# 2024年【科學探究競賽-這樣教我就懂】

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題目名稱：**The Quest of Finding the "Golden Ratio" for Seeds**

一、摘要


This paper investigates the phenomenon of wind dispersal using innovative paper seeds as a model system. The main idea revolves around understanding the intricate interplay between wind patterns and seed dispersal dynamics. The purpose of the study is to gain insights into the factors influencing seed dispersal distances and directions in order to contribute valuable information for ecological and agricultural applications.

The procedure involves the design and fabrication of paper seeds with characteristics mimicking natural seeds. These paper seeds are then subjected to controlled wind conditions in a specially designed wind tunnel. By observing the trajectories and distances covered by the paper seeds under varying wind speeds, the study aims to unravel the underlying principles governing wind dispersal.

Results indicate a clear correlation between wind speed and the dispersal distance of paper seeds. Additionally, the study reveals the influence of seed morphology on dispersal patterns, shedding light on how natural seeds may adapt to maximize their dispersal potential. The discussion delves into the broader ecological implications of the findings, emphasizing the importance of considering wind dynamics in understanding plant population dynamics and colonization patterns.

In conclusion, this paper highlights the efficacy of paper seeds as a model for studying wind dispersal, providing a cost-effective and scalable approach for investigating seed dispersal mechanisms. The insights gained from this study contribute to the broader understanding of ecological processes and offer practical applications for optimizing seed dispersal strategies in agriculture and environmental conservation.


二、探究題目與動機

**(2.1 The Background of Seed Dispersal)**

The following will be an introduction to seed dispersal. Firstly, what is seed dispersal? Seed dispersal is an essential process for the survival and propagation of plant species. The fundamental point of such a process is to move seeds away from their parent plant to new locations, allowing them to colonize a new area and establish another plantation family. Seed dispersal involves many different variations, including the following:

1. Animal Dispersal - Occurs when plants rely on animals to transport their seeds. This may happen through ingestion and subsequent defecation or most often seeds clinging to an animal's body. In

order to cling to an animal to bind themselves to the animal's fur, the plants might grow "Insect guides", and hooks, or have sticky surfaces.

2. Water dispersal - A method where water is used to carry seeds to new places. Seeds that can float or survive in water are carried by currents to different places. Generally, the seeds made for water dispersal have low density, have a big body, and are very light.
3. Explosion Dispersal -A method by which plants disperse their seeds using explosive mechanisms. These plants have structures that store energy, which is rapidly released, shooting the seeds away from the parent plant. When the seed pods or fruit of these plants reach adulthood, they go through a sudden process forcing them to "split open", causing the stored energy to be released. This energy creates an explosive effect that launches the seeds into the surrounding environment.
4. Wind dispersal - A method used which involves producing lightweight structures like wings or hairs that catch the wind and carry them over long distances. It's an effective but unpredictable strategy that relies on wind patterns and environmental conditions.

**(2.2 The Pros and Cons of WIND Dispersal + The Importance of Design)**

The method of seed dispersal this experiment will focus on is "wind dispersal". This method of wind dispersal generally requires two main components to be able to succeed.
There are both merits and drawbacks associated with wind dispersal.

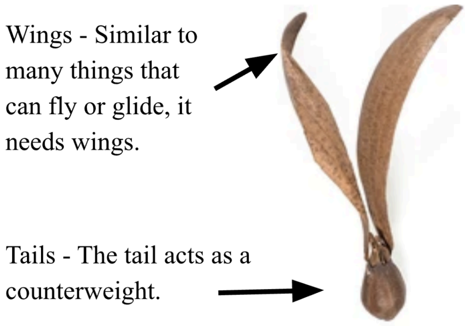


Fig 1. Helicopter Design

**Merits:**

- Wide dispersal range: Wind dispersal allows seeds to be carried over long distances, aiding in the colonization of new habitats along with reducing competition with the parent plants.
- A vast range of distribution: Wind dispersal enables seeds to be scattered in various directions (because wind can go from all directions), which leads to a broader distribution of the plant species.
- Energy / Cost-effective: This method does not require any extra amounts of energy from the parent plant, as the wind by itself can do the work of dispersing the seeds.

**Drawbacks:**

- Unpredictability: Since we are unable to control nor stabilize wind patterns, it allows wind dispersal to create unexpected seed distribution, resulting in a lack of control over where the seeds land.
- High seed wastage: Wind-dispersed seeds frequently miss the ideal germination locations,

resulting in the waste of resources for the parent plant.

- Limited possibility for colonization: Wind dispersal is less efficient in heavily wooded areas, densely vegetated regions, or habitats with obstacles, which restricts the capacity of plants to colonize such ecosystems.

**(2.3 Reasoning and Motivation)**

Recognizing the advantages of wind dispersal, we can use these findings to simulate wind dispersal using folded paper seeds to examine the mechanism behind it. Our ultimate goal is to comprehend the ideal setup for obtaining the longest flight time using wind dispersion. As a model for naturally scattered seeds by the wind, the paper will be folded into seed-like forms for this experiment. We will then measure and compare the flight time of these paper seeds in a controlled setting. Just like any flying machine the design has to be delicate, the material, size, height etc. all play an important role. This experiment will be focusing on "ratio", ratio is one of the most important factors in everything: paints, architecture, and machines all have to consider ratio when making them. Leaving us left with this question.

三、探究目的與假設

**(3.1 Question)**

"What is the best ratio of the seed? (comparing the wings to the tail)"

**(3.2 Hypothesis)**

With some background knowledge of seeds, based on observations found in nature, the hypothesis that emerged is that a ratio where the wings are slightly longer than the tail would be the most optimal. This is because many natural seeds have wings that are slightly larger than the tail, suggesting that such a design would be ideal.

四、探究方法與驗證步驟

**(4.1 Procedure of The Experiment)**

1. Find many papers
2. Fold and cut them creating 5 paper stripes that are identically 4x26cm papers (due to the original length of the paper being 26cm)
3. Fold the paper strips vertically in half creating two 2x26cm papers
4. Cut the 5 papers into 6 : X papers (keeping the wings length the same while changing the length of the tail creating these ratios: 1 : 3 , 1 : 2 , 1 : 1 , 1 : 0.5 , 1 : 0.25)

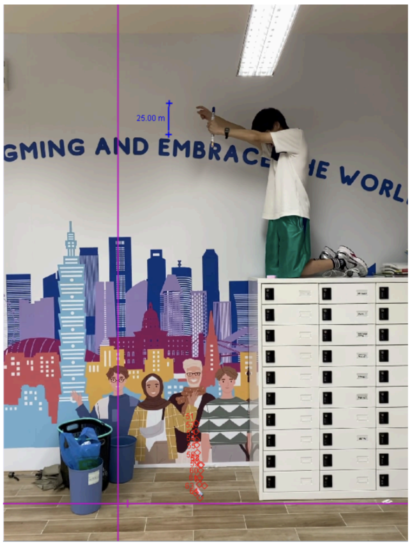

Fig 2. Dropping the Seed

5. Then we take each seed then tape the bottom (each having 4 rounds)
6. Move to a set location (the school gym in this case) then drop the seeds from a high elevation one by one (7 times in order to get a precise average)

**(4.2 Paper Seed's "Blueprint")**

The seeds were inspired by numerous "helicopter winged leaves", the name is self-explanatory, 'helicopter' describes the motion of the wings while airborne, and 'winged leaves' are leaves in the shape of wings.

**(4.3 Result of The Experiment)**

This image shows the process of using "Tracker" to process the velocity. I went to the top of the lockers in 114's classroom to drop the paper seed. 2 Markers were used as a distance scale.
This graph shows how a seed's velocity changes as it moves from the top of the locker to the bottom. (Please be aware that the velocity initially began at about -2 owing to software difficulties, needing to inverse the graph.)

We can identify the following phases after analyzing the graph:

- 0 - 0.3 seconds: During this time, also referred to as the "free-fall" phase, the seed descends quickly and with a lot of speed on its own.
- 0.3 - 0.8 seconds: This period symbolizes the "slow-motion" phase of the fall, during which the seed notably slows down in comparison to the "Free-fall" phase that came before it.
- 0.8 - 1.35 seconds: Known as the "Slow Flight" phase, this portion shows a minor decrease in velocity, taking a brief amount of time to further slow down.
- 1.35 - 1.75 seconds: Designated as the "Terminal Velocity" phase, the seed maintains a relatively constant velocity for a short duration.
- 1.75 - 2+ seconds: This final segment of the descent is known as the "landing" phase, where the seed gradually reduces its velocity until it reaches the ground.

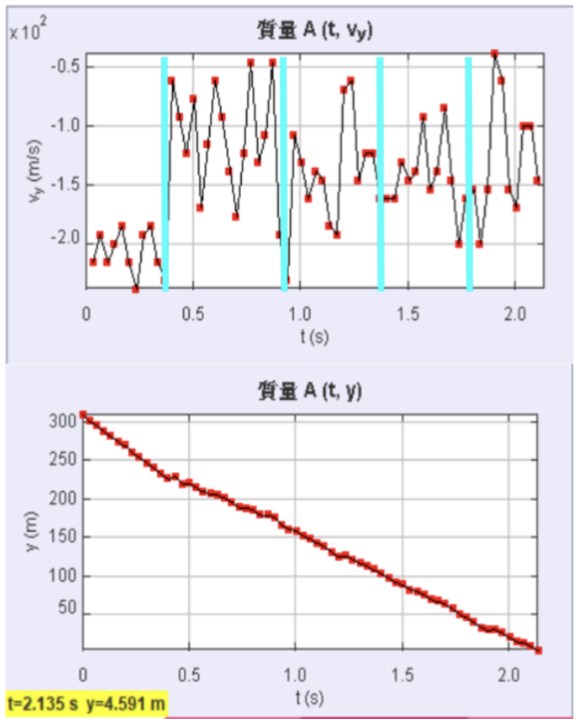

Fig 3. Graphing of Seed's Velocity and Distance

**(4.4 Discussion)**

Based on the results, it is shown that the ratio "1: 0.5" is the most successful. In general, smaller ratios cause the seeds' flight times to be longer. On the other hand, larger ratios result in a faster fall of the seed with a longer flight time.

The impact of gravity is one of the main factors. Larger seeds typically have a higher mass, which causes them to be pulled toward the ground by gravity more strongly. They descend more quickly as a result of the stronger gravitational force.

In addition, the surface area of larger seeds tends to be larger, which may result in greater air resistance as they fall through the air. However, the larger mass of the seed typically outweighs this increased air resistance, producing a net effect of a faster descent.

Understanding that the seed ratio mustn't be too large, it shouldn't be too small either. Though it is clear that smaller ratios typically cause the seeds' flight times to be longer, the ratio of 1:0.5 still outperforms the ratio of 1:0.25. It is important to remember that ratios that are too small should be avoided. For example, a ratio of 1:0.25 produces a large disparity in seed size which causes the seeds to be unable to balance correctly, then dropping at an unfavorable rate. Finding a good ratio that increases flight time while avoiding extreme smallness is therefore essential.

All of the seeds were also dropped from the same location and height to show the stability of the data. To maintain consistency in the experimental setup, care was taken to reduce any time variations between the drops. By regulating these variables, we can increase the accuracy of the findings and attribute any observed variations in flight times to the properties of the seeds themselves rather than to uncontrollable outside forces.

During the experimentation, an intriguing finding regarding the effect of paper softness on seed flight time was made. The experiment was repeated twice, and during the first drop there was a sudden rain which increased the moisture and caused the paper to become softer. A softer paper caused the seed to lose some of its structure and become floppy. This result emphasizes how important paper softness is in influencing seed flight time. It suggests that seeds should be kept at a particular hardness for consistency. The findings emphasize the significance of taking environmental factors into account and making sure that experimental conditions match the desired traits of the seeds to obtain accurate and trustworthy data.

五、結論與生活應用

**(5.1 Conclusion)**

At the end of our experimentation and subsequent analysis, we are able to deduce that the hypothesis has proven to be correct. The ratio of 1:0.5 is the most effective for extending flight times. This result suggests that it is advantageous to have wings that are just a little longer than the tail. The wing should not however, be disproportionately larger than the tail, as this can have negative effects and shorten travel distances.

**(5.2 Three Significant Ideas)**

1. The importance of ratio: To extend flight time, it's essential to consider the wing-to-tail length ratio. The performance of seed dispersal is enhanced by maintaining a small length difference between the wing and the tail.
2. The key is balance: It's critical to strike the ideal balance between the lengths of the wing and tail. While a small amount of asymmetry is advantageous, extreme differences can have unfavorable effects and hinder the seed's overall ability to fly.
3. Environmental Components that Affect Seed Flight Time: The experiment demonstrated how the environment affects the seed flight time. The aerodynamic characteristics of seeds and their flight performance are impacted by factors like paper softness (which could be influenced by moisture from rainfall.) Optimizing seed dispersal strategies requires an understanding of such dynamic interaction.

**(5.3 Further research suggestions)**

- Figure out what material works best to make paper seeds with.
- Examine the effects of different wing structures on seed flight performance.
- Change the seed density to see the influence it has on dispersal patterns.

**(5.4 Summary of The Experiment)**

In summary, according to the investigation, a ratio with somewhat longer wings than tails produces the best results. However, it's crucial to achieve a balance since ratios that are too high will shorten flying times. The experiment also demonstrated the importance of environmental conditions on seed flight time, such as paper softness impacted by rainfall. It stresses the necessity of carefully monitored experimental settings and the interaction between seed properties and the surrounding environment.

參考資料

Howe, H. F., & Smallwood, J. (1982, November). *Ecology of Seed Dispersal*. University of Iowa. https://www.researchgate.net/publication/234150438_Ecology_of_Seed_Dispersal