double the speed and the drag quadruples
– exerting four times the force at twice the speed
necessitates EIGHT times the power

Thus, drag will affect fast-flying birds much, much more than slow-flying species....

Photo: colourbox.com

In our protocols, we do not ask about flight speed

We do not ask about time spent flying per day

Even though we know that birds modulate speed according to drag

Photo: colourbox.com

# African penguins swim slower with higher drag

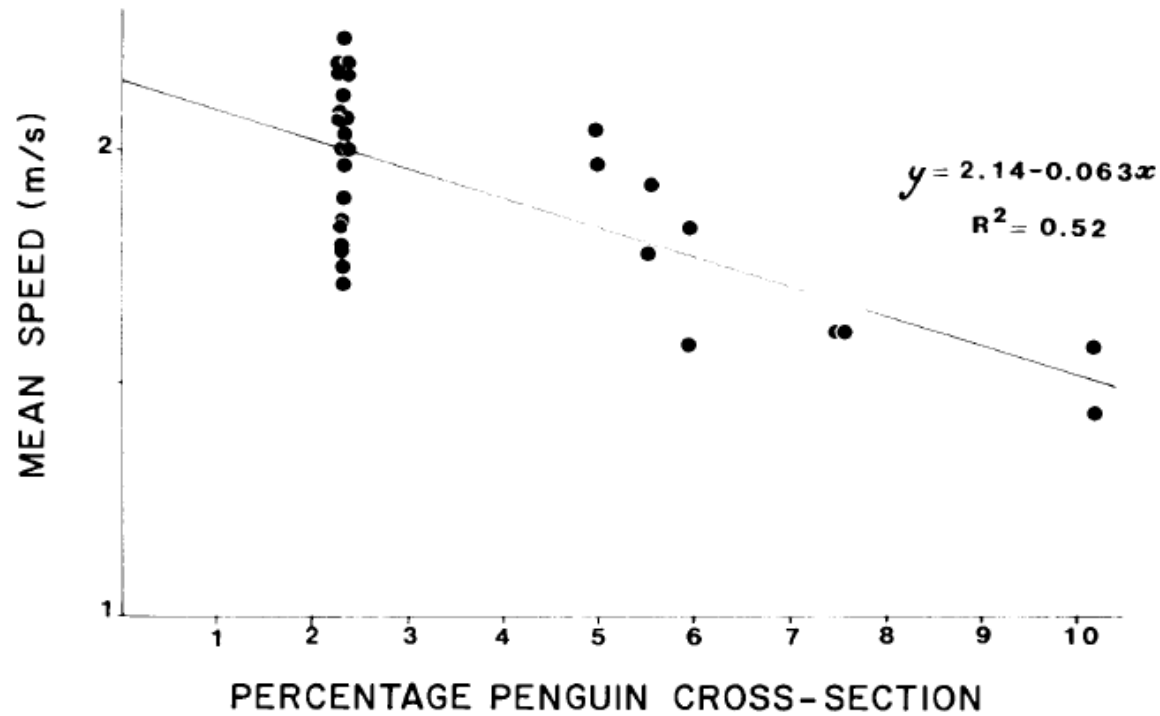



FIG. 1. Relationship between mean speed ($y$) during a typical foraging trip and percentage cross-sectional area ($x$) of an attached device relative to the frontal cross-sectional area of an African Penguin.

Wilson et al. (1986) Ecology

What does this mean in terms of energy and how this might impact lifestyle?

African Penguins with devices do not use significantly more energy per foraging trip than do free-swimming penguins (mean $CO_2$ productions of 1.027 $mL \cdot g^{-1} \cdot h^{-1}$, SD = 0.147, $n = 5$, and 0.992 $mL \cdot g^{-1} \cdot h^{-1}$, SD = 0.069, $n = 8$, respectively, $t = 0.59$, $P > .05$ [data from Nagy et al. 1984]). If we assume that free-swimming penguins and penguins with devices spend a total of 4.5 h swimming per day, and that they expend 212 kJ/h (Nagy et al. 1984), a total of 954 kJ is consumed in swimming. When this energy expenditure is added to the maintenance cost of 1137 $kJ \cdot bird^{-1} \cdot d^{-1}$ (Nagy et al. 1984), the total energy expenditure is 2091 $kJ \cdot bird^{-1} \cdot d^{-1}$. The surplus energy available to chicks from free-swimming penguins would be 510 kJ or 99 g of anchovy per day. African Penguin chicks between 2 and 5 d old require ≈50 g of anchovy per day (Cooper 1977). Therefore, free-swimming adults with two chicks catch enough anchovy for themselves and their chicks. Penguins carrying devices 10% in cross-sectional area have a deficit of 239 kJ (47 g of anchovy) in their own energy needs, and would have no anchovy available to feed their chicks. Devices up to a maximum of 6.8% in cross-sectional area could be put on nonbreeding adult penguins, following the same foraging pattern as a breeding bird, and the penguins could still balance their energy budgets.

# Drag affects behaviour and space use



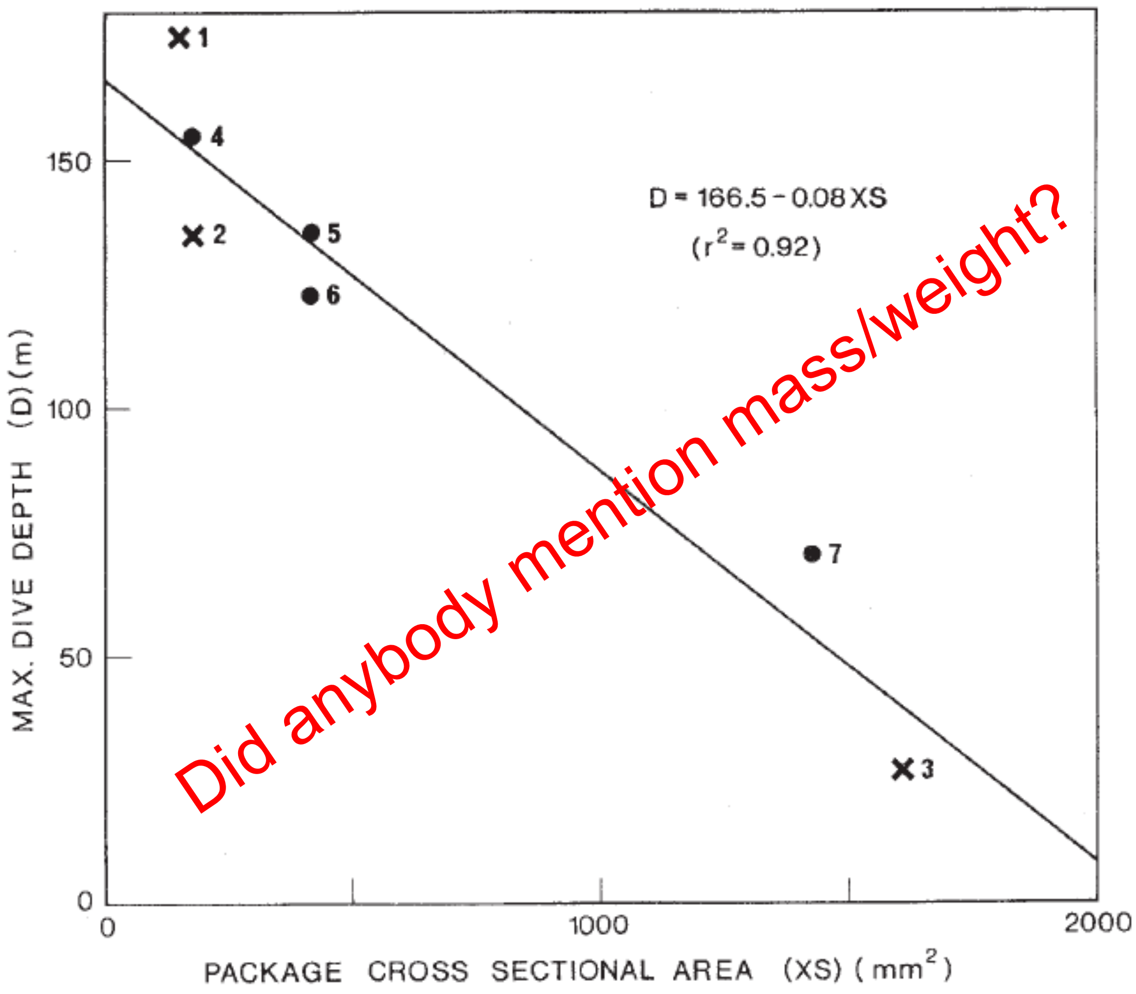


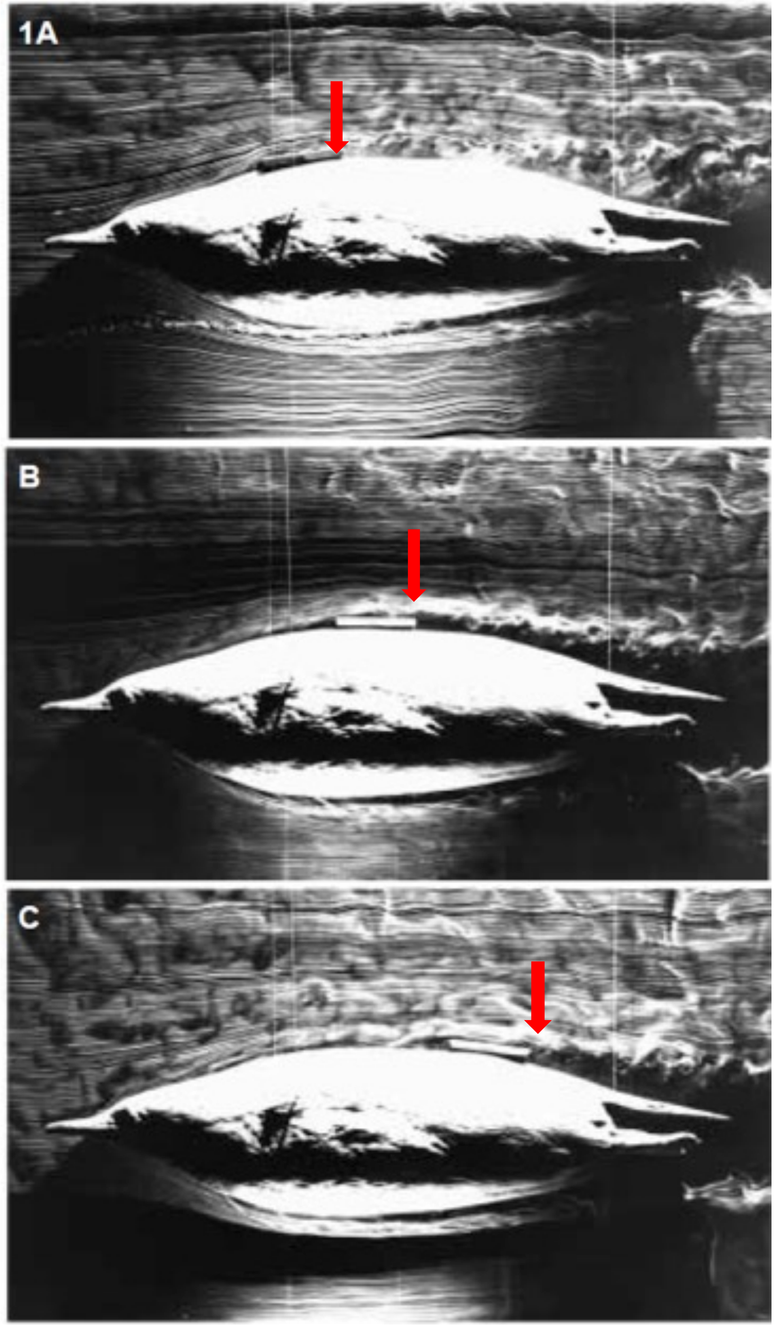

Figure 3

Maximum recorded dive depth as a function of calculated package cross-sectional area for Adélie (crosses) and Gentoo (circles) Penguins. Data from: (1) Whitehead (1989), (2) this paper, (3) Naito *et al.* (1988), (4) this paper, (5) D. Costa, cited in Trivelpiece *et al.* (1987) (6) Croxall *et al.* (1988), (7) Adams & Brown (1983)

Why has this not been done with flying birds?

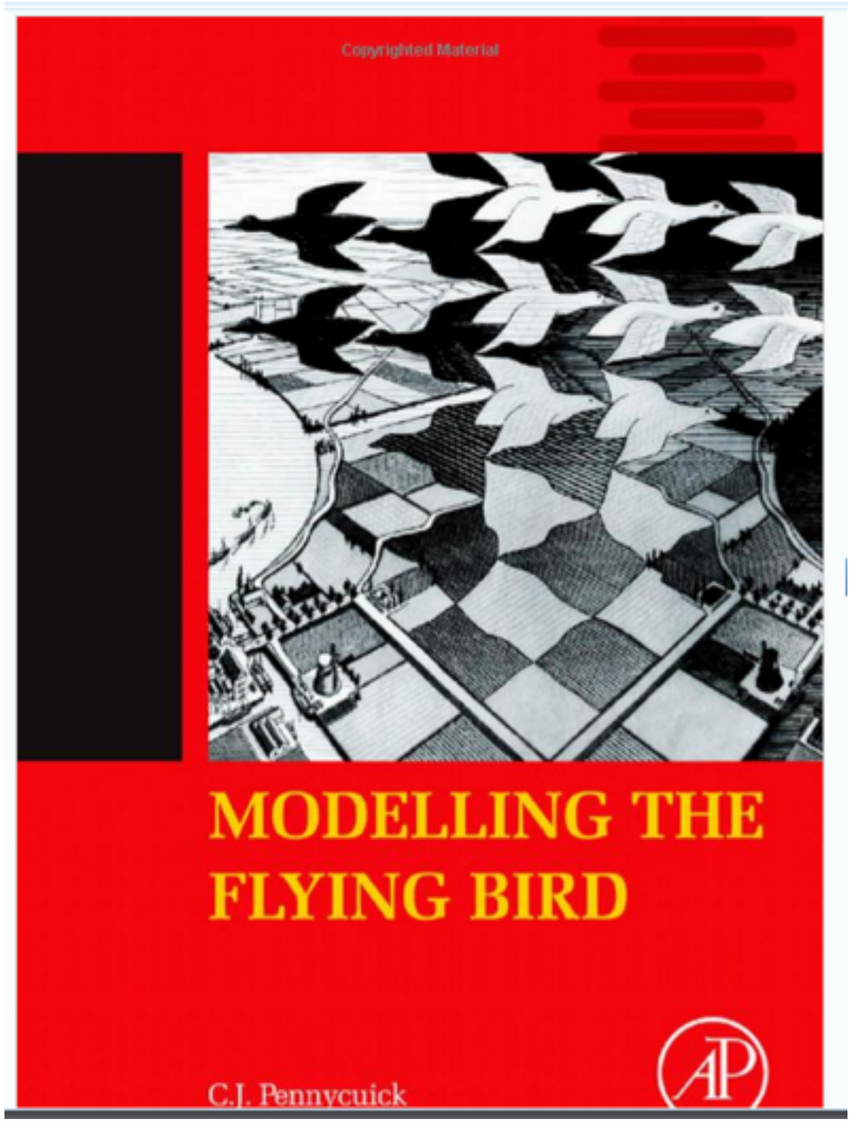
Because it is technically difficult!! – But underwater stuff is really no different.

# There are tips from flow visualisation – Put tag at rear!



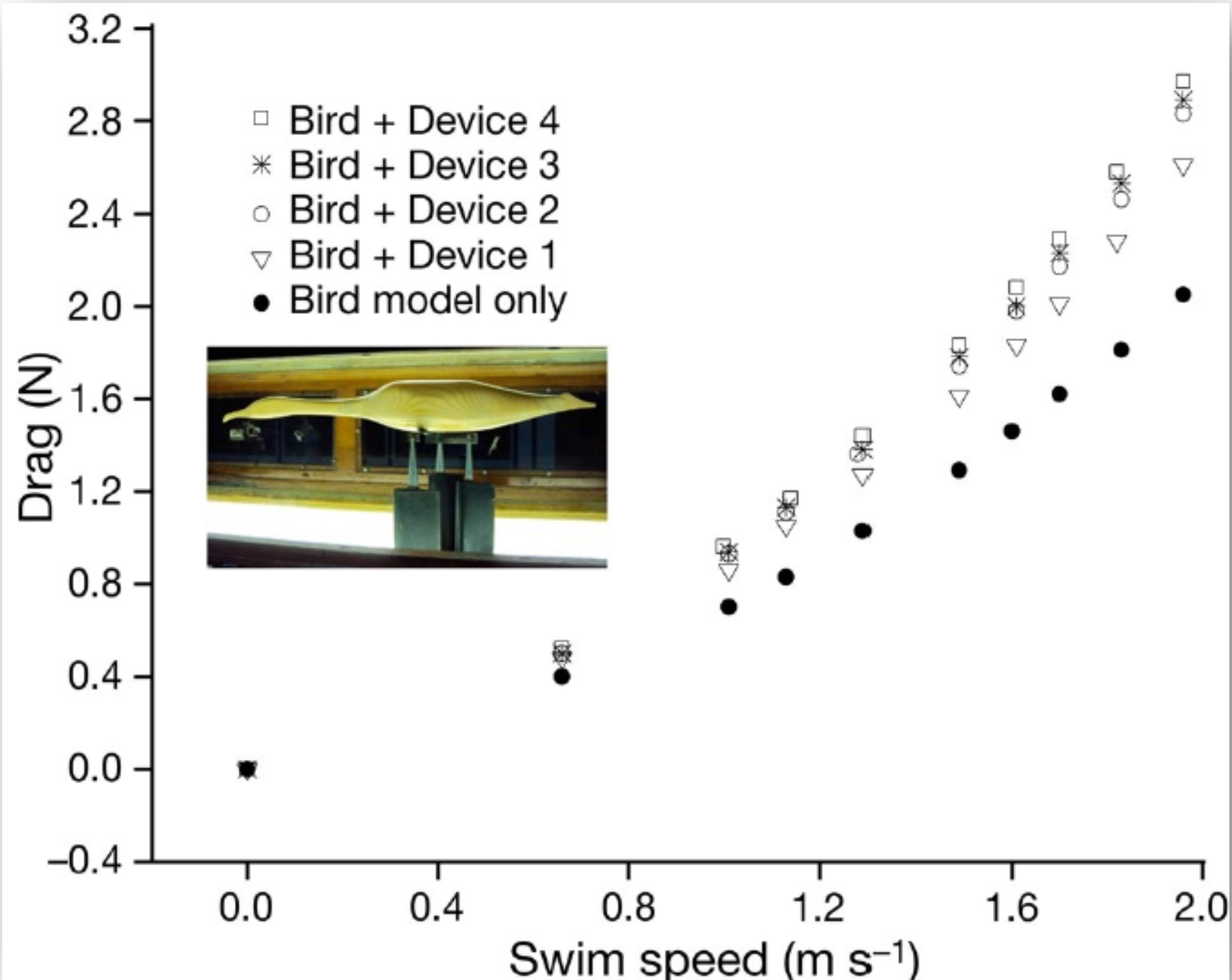

Bannasch et al. (1994) J Exp Biol

# Can we estimate drag?




https://www.elsevier.com/books/modelling-the-flying-bird/pennycuick/978-1-4933-0110-2

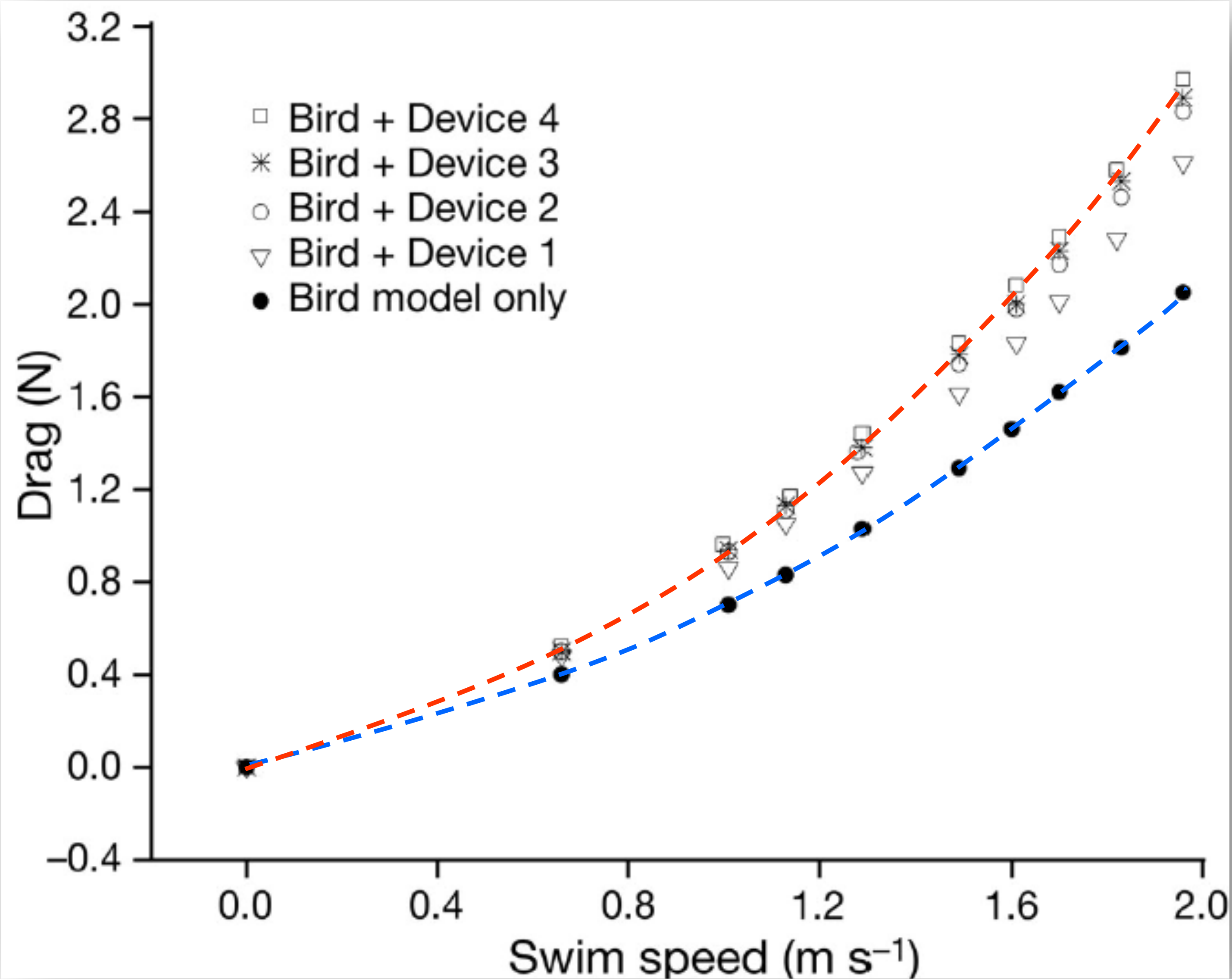
# Yes indeed. See wind tunnel work



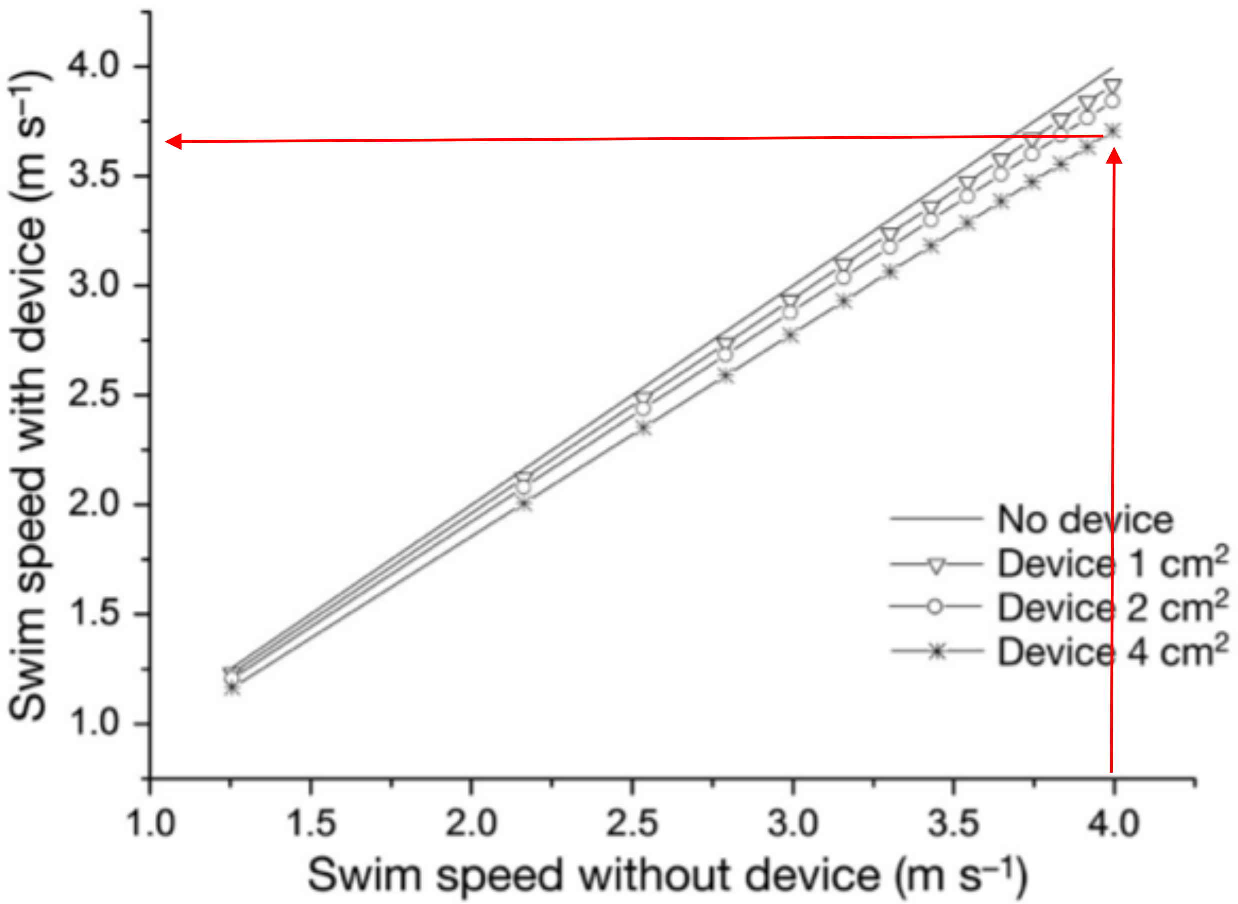

Vandenabeele et al. (2015) MEPS

The bottom line;

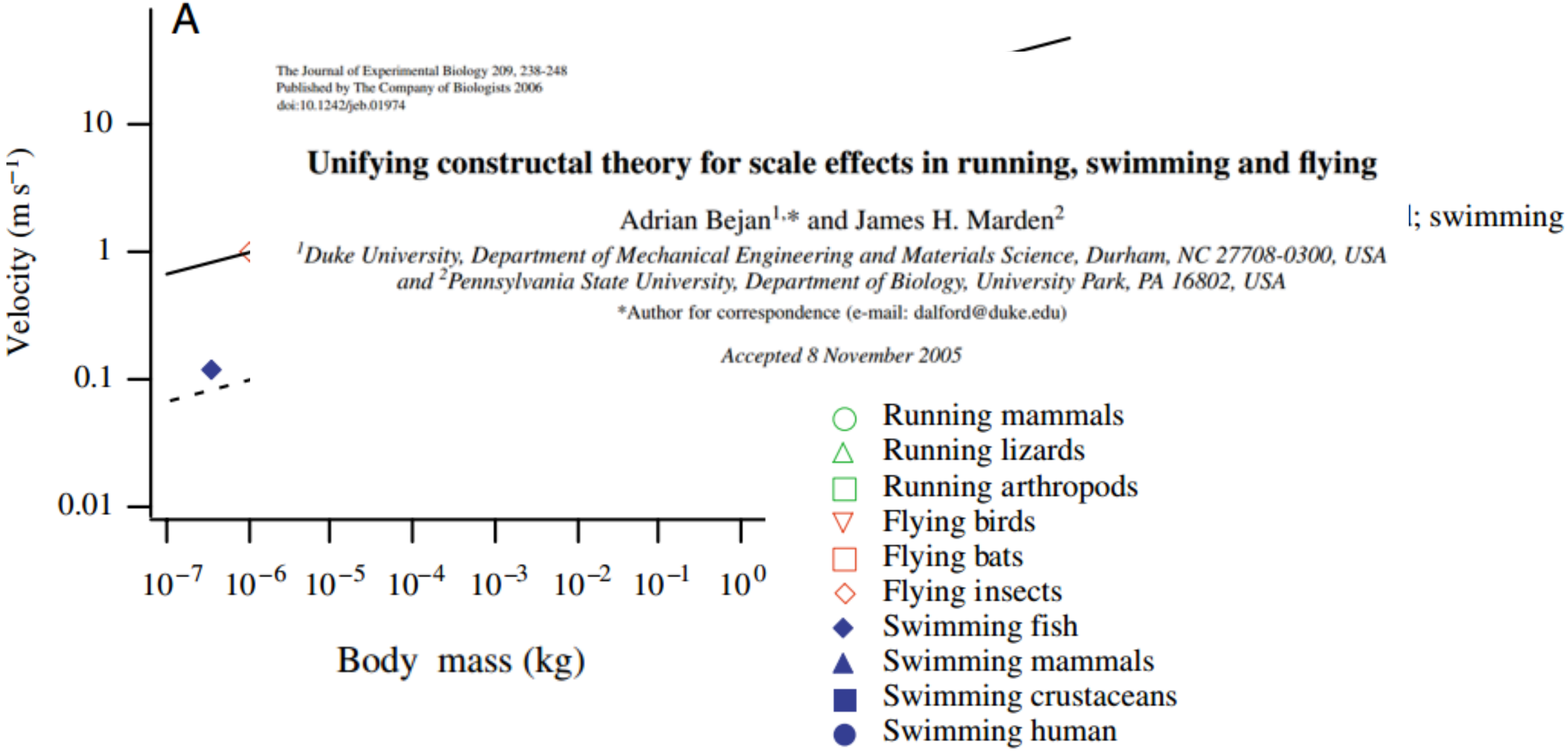
Higher speed (lower drag) animals suffer the most!!



So increasing the drag precludes high speeds.. and……..



## ..the big meals swim fastest!!




The Journal of Experimental Biology 209, 238-248
Published by The Company of Biologists 2006
doi:10.1242/jeb.01974

**Unifying constructal theory for scale effects in running, swimming and flying**

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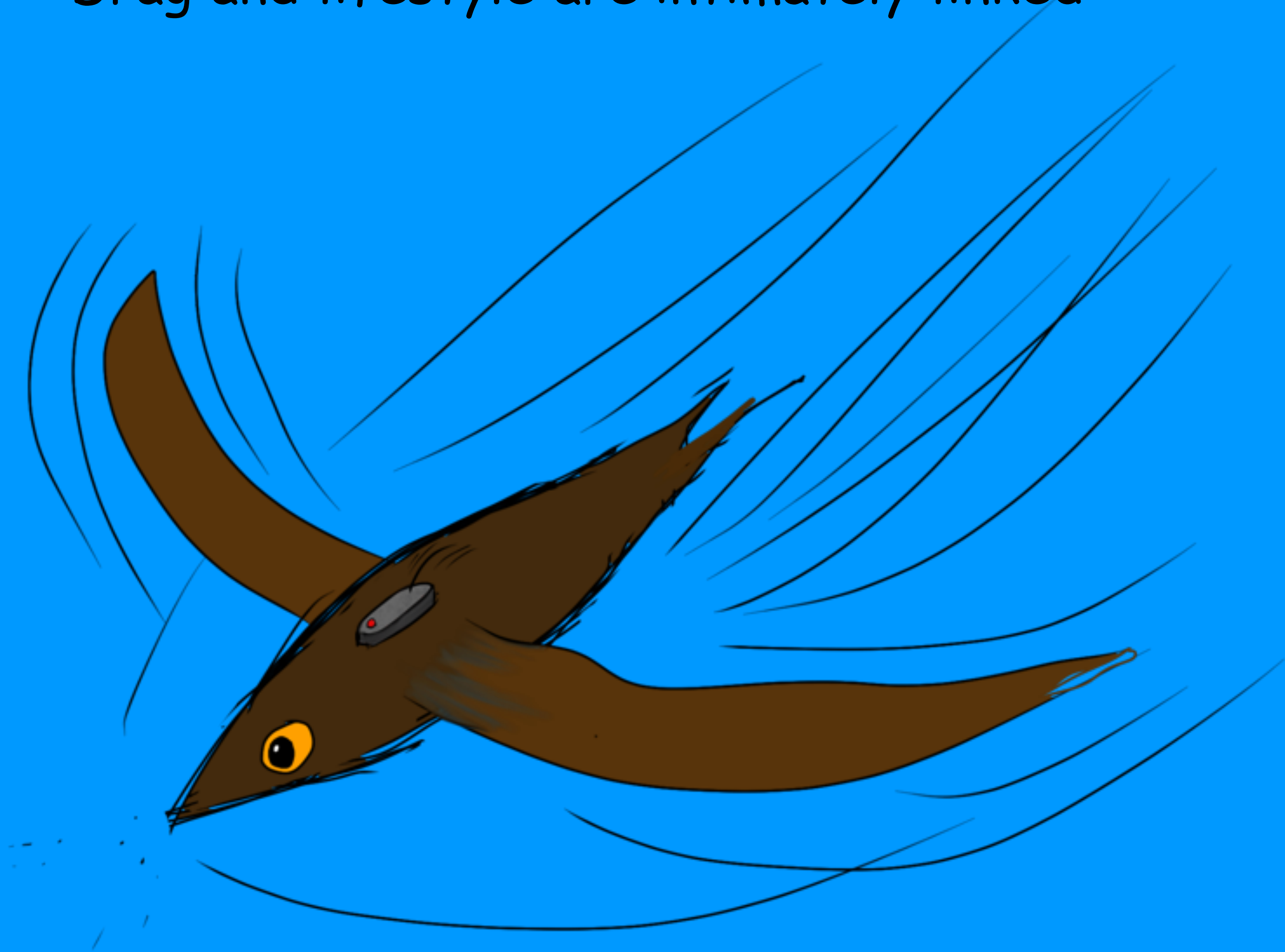
*Author for correspondence (e-mail: dalford@duke.edu)

*Accepted 8 November 2005*

If you can't swim fast, you can't catch big meals

# Drag and lifestyle are intimately linked



# Drag and lifestyle are intimately linked

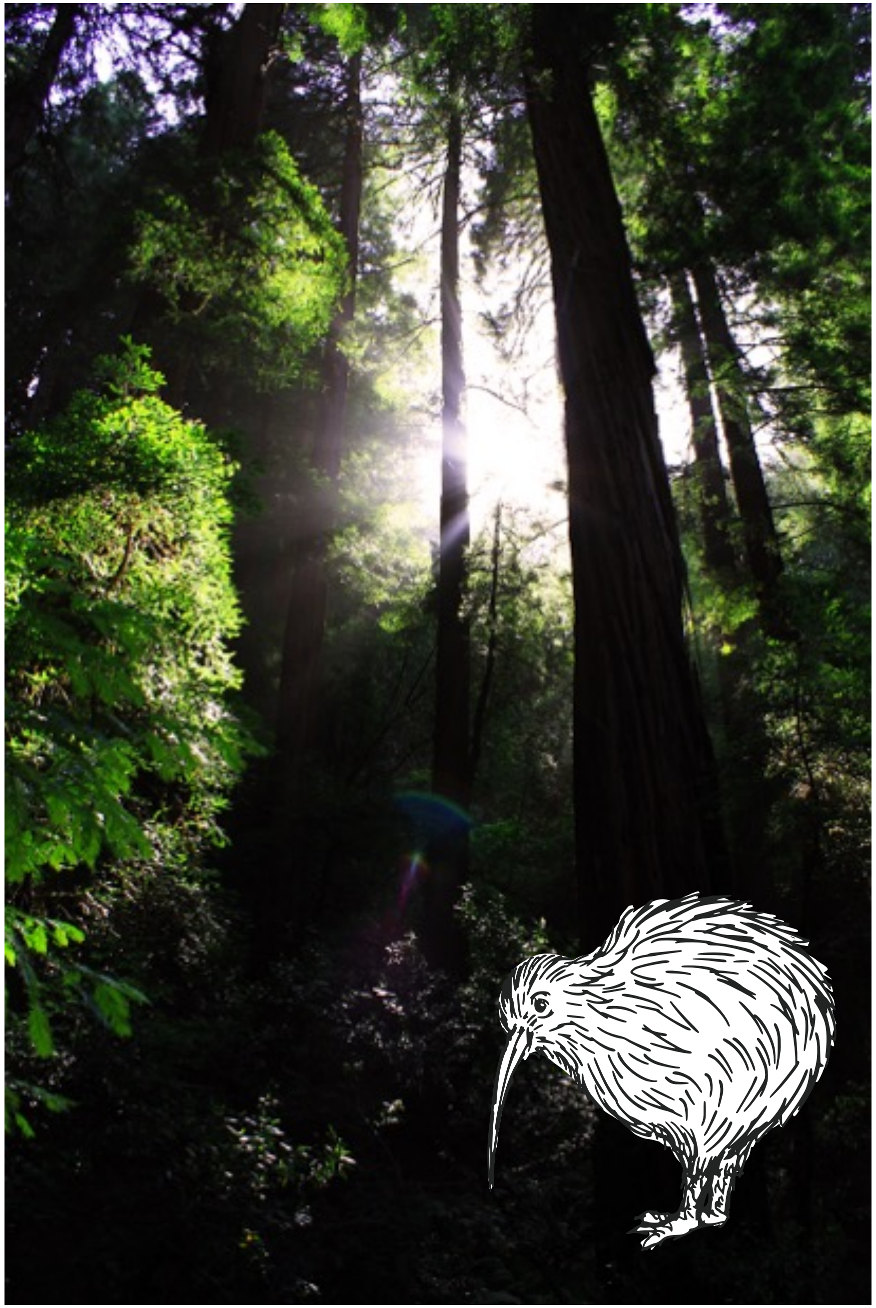
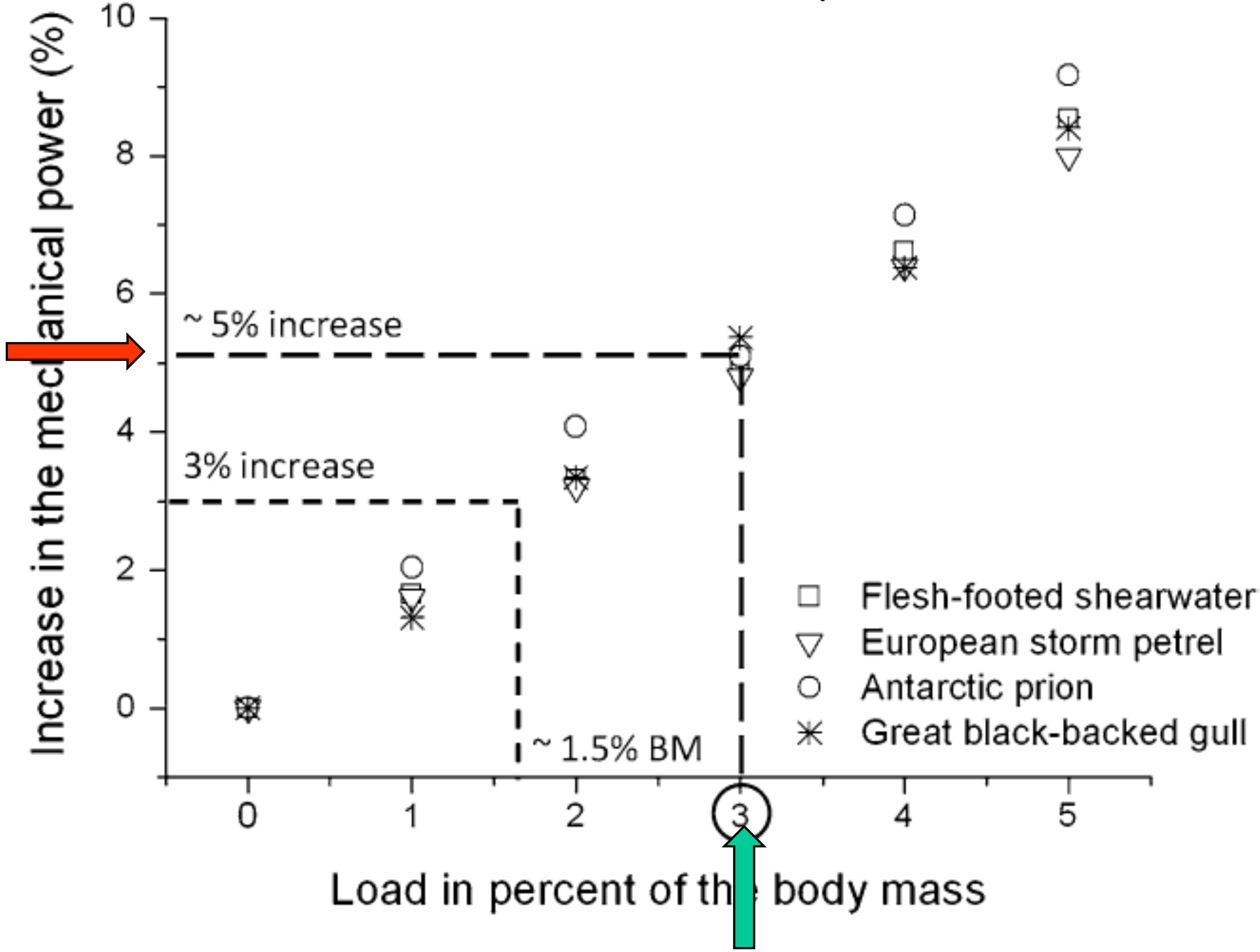


Photo: colourbox.com

# What about the weight of the baggage?
# 3% is not actually 3%




Vandenabeele et al. (2012) Marine Biology

# And how about including the percentage time spent flying?

Photo: colourbox.com

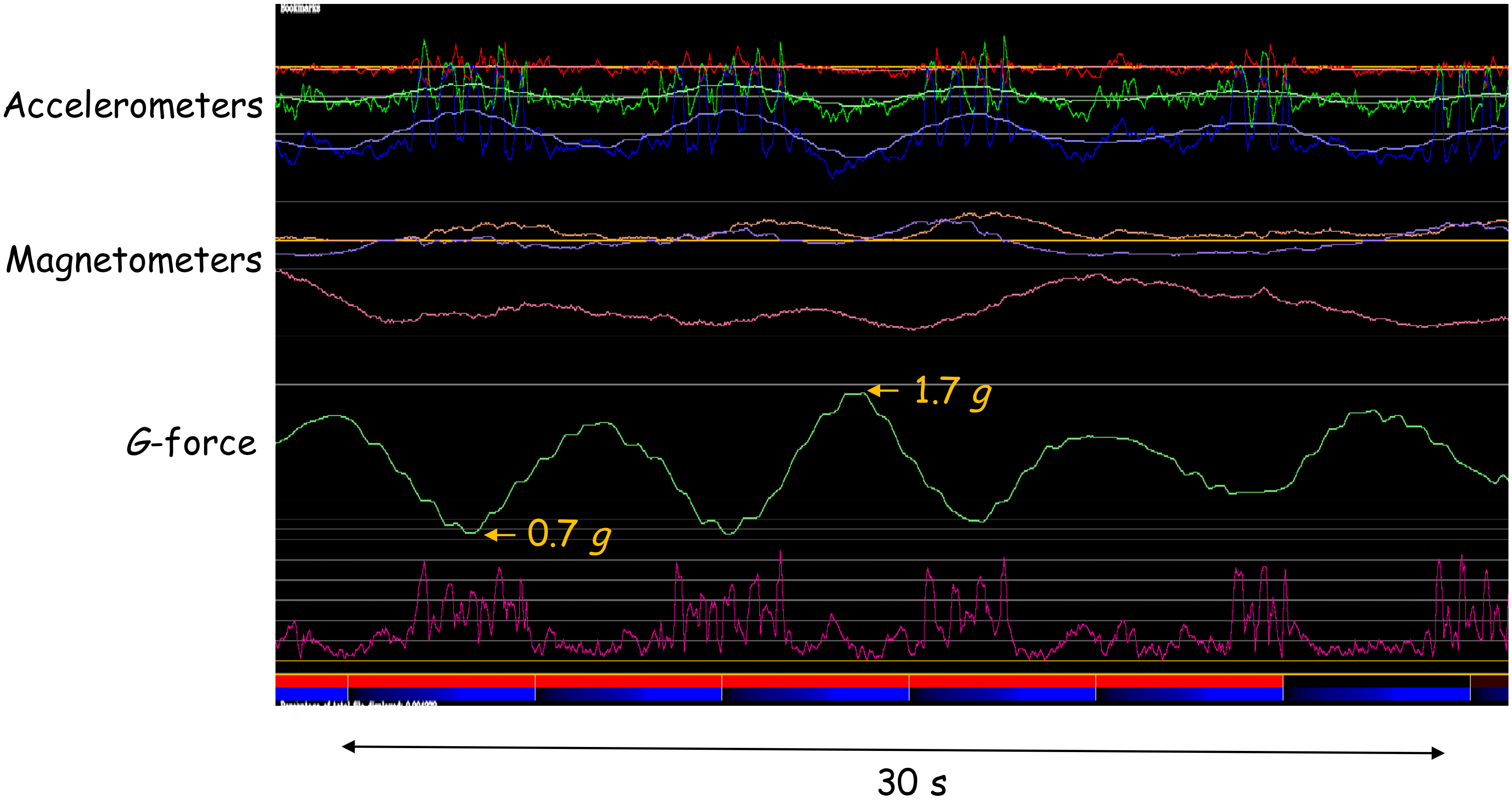
# And considering powered vs soaring flight

Photo: colourbox.com

# And performance flying - How many g?

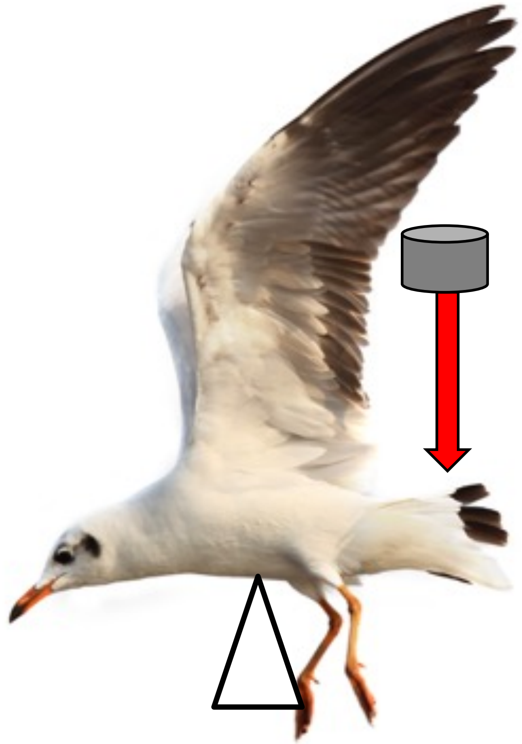
Photo: colourbox.com

# Some animal live at unearthly 'g'



Where should the baggage go?

# A word on 'moment arms'!

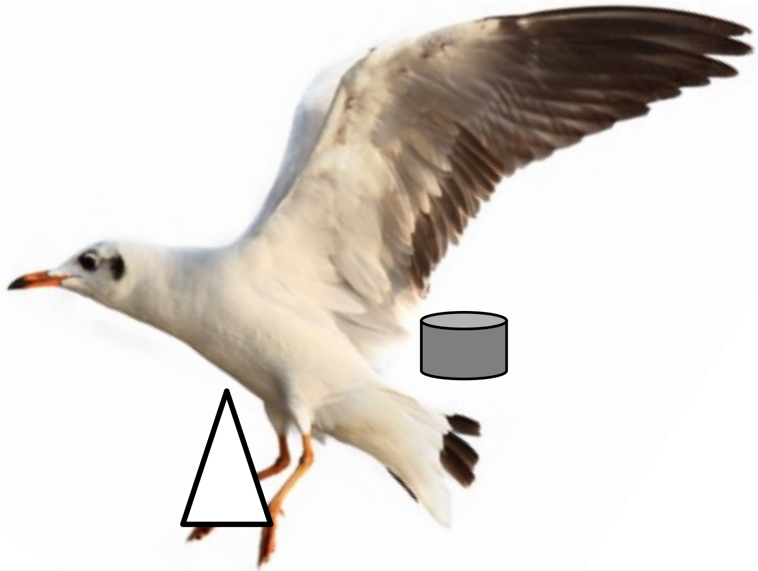


Moment of the force = Force X distance

The imbalance in the moment arm can be calculated by knowing the mass of the tag and its distance from the centre of gravity

Photo: colourbox.com

# Moment arms!

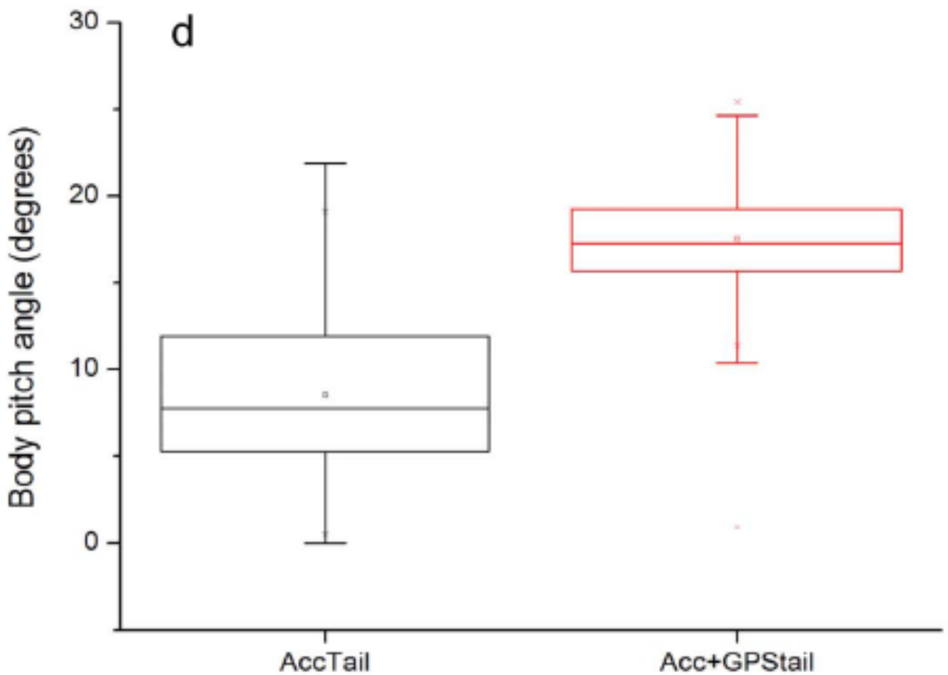


Moment of the force = Force X distance

The imbalance in the moment arm can be calculated by knowing the mass of the tag and its distance from the centre of gravity

Photos: colourbox.com

# Weight on the tail makes gannets 'pitch up'....




## ...increasing the frequency of flap-glide cycles

Vandenabeele et al. (2014) PLoS One

Photo: colourbox.com

# Conclusion – Place the tag at the centre of gravity

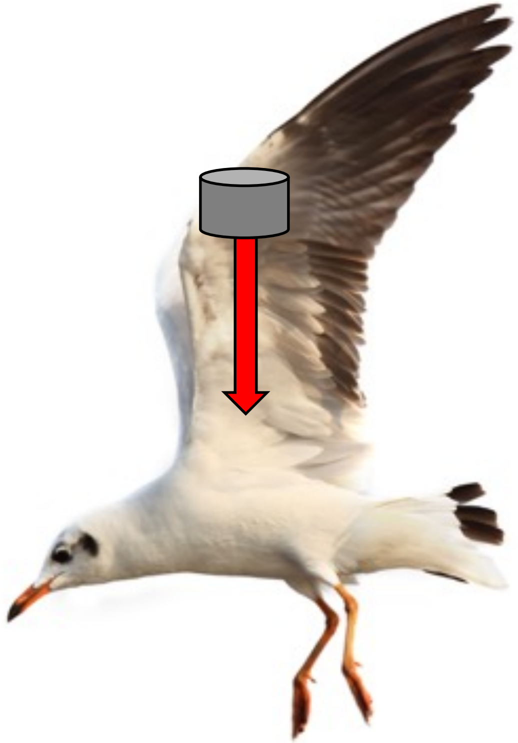


Photo: colourbox.com

Not forgetting the importance of time…

What are the consequences of time for tag detriment?

Illustration: colourbox.com

Actually, we know quite a lot if we think about it. So there is no excuse for ethics bodies not to be using a framework like this..

which would get us away from this 3% mass thing!

And finally – a quick word on; the 'mental' effects of tags!!

Does somebody else mind your tag?

Photo: colourbox.com

In the UK, we say
…no more stress than that caused by a needle…

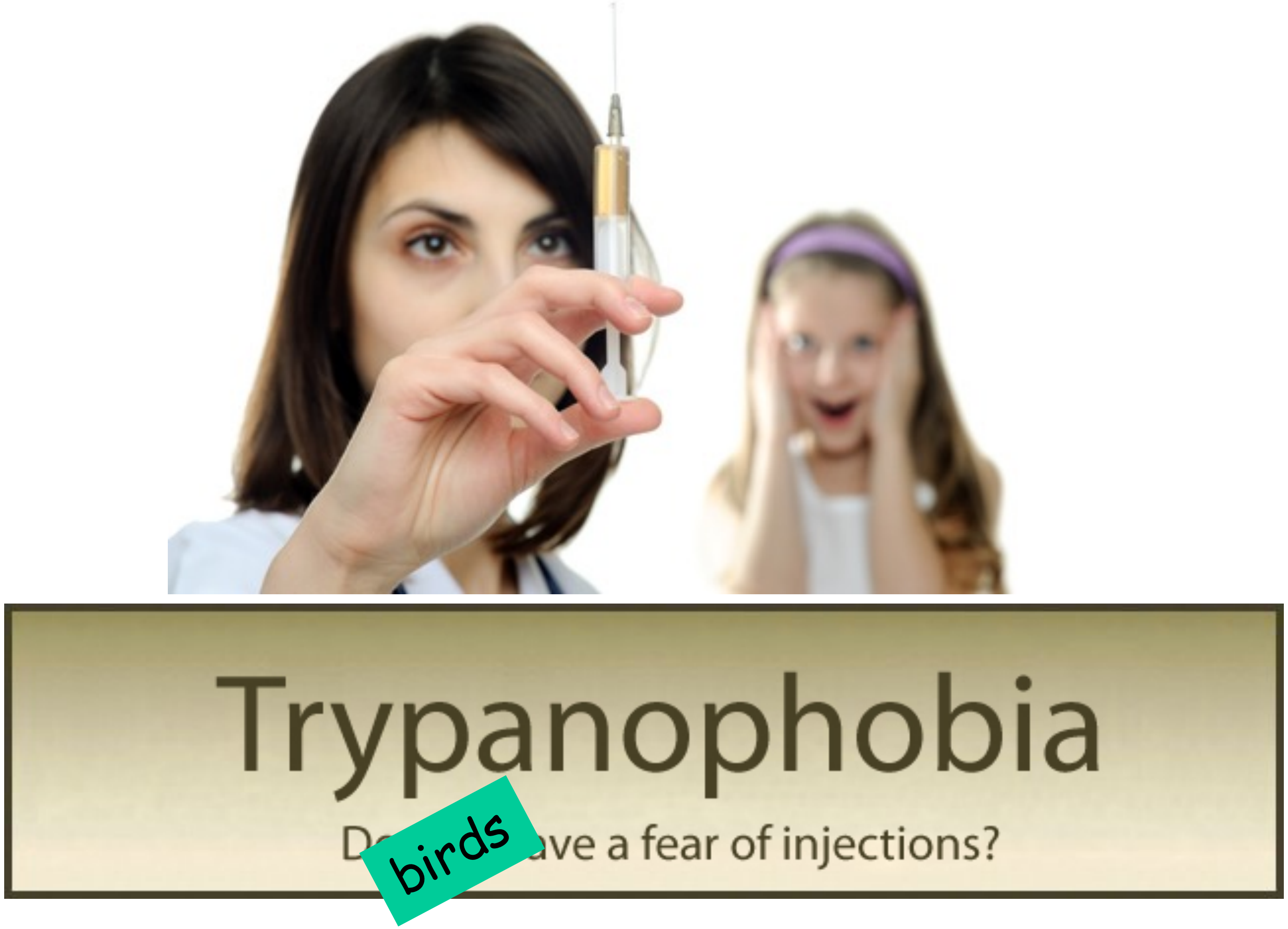



Photo: colourbox.com

# A MINIMAL-STRESS BIRD-CAPTURE TECHNIQUE

RORY P. WILSON, Institut für Meereskunde an der Universität Kiel, Düsternbrooker Weg 20, D-2300 Kiel 1, Federal Republic of Germany

J. Wildl. Manage. 53(1):1989

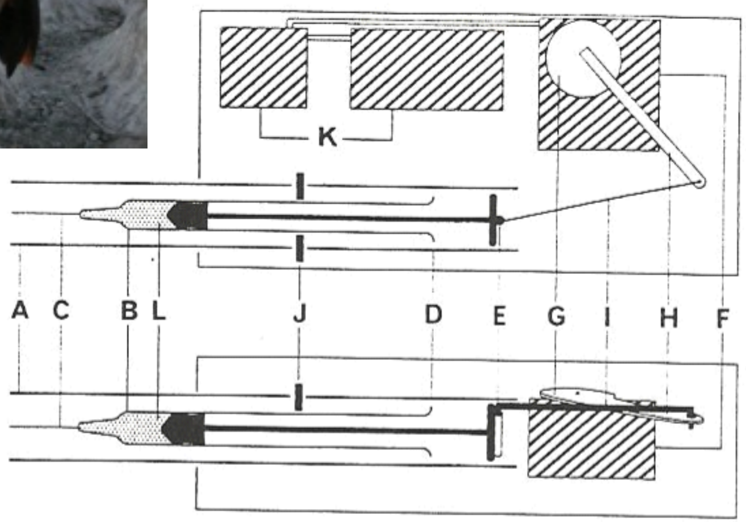



Fig. 1. Schematic diagram of a remote-controlled sedative injection unit viewed from above (top) and laterally (bottom). A = brass piping to act as conduit for syringe, B = syringe, C = needle, D = syringe finger holds, E = brass tubing to act as pivot, F = motor-drive unit, G = rotating wheel on motor-drive unit, H = plastic gearing arm, I = wire linking gearing arm to pivot on syringe, J = plastic insert, K = radio-control receiver, and L = sedative.

Can tags give us clues as to what does bother birds?

Photo: colourbox.com

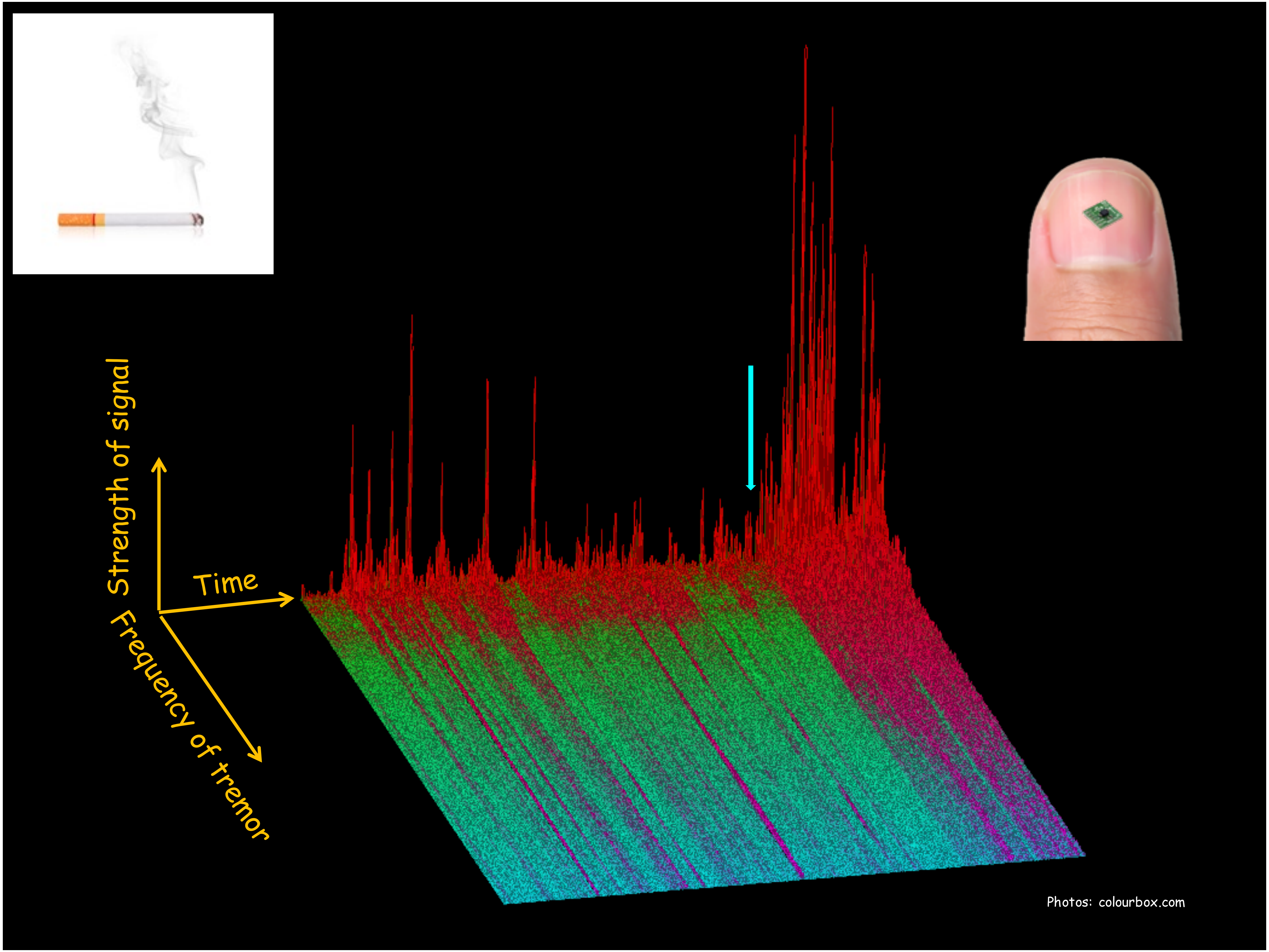
# State secrets (accelerometry)

Because our body moves in tiny ways according to state!

What about stress?

Start with humans – use accelerometers

Accelerometers can record movement in 3D!



Strength of signal
Time
Frequency of tremor
Photos: colourbox.com

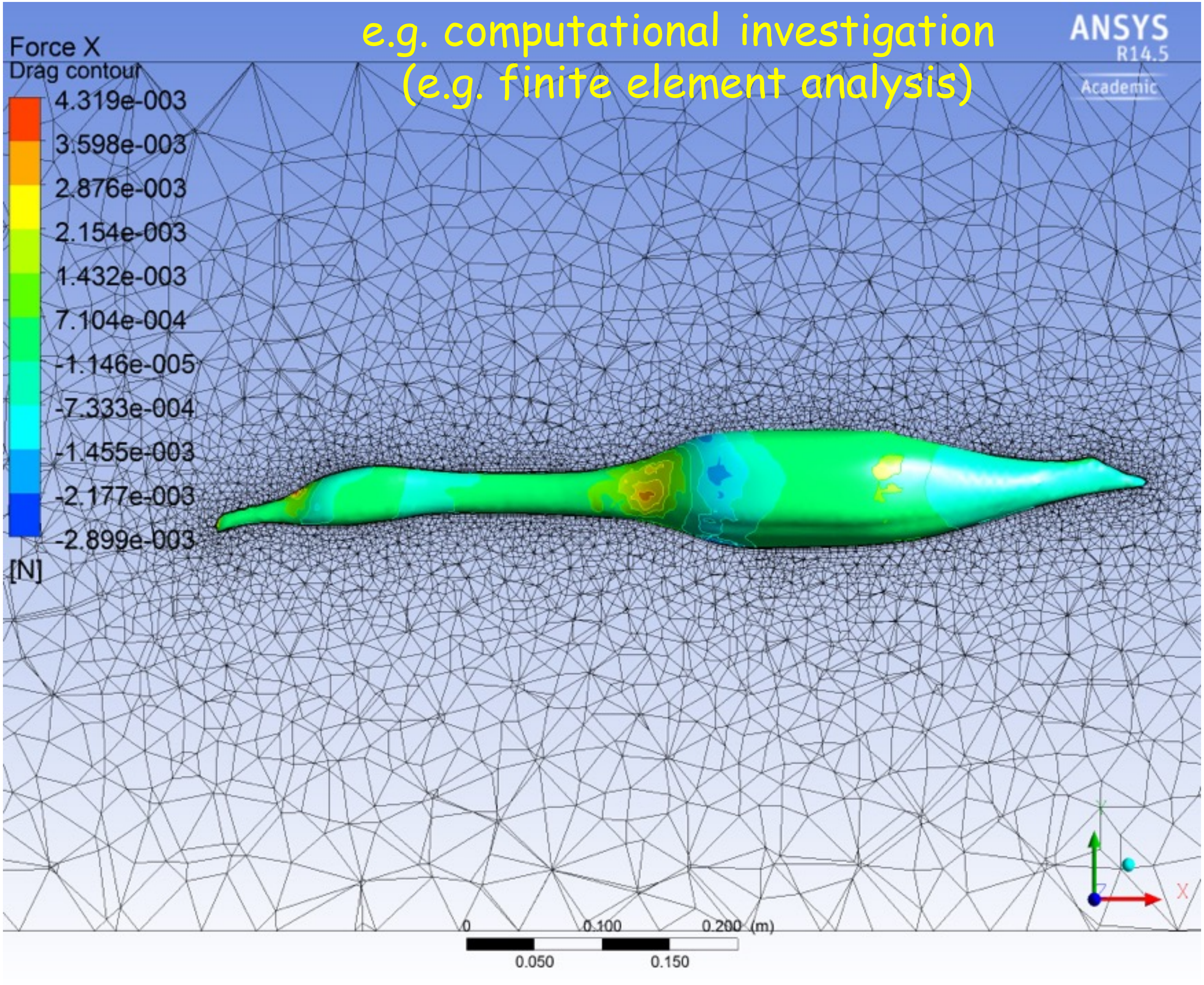
The elephant in the room:

The stress of capture and restraint!

# Time for reflection about our procedures and best practice

But we can use new
technology to help.

Photo: colourbox.com


e.g. computational investigation
(e.g. finite element analysis)
ANSYS
R14.5
Academic
Force X
Drag contour
4.319e-003
3.598e-003
2.876e-003
2.154e-003
1.432e-003
7.104e-004
-1.146e-005
-7.333e-004
-1.455e-003
-2.177e-003
-2.899e-003
[N]
0
0.100
0.200 (m)
0.050
0.150
Y
X

# So, finally

bringing our 'transparent' procedures up to date…. should be easier today than at any time in the past.

**What this means is that birds now have the best chance they ever had of being understood!**

Photo: colourbox.com