



Mountain landscape UV light as perceived by insects. Somiedo Pass, Asturias, Spain.  
Courtesy of the author O. Aguado.



Article

# *Who Controls Whom? Part II*

Manuel Quirós and Oscar  
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According to the European Environment Agency, Spain has one of the highest biodiversity indices in Europe, with more than 5,200 pollinator species pollinating the approximately 7,100 flowering plant species found on the Iberian Peninsula. Of the 2,000 species of solitary and wild bees found in Europe, Spain is home to 1,180 species (60%). Pollinators are fundamental to the maintenance and resilience of terrestrial ecosystems, with an economic contribution in Europe around €15 billion annually, primarily in the agricultural sector. One in three bites of what we eat is due to pollinators. Based on frequency of visiting flowers, their tendency to actively collect pollen, as well as the likelihood of successfully depositing pollen on stigma, solitary and wild bees appear to be the most effective at over 70%, compared to 35% for the better-known bumblebees and honeybees<sup>1</sup>.

Co-evolution drives the diversity of both plants and pollinators. Pollinators gain access to food from plants in the form of nectar along with protein-rich pollen. In turn, pollinators transfer the pollen to other plants. Plant species can improve pollination efficiency by attracting specific pollinators using advertising (colours, scents), rewards (nectar, nutrient rich pollen), and timing (when flowers open). Some plants also restrict access to the rewards. Darwin

predicted the existence of a hawkmoth with a 35cm long proboscis based on the long ‘spur’ of the white orchid *Angraecum sesquipedale*. The giant hawkmoth was only discovered 41 years later.

Pollinators are under evolutionary pressure to adapt and maintain access to important food sources. They also benefit from reduced competition by specialization. The interplay of these two evolutionary pressures results in multiple diverse plant/pollinator niches. But over-specialization brings risks. Falling pollinator populations may disrupt the pollination of the related plants. If the plant population collapses, pollinators dependent on the plants for food are at risk.

As discussed in Part 1 of this article ([https://zqjournal.org/pdfs/ZQ\\_issue\\_38.pdf#page=36](https://zqjournal.org/pdfs/ZQ_issue_38.pdf#page=36)), flower colour plays an important role in pollination success. Numerous plant families visited by insects have incorporated spots or lines called “honey marks” on their corollas oriented toward the

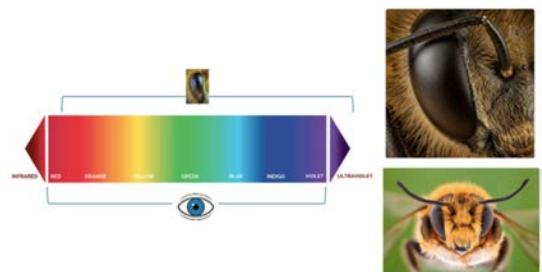
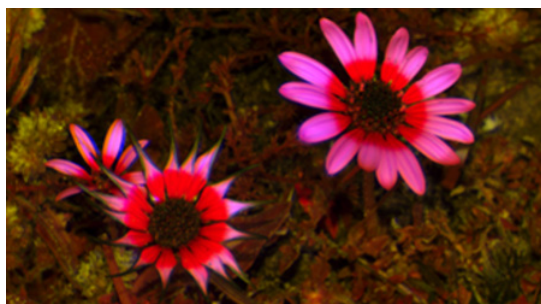


Figure 1: Spectrum of vision between humans and bees. Close-up view of solitary bee eyes.

<sup>1</sup> <https://nora.nerc.ac.uk/id/eprint/500510/1/No500510PP.pdf>

center of the flower that direct the pollinating insects toward the nectar. Human eyes can visualize colours from red to violet, but many pollinators including bees and butterflies have UV photoreceptors that extend their colour range (Figure 1).

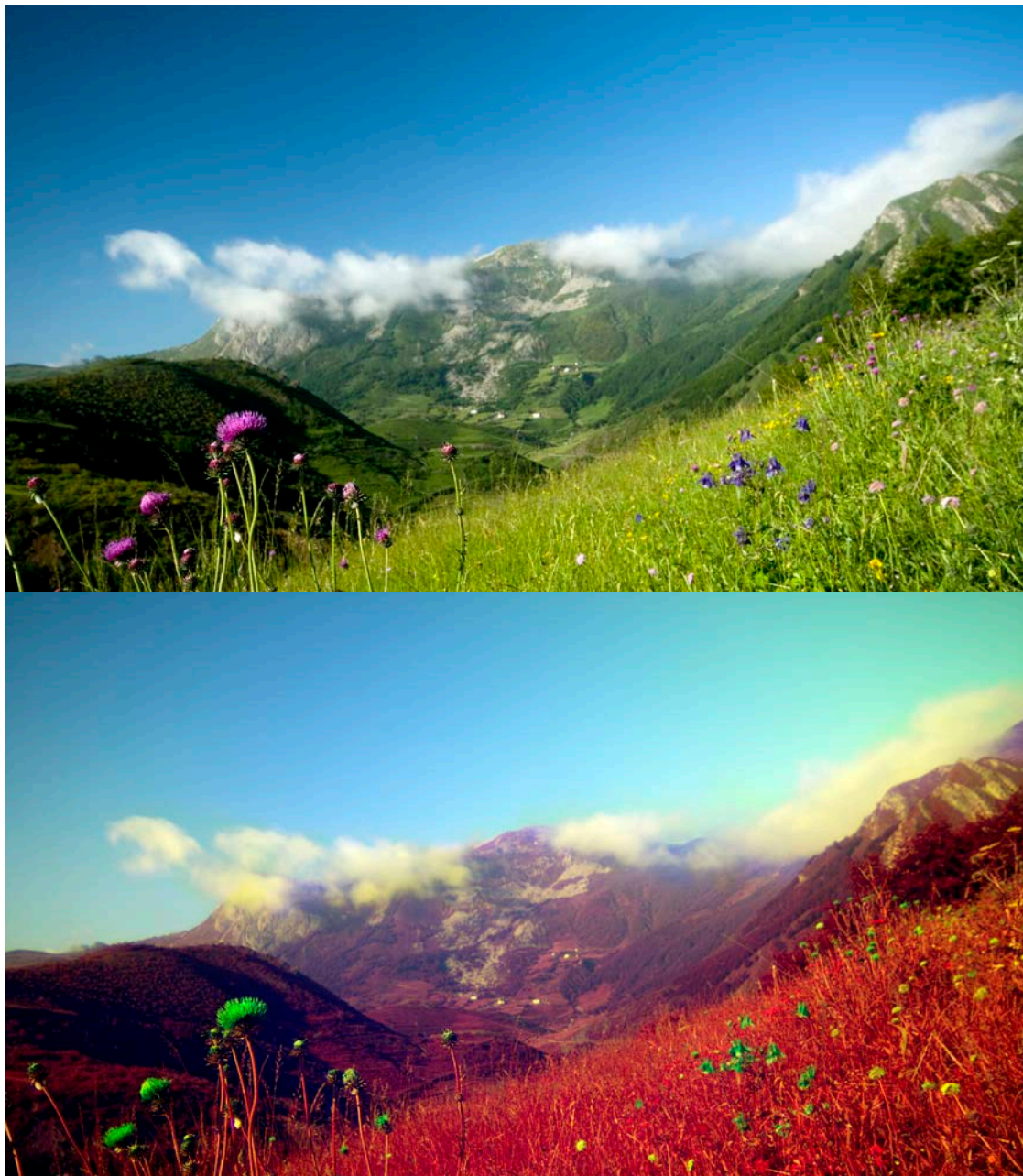
Some flowers have honey marks that are only visible in UV light. Images 1 and 2 show examples from different plant families, each accompanied by two photographs: as we humans perceive them (on the left) compared to how we believe they look to bees (on the right).



Images 1: Flower recognition: Top left: poppies (genus *Papaver*) as seen by humans; right: as perceived by pollinating insects. Center: flowers of *Arctotheca calendula*, which under ultraviolet light display honeycombs to encourage visits by pollinators. Below left: flowers of *Anagallis arvensis* or scarlet/red pimpernel, as perceived by bees; its turquoise-blue petals contrast sharply with the red pollen stains and a green central area that indicate where they should go to obtain nectar. Photos by L. O. Aguado.

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Images 2: Mountain landscape as seen by humans (above) and UV light as perceived by insects. Somiedo Pass, Asturias, Spain.  
Courtesy of the author O. Aguado.

Flower colour can also convey additional information to pollinating insects. In some legumes, such as *Lotus corniculatus* (the common bird's-foot trefoil), yellow predominates when flowers emerge, but they turn orange when pollinated, signaling insects to stop visiting. This discrimination between different colours is not only due to greater informational visibility, but also due to learned associations: certain bumblebees can learn to recognize certain colours or markings, providing them with information about beneficial rewards.

Colours in plants, like animals, depend on how they reflect different frequencies of

light. The most common method is through pigments that absorb certain frequencies of light while reflecting the rest. Chlorophyll absorbs violet-blue through orange-red light strongly, but not green light. Although more commonly seen in butterflies, beetles, and birds, some plants can produce structural colours through a nanostructured surface that enhances certain frequencies of light through constructive interference, while reducing others through destructive interference (Figure 2). Examples are hibiscus plants that display an oily iridescence and the iridescent petals of the tulip cultivar “Queen of the night”.

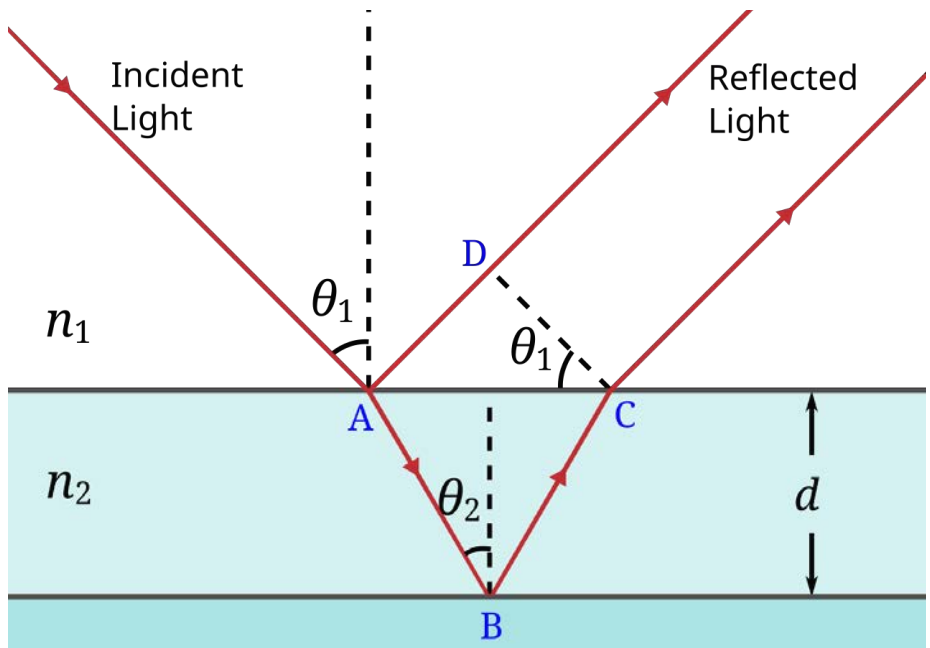


Figure 2: Depending on the angle, light rays bouncing off the upper and lower surface of a thin film travel different distances, resulting in wave interference. ([https://en.wikipedia.org/wiki/File:Thin\\_film\\_interference.svg](https://en.wikipedia.org/wiki/File:Thin_film_interference.svg))

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Buttercup petals (Figure 3) combine starch pigments that strongly reflect yellow, an air layer, and a highly reflective outer thin film that makes the petals glossy while also filtering the backscatter from the starch layer<sup>2</sup>.

Some pollinators are adapted to seeing movement, even while flying at speeds of 25-30 km/h. Plants have been able to take advantage of this ability by growing small or medium-sized flowers on long, slender stems which sway in the wind, standing out from their surroundings. Many bumblebees, honeybees, and butterflies associate the

swaying of flowering plants with abundant food rewards.

It is time-consuming to observe specific pollinator/flower interactions. Researchers have identified clusters of floral traits that are preferred by specific pollinators. These “pollination syndromes” can help predict what pollinator is likely to visit a specific flower. For example, bees are attracted to bright white, yellow, blue, or UV colours; nectar; nectar guides; fresh scents; and shallow flowers with landing platforms. In contrast, bats are attracted to dull white, green, or purple flowers; abundant nectar but without nectar guides; musty scents;

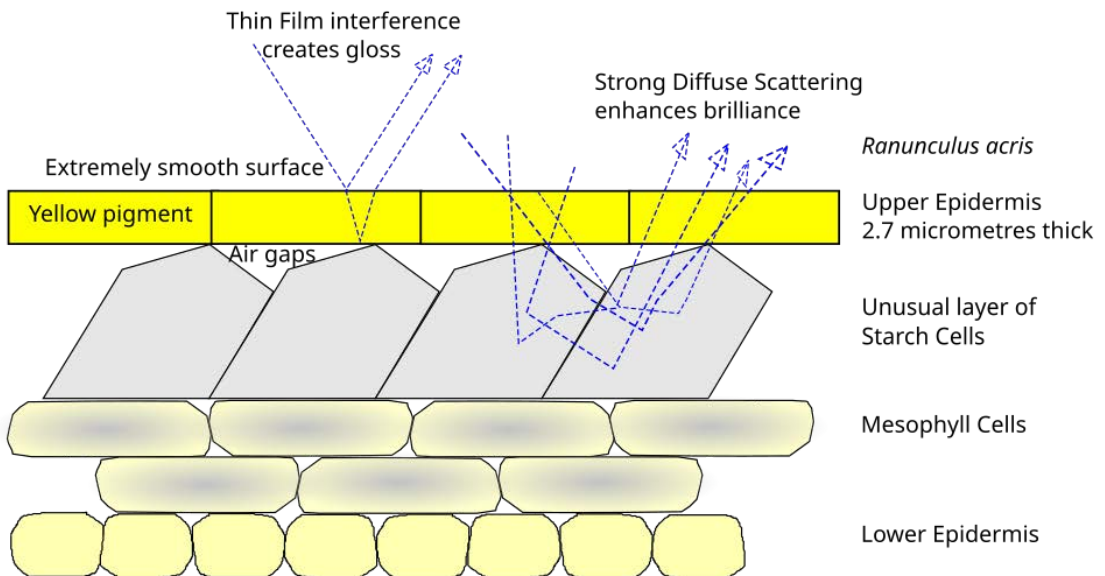


Figure 3: The buttercup (*Ranunculus acris*) petal combines an upper 2.7 micrometer layer that is both iridescent and reflective, above starch cells that function as strong reflectors diffusing the light. ([https://commons.wikimedia.org/wiki/File:Buttercup\\_petal\\_structural\\_and\\_pigment\\_coloration.svg](https://commons.wikimedia.org/wiki/File:Buttercup_petal_structural_and_pigment_coloration.svg))

<sup>2</sup> <https://royalsocietypublishing.org/rsif/article/14/127/20160933/35777/>

and bowl shaped flowers that are closed during the day (adapted from [https://www.fs.usda.gov/wildflowers/pollinators/What\\_is\\_Pollination/syndromes.shtml](https://www.fs.usda.gov/wildflowers/pollinators/What_is_Pollination/syndromes.shtml)).

Many food crops, particularly almonds, blueberries, coffee, and apples, depend on animal pollinators. Understanding pollination syndromes helps identify which pollinators are most effective for a specific crop, improving yields as well as yield stability. In natural habitats, these specialized relationships maintain plant diversity, improving ecosystem resilience. Knowing the pollination syndromes of native and cultivated plants supports habitat design and pollinator conservation strategies, particularly important as pollinators decline globally.

Pollinators and flowers have been partners in nature's emergent complexity for millions of years. By understanding and protecting pollinators, we not only safeguard terrestrial biodiversity, but also ensure our own future. The survival of these sophisticated organisms and masters of life is closely linked to the health of ecosystems, human culture, and food systems - an interdependence that deserves our attention, respect, and action. ×

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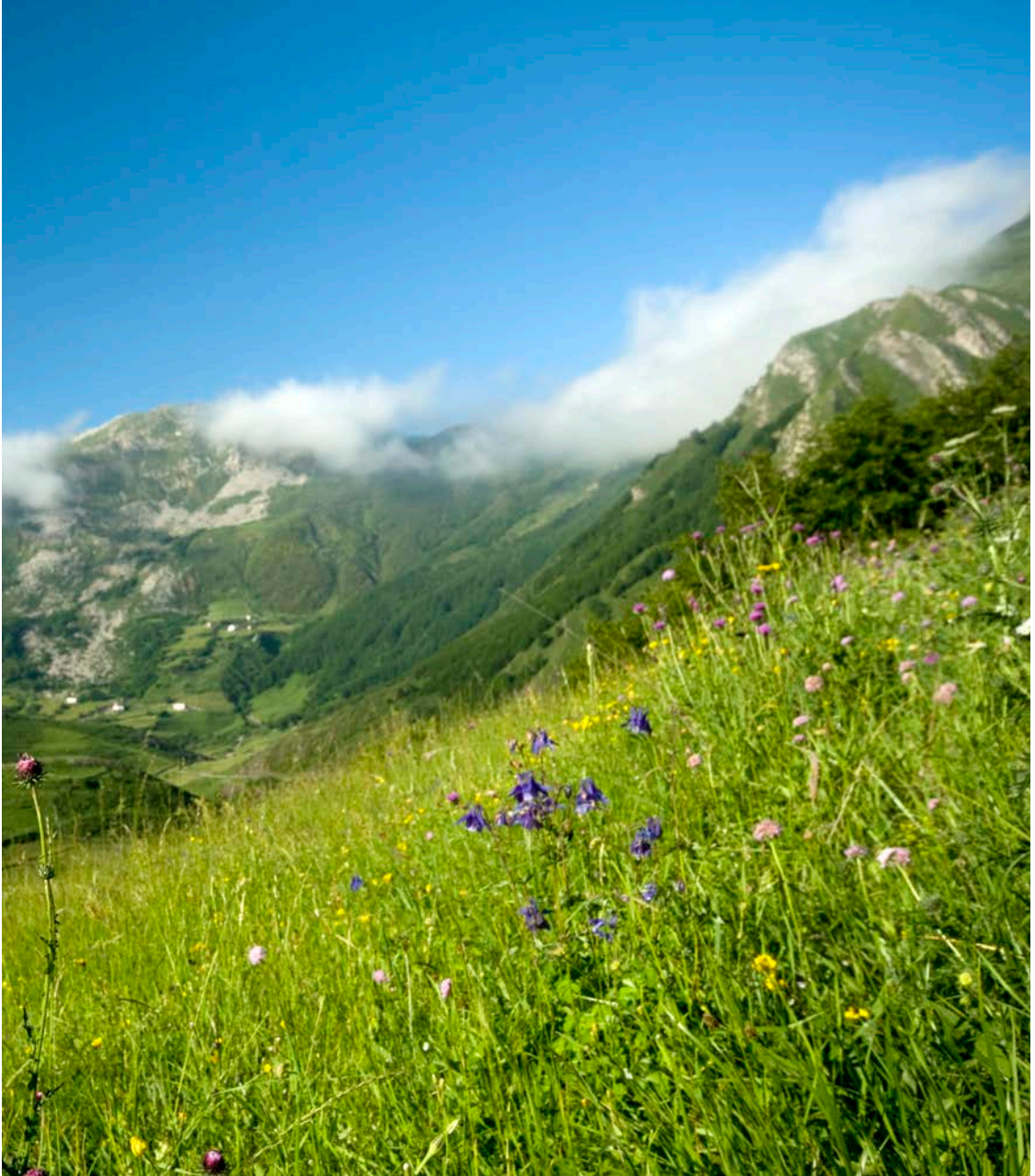
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Manuel Quirós, BSc, MSc, PhD in zoology, is a passionate nature conservationist. He guides, and as an independent teacher at several Spanish universities inspires the next generation of leaders to adopt sustainable and regenerative practices as well as biomimicry as a transformational behavior strategy. He is the owner of NIU ([www.natureinspireus.com](http://www.natureinspireus.com)), co-founder of Biomimicry Iberia and Red Internacional Biomimesis (RI3: <https://redinternacionalbiomimesis.org/>). He participates as a speaker in many international symposia such as ONU-Habitat and COP 25. He has been a contributing editor and author at *Zygote Quarterly* (ZQ29/30/34/38) since 2013.



For over 25 years, Luis Oscar Aguado has focused on the study, dissemination, and conservation of pollinators, including plant-insect interactions, as well as their ecology and taxonomy. He works as a consultant on entomological biodiversity for various government agencies and the private sector, both on the Iberian Peninsula and in the Canary Islands, as well as in countries such as Chile, Costa Rica, and Argentina. Since childhood, he has curated a significant collection of pollinating and saproxylic insects, with more than 150,000 specimens from around the world, with the goal of creating his own foundation in Spain. He has achieved national prominence through numerous articles, his courses, conferences, and events. He authored the award-winning *Guide to Pollinators of Spain* and two volumes of *Butterflies of Castilla y León*.



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