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P1 8 Flight of the Rathalos

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Abstract

In this paper we examine the mechanics of flight in *Monster Hunter: World*, and whether a Rathalos would be able to fly as depicted in the game. We calculate that the minimum flapping frequency to maintain a hovering state is 1.81 Hz, and conclude that a Rathalos would be unable to fly as it is portrayed in *Monster Hunter: World* due to its flapping frequency of 1.71 Hz.

Introduction

The *Monster Hunter* series depicts monsters far larger than anything we see in real life; some of these are comparable to dinosaurs, and some grow much larger. In particular, many of the "flying wyverns" present in the game are much larger than any flight-capable animal. The most iconic of these is the "Rathalos" (See Reference [1] for visualisation), boasting a wingspan of 17.0 m[2] and a length of 15.5 m[2]. In *Monster Hunter*, animals such as the Rathalos are illustrated with adept flying capabilities, a fact which we will examine in this paper.

Method

In order to calculate the overall lift of a Rathalos to determine if its flight is sustainable, we need to calculate the lift force[3],

$$F_L = \frac{1}{2} C_L \rho_{air} v_{air}^2 S \tag{1}$$

where lift coefficient, C_L, is 4.75[4], density of air, ρ_{air}, is 1.29 kg m^{-3} [5], surface area, S, is 29.5 m^2, calculated by measuring wing size in-game, and v_{air} is the velocity of air moving across the wing, which we derived in Equation 2.

$$v_{air} = 2Af_{flap} \tag{2}$$

The amplitude of the flap, A, is 14.2 m, which we measured in-game, is defined as the complete distance the wing tip travels through a full wingbeat, and f_{flap} is the flapping frequency.

By looking at resultant forces we can derive an equation for the upwards acceleration, a_{flap} of a Rathalos during a downwards wingbeat;

$$m_{Rath} a_{flap} = F_L - m_{Rath} g \tag{3}$$

where g is 9.81 ms^{-2} is acceleration due to gravity and m_{Rath} is the mass of the Rathalos.

As no real life animal can be easily likened to the body proportions of a Rathalos, we have substituted its form with an approximation of a Komodo dragon with additional bat wings. This approximation is chosen due to Rathalos' dragon-like appearance and its bat-like wings. To calculate m_{Rath} we use the relationship

$$mass \propto volume \propto length^3 \tag{4}$$

and use statistics for an average Komodo dragon: the mass, m, is 85.0 kg[6] and the length, l,

is 2.59 m[6], and add the mass of the wings. These will be 15% of the final mass, assuming bat proportions[7]. Scaling these up results in a final mass $m_{Rath} = 21,400$ kg.

In order for flight to be achieved, the Rathalos must average a vertical velocity of at least 0 ms^{-1}. We therefore create a cycle, where the Rathalos accelerates upwards with a constant acceleration, a, is a_{flap} during the phase in which its wings beat downwards, and it accelerates downwards with a constant acceleration $a = g = -9.81$ ms^{-2} while it falls as its wings return upwards. The final velocity of each phase is equal to the initial velocity of the following phase, so we can form simultaneous equations as follows:

$$v_{flap} = v_{fall} + a_{flap}t_{flap} \tag{5}$$

$$v_{fall} = v_{flap} + gt_{fall} \tag{6}$$

These can be rearranged to form an equation to determine the minimum value of a_{flap}:

$$a_{flap} = -g\frac{t_{fall}}{t_{flap}} \tag{7}$$

and by substituting in Equations 1 and 2 and accounting for both wings we arrive at a relationship between a_{flap} and f_{flap},

$$a_{flap} = \frac{4C_L\rho_{air}A^2S}{m}f_{flap}^2 - g \tag{8}$$

Results

To demonstrate the comparison between a_{flap} and f_{flap} we plotted Figure 1 below:

For the minimum of a_{flap} we measured the in-game ratio of t_{fall} to t_{flap} from Equation 7 to be approximately equal to 1.29, this gives a minimum value of

$$a_{flap} = -gt_{ratio} = 12.6ms^{-2} \tag{9}$$

To compare, we timed the period of a single Rathalos wing flap as depicted in *Monster Hunter: World* to calculate a frequency,f_{flap}, of 1.71 Hz, giving Rathalos a value for a_{flap}, of 10.3 ms^{-2}, not large enough to maintain flight while hovering.

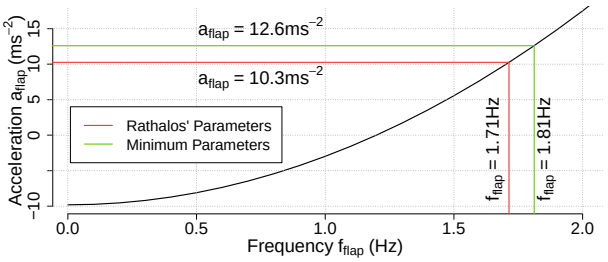

Figure 1: Relationship between flapping frequency and flapping acceleration. A minimum of acceleration of 12.6 ms^{-2} means a Rathalos would be unable to fly.

Conclusion

We can conclude from our calculation and from Figure 1 that a Rathalos would not hover if it flapped its wings as portrayed in *Monster Hunter: World*. However, we have also proven that the discrepancy is small enough that it is believable that a Rathalos could flap at the required frequency.

References

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