

Fibonacci numbers in sunflowers

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PAPER:

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Novel Fibonacci and non-Fibonacci structure in the sunflower: results of a citizen science experiment, Swinton et al. *R. Soc. Open Sci.* 3, 160091 (2016)



Leonardo Pisano (1170-1242)

Sunflower (Helianthus)

Aloe polyphilla

• Fibonacci numbers:

 $F_0=0, F_1=1$ (by definition) $F_n = F_{n-1} + F_{n-2}$ for n>1 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ...

• Lucas numbers:

 $L_0=2, L_1=1$ (by definition) $L_n=L_{n-1}+L_{n-2}$ for n>1 2, 1, 3, 4, 7, 11, 18, 29, 47, 76, 123, 199, ...

• Lucas - Fibonacci relationship:

$$L_n = F_{n-1} + F_{n+1}$$
 e.g.: n=5, $L_5 = F_4 + F_6$
7 = 2 + 5



François Édouard Anatole Lucas (1842-1891)

Turing's Sunflowers CS Project

- Citizens are invited to grow their own sunflowers
- A guide to counting was provided
- Participants submitted a photo and/or parastichy counts
- Experiment consisted of four phases: 1) get planting, 2) keep growing,
 3) measure and count, and 4) see the results
- Data provided would be pooled and made public
- Data submitted were reviewed by the project leaders (professional scientists)
- 745 parastichy counts, 479 in agreement and 266 in disagreement with the scientists

Fibonacci pair structure (89,55)



Clockwise (89) Anticlockwise (55)

Double Fibonacci structure (68,42)



Clockwise (68) Anticlockwise (42)

Lucas pair structure (76,47)



Clockwise (76) Anticlockwise (47)



Main results

- Fibonacci structures are commonly found in the patterns in the seedheads of sunflowers: Fibonacci pairs (F_n/F_n) represent the 66.6% of all the observations
- Evidence that Fibonacci structures do not appear in all sunflowers – deviations are often observed
- Departure from rotational symmetry
- Clockwise/anticlockwise asymmetry
- Disordered regions prevent a correct assignment of the parastichy number

Figure Credits

- Figure 1: https://it.wikipedia.org/wiki/Leonardo_Fibonacci#/media/File:Fibonacci2.jpg
- Figure 2: https://en.wikipedia.org/wiki/Helianthus#/media/File:Helianthus_whorl.jpg
- Figure 3: https://en.wikipedia.org/wiki/Phyllotaxis#/media/File:Aloe_polyphylla_1.jpg
- Figure 4:

https://en.wikipedia.org/wiki/Édouard_Lucas#/media/File:Elucas_1.png

• Figures 5-12:

Swinton J, Ochu E, The MSI Turing's Sunflower Consortium. 2016 Novel Fibonacci and non-Fibonacci structure in the sunflower: results of a citizen science experiment. R. Soc. open sci.3: 160091. http://dx.doi.org/10.1098/rsos.160091