Journal of Interdisciplinary Science Topics

How to Train Your Dragon… to Fly?

Edward Reynolds

The Centre for Interdisciplinary Science, University of Leicester
19/03/2015

Abstract

This paper will explore the concept that the Dragons in the motion pictures "*How to Train your Dragon*" and "*How to Train your Dragon 2*" have impractical wing sizes. It does so by estimating a surface area of the wings and then a weight before using an equation for lift for four different types of dragon; the "Terrible Terror", the "Gronkle", the "Night Fury" and the "Red Death". Finally the forward velocity required for each dragon to provide lift is calculated and determined that the dragons would have to move faster than shown in the films to have any lift whatsoever. For instance the least practical breed, the "Gronkle" would need a forward velocity of 299.6 ms^{-1} to achieve lift while the most practical breeds are the Terrible Terror and the Night fury with 36.5 ms^{-1}.

The Dragons

The breeds of dragon from the movie "*How to Train Your Dragon*" are of varying size and shape. These can be anything from the small sized "Terrible Terror" which is just over a foot and a half tall, to the gargantuan "Red Death Dragon" which would tower over a house at almost 100 feet tall [1]. This paper will analyse the flight feasibility of the 4 dragons seen in figure 1.

As can been seen in these images, these dragons vary in wing size-to-body ratio so an educated estimate has been made in each case, using various scenes from movies as a point of reference. These estimates are stated in table 1.

Dragon Breed	Wingspan (m)	Wing Width Average (m)	Wing Surface Area (m^2)
Terrible Terror	1.0	0.3	0.30
Gronkle	1.5	0.5	0.75
Night Fury	15.0	2.5	37.50
Red Death	30.0	20.0	600.00

Table 1 – Showing estimated wingspans (m) and wing surface area (m^2).

- The Terrible Terror:
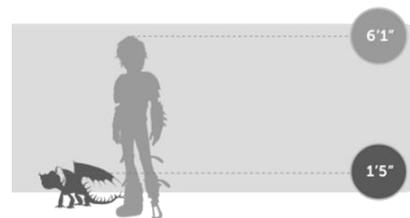
- The Gronkle (Shown compared to a shorter Character)

- The Night Fury
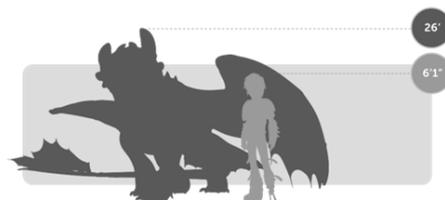
- The Red Death
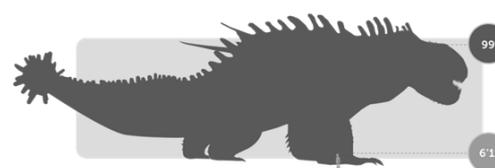
Figure 1 – Showing the four breeds of dragon analysed in this paper [2].

This wing surface does not show the ability to fly or not, so the mass of each dragon was also estimated allowing a weight to force exerted ratio to be calculated. This was done by taking the mass of a similar animal, the Salt Water Crocodile, and estimating the body volume (5 m long and 0.50 m wide) as a cylinder of 3.93 m^3 which gives a density of ~117Kgm^{-3} if the mass of a 5 m Crocodile is 450 kg [3]. This density applied to the Dragons with the volume of each Dragon estimated from the measurements in figure 1 and a cylinder for their body shape gives a mass as follows in table 2:

Dragon Breed	Estimated Volume (m^3)	Estimated Mass (kg)	Weight (N)
Terrible Terror	0.13	14.7	144.2
Gronkle	21.21	2,481.1	24,339.3
Night Fury	15.71	1,837.8	18,029.1
Red Death	2356.19	275,674.8	2,704,369.4

Table 1 – Showing the estimated volumes, masses and weights of each breed of dragon.

Using the results seen in Table 2 and the lift equation from [4]. Seen below for equation 1, a forward movement speed necessary to achieve lift was formulated for each breed of dragon.

$$W = 0.3 \, dV^2 S \quad (1)$$

Equation 1 was rearranged to find forward velocity, *V* (ms^{-1}):

$$V = \sqrt{\frac{W}{0.3 \, dS}} \, , \quad (2)$$

where *d* is air density, taken to be 1.205 kgm^{-3} at 20°C and atmospheric pressure [5], *S* is surface area of the wings (m^2) and *W* is the weight (N) of the dragon.

Table 3 was calculated from Equation 2 for each breed. Table 3 clearly shows that while the "Terrible Terror" and the "Night Fury" fly at more reasonable speeds the "Red Death" has to move very fast to produce lift and the "Gronkle" is not far off breaking the sound barrier (344 ms^{-1}) [6].

Dragon Breed	Wing Surface Area (m^2)	Weight (N)	Velocity (ms^{-1})
Terrible Terror	0.30	144.2	36.5
Gronkle	0.75	24,339.3	299.6
Night Fury	37.50	18,029.1	36.5
Red Death	600.00	2,704,369.4	111.7

Table 2 – Showing the necessary forward velocity to achieve lift for each breed of dragon.

These results do not take the speed of wing beats into account. This can be seen on screen as the "Gronkle" wings are shown as a blur of movement when in flight, similar to that of a humming bird while the other three breeds are seen to flap more slowly with the "Night Fury" gliding a lot of the time as fits its more stealthy hunting style.

The high speeds may be due the use of a Saltwater Crocodile as a basis for mass. These are dense and powerful animals and the dragons could have a more lightweight body structure or hollow bones similar to those of birds to reduce weight. This would reduce the speed needed to provide lift and so may give results closer to the effects seen in the films.

Conclusion
The forward movement speed needed to provide any sort of lift for these dragons are very fast, with the slowest speed still being around 80 mph and the fastest (299.6 ms^{-1}) almost breaking the sound barrier as seen in table 3. There is scope for further exploration into whether the speed of wing beating would provide enough lifting force to let the dragons hover as they do in movie. The "Gronkle" especially is seen to act more like a helicopter than a bird in its vertical motion.

To finish, it seems these dragons could fly if they moved significantly faster than shown in the films.

References

[1] Howtotrainyourdragon.wikia.com (2015) How To Train Your Dragon Wiki. Available: http://howtotrainyourdragon.wikia.com/wiki/How_to_Train_Your_Dragon_Wiki [Accessed 13/03/2015].

[2] DreamWorks (2014) How to Train Your Dragon: Dragonpedia. Available: http://www.howtotrainyourdragon.co.uk/explore/dragons [Accessed 13/03/2015].

[3] Department of Fisheries (2012) Fisheries Fact Sheet: Estuarine Crocodile. Government of Western Australia, Department of Fisheries. Available: http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_estuarine_crocodile.pdf [Accessed 13/03/2015].

[4] Tong, J. & Schwab, J. (2004) The Flight of Birds. From The Engineering of Birds presentations, MIT Open Courseware, Massachusetts Institute of Technology. Available: http://ocw.mit.edu/courses/materials-science-and-engineering/3-a26-freshman-seminar-the-nature-of-engineering-fall-2005/projects/flght_of_brdv2ed.pdf [Accessed 12/03/2015].

[5] Engineering Toolbox (2015) Air Properties. Available: http://www.engineeringtoolbox.com/air-properties-d_156.html [Accessed 13/03/2015].

[6] Nave, R. (n.d.) Speed of Sound in Air, Hyperphysics. Available: http://hyperphysics.phy-astr.gsu.edu/hbase/sound/souspe.html [Accessed 13/03/2015].