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S3_3 The Shadow of Balerion the Dread

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Abstract

We investigated a legend within Game of Thrones which suggested that there was once a dragon large enough to cast a shadow over entire towns as it flew overhead. For casting a shadow over Leicester, we would need a wingspan of 29.7 km. For Manchester, the wingspan would be approximately 37.2 km. For Birmingham, the wingspan would be 56.7 km and for London, the wingspan would need to be 137 km.

Introduction

According to Game of Thrones legends, it is said that the biggest dragon to ever live, Balerion the Dread, had a wingspan so huge he would cast a shadow over entire towns as he flew overhead. We calculated what Balerion's wingspan would have to be to cast a shadow over different cities in England: Manchester, Birmingham, London and Leicester. We assumed the shape of the cities to be circular and that Balerion would fly at 10 km directly over the cities.

Theory

Initially, we calculated the solid angle from the Sun to work out how much sunlight would reach a city without any obstacles. We used the following equation:

$$\Omega = \frac{A}{r^2} \tag{1}$$

Where Ω is the solid angle from the Sun, A is the area of the city, which is equal to πR^2 as we are assuming the city is circular, and r is the distance from the Sun to the Earth at 146 million km [1]. The solid angle is calculated using (1). As solid angle remains constant regardless of distance from the Earth, we calculated the required wingspan of the dragon by taking our original value of solid angle, and the dragon's altitude at 10 km, we rearranged (1) replacing A with A_D to find the area of the entire dragon.

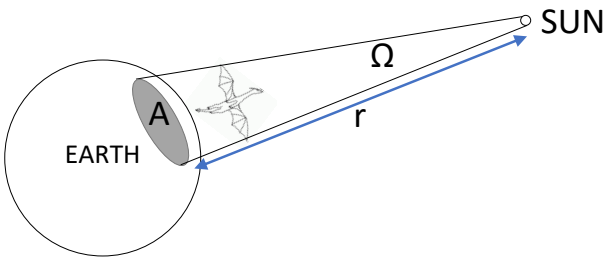

Figure 1: The schematic diagram above shows how a dragon's wingspan would create a shadow over a city of area A, Ω is the solid angle coming from the Sun, and r is the distance between the Sun and Earth.

We treated the area of the dragon's body as negligible as most of its area would be its wings. The wing shape of the dragon is estimated to be a rectangle split in half diagonally with one side of the rectangle being three times the length of the other. The area of the dragon is set as $A_D = 3x^2$. We rearrange for x and multiply by

6 to get $6x$ which is the wingspan of Balerion.

Table 1: Table showing area of cities with corresponding wingspans of Balerion [2] [3] [4] [5]

City	City Area(km^2)	Wingspan(km)
Leicester	73.32	29.7
Manchester	115.6	37.2
Birmingham	268.0	56.7
London	1572	137

We plotted the data shown in Table 1 to visually represent the relationship between the area of the cities we have chosen for the purpose of this paper, and the estimated wingspan that Balerion would need to have to block out the Sun.

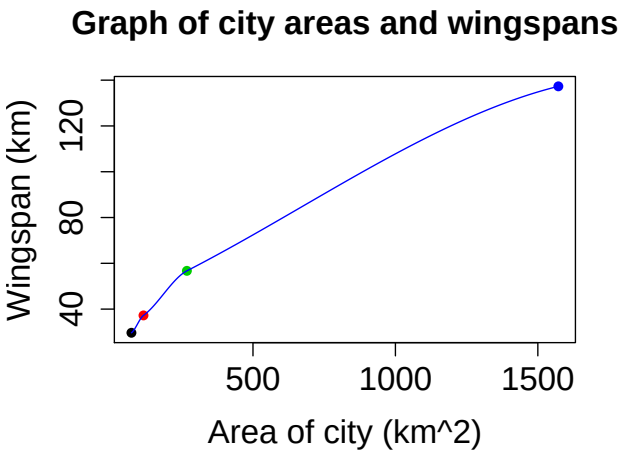

Figure 2: This graph shows the relationship between the area of the cities and the wingspan of Balerion. The black data point is Leicester, the red data point is Manchester, the green data point is Birmingham and the blue data point is London.

Results and Discussion

When calculating the area of Balerion, we found that the area of the city and the area of the dragon were almost identical. This means that for a city to be cast into shadow by Balerion, he would have to be almost the same size as the city he would fly over. This is a result of the solid angle of the Sun. The distance that the dragon is flying overhead at 10 km is minuscule compared to the distance between the Sun and Earth. Therefore, in order to block out all the light coming from the Sun, Balerion would need to be nearly as big as the city he flew over. The graph shows a positive correlation between the area of a city and the wingspan that Balerion as we expected. One point of interest that the graph shows is that the smaller area the city, the larger the wingspan in relation to the city. For Leicester, which is the smallest city measured in this paper, the gradient is 0.405, however for London, the largest city, the gradient is 0.0874.

Conclusion

To conclude, we found that for Balerion to cast shadows on cities, he would have to be roughly the same area as the city he was flying over. For casting a shadow over Leicester, we estimate that Balerion would need a wingspan of 29.7 km. For Manchester, the wingspan would be approximately 37.2 km. For Birmingham, the wingspan would be 56.7 km and for London, the wingspan would need to be 137 km. We also found that the smaller city would have a higher ratio of the area of the city to wingspan in comparison to larger cities.

References

[1] `https://www.space.com/17081-how-far-is-earth-from-the-sun.html` [Accessed 24 Oct. 2017]

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[3] `https://www.britannica.com/place/Manchester-England` [Accessed 24 Oct. 2017]

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[5] `https://web.archive.org/web/20080124102915/http://www.gos.gov.uk/gol/factgol/London/?a=42496` [Accessed 24 Oct. 2017]