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P2_4 Thinking Bee

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Abstract

In this paper, we calculate the number of bees needed to carry a powerless plane from cruising altitude to the airport after a technical fault as seen in the film Bee Movie. We also find the number of bees needed on the airport tarmac showing the pilot where to land. These values were found to be 5.3×10^9 bees and 17×10^6 bees respectively.

Introduction

In the cult classic Bee Movie, flowers are transported via plane to re-pollinate the Earth. During this scene, the plane is struck by lightning and the plane's engines malfunction. At this point, a colony of bees carry the powerless plane to the airport, where the plane is then directed to a landing site that is highlighted by a group of bees gathering into a flower-shaped pattern on the ground. We have calculated the number of bees needed to carry the plane, and the number of bees needed to make a visible pattern on the ground for a plane at cruising altitude to see.

Theory and Results

To find the number of bees needed to carry the powerless plane from cruising altitude, we first had to find the carrying-capacity of the average honeybee drone. The average drone, when collecting pollen from flowers, can carry approximately 15 mg of pollen in their pollen baskets [1]; we therefore assume this value to be the maximum mass a bee can carry. We then found the average Boeing 737's maximum mass (including the passengers, luggage, fuel and the plane itself) to be $80,000$ kg [2]. By dividing the mass of the plane by the mass a bee can carry, we found that 5.3×10^9 bees are needed to carry the mass of the plane. By regarding angular resolution, we could find the minimum size that the pattern of bees would need to make in order for the pilot to see it from cruising altitude. Therefore Equation 1 is given as;

$$\frac{a}{1rad(arcsecs)} = \frac{d}{D} \tag{1}$$

, where a is the angular size in arcseconds, d is the bee-pattern diameter and D is the distance from the plane to the bees. The angular size a used in this equation is $a = 60$ arcseconds, as the minimum angular resolution a person with 20/20 vision can see is 1 arcminute [3]. To find the distance from the plane to the bees, D, trigonometry had to be used; this scenario is shown in Figure 1.

First, the horizontal distance s, between the plane and the bees had to be found. We assume it takes 3 nautical miles (5.6 km) in horizontal distance for the plane to descend 1000 ft [4]. Using the average cruising altitude of a Boeing 737 as $h = 9100$ m $(30,000$ ft) [5], it takes a horizontal distance of $s = 170$ km for the plane to

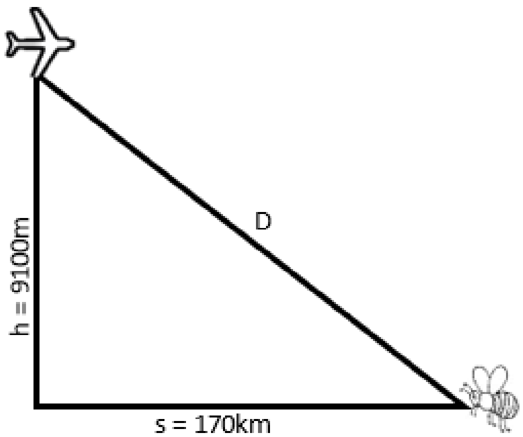

Figure 1: The distance D between the plane and the bee pattern formed on the ground, where h is the cruising altitude and s is the horizontal distance between the two.

land once landing procedures have commenced. Using this value alongside the plane's cruising altitude, we can find the distance from the plane to the bees to be $D = 170$ km through trigonometry. Inputting these values into Equation 1 finds a pattern diameter of $d = 49$ m, which equates to an area of 1900 m^2 if we assume the flower-pattern to be a circle. In order to find the number of bees within this pattern area, we had to find the area of one bee. This was found using the average drone length of 15 mm [6]. We assumed the width of the bee would be approximately half of the length, and therefore found an area of a bee as 1.1×10^{-4} m^2 (assuming a rectangular area). Dividing the area of the pattern by the area of one bee, we find the number of bees within the pattern area to be 16888888 bees, approximately 17×10^6 bees.

Discussion

In this paper, assumptions have been made regarding the planes mass and cruising altitude. The plane was assumed to be a Boeing 737 as this is the most common type of plane in commercial use [7], and therefore assumed to be the plane model in the film. An approximation of 15 mm was used as the bee's length; this length is for a honeybee drone, of which the vast majority of a hive are. Further consideration into air resistance could be done, however we have assumed that the forward thrust created by the bees would overcome this resistance. A further investigation may wish to find the forward thrust needed to overcome this air resistance. We have assumed the pilot to have 20/20 vision as this is a usually a requirement for commercial airline pilots [8], and for flying conditions to be clear for the pilot to see the landing site.

Conclusion

In order for a powerless plane to land safely from cruising altitude, 5.3×10^9 bees would be needed to carry the plane to the ground in a regular descent, while a minimum of 17×10^6 bees would be needed to highlight the area on the airport tarmac for the pilot to land the plane.

References

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