Rethinking Pliny's "Sicilian Crocus": Ecophysiology, Environment, and Classical Texts

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Abstract: Classical scholars have long held that the saffron in widespread use throughout the ancient Mediterranean was *Crocus sativus* (Iridaceae), a sterile triploid descendant of the wild *Crocus cartwrightianus*, and indeed use of *Crocus sativus* in antiquity has been extensively borne out both by iconographic and phylogenetic studies. Two principal scholars of the Roman world, Dioscorides the physician and Pliny the natural historian, disagreed radically over the virtues and commercial value of saffron crocus from Sicily, with one praising its quality, and the other excoriating it. This study draws on ecophysiology, classical texts, environmental archeology, and phytochemistry to explain this disagreement and its implications. It explores the potential impact of microclimate on crocus cultivation in the ancient Mediterranean and proposes a new species identification for Sicilian crocus: *Crocus longiflorus*. The identification of *Crocus longiflorus* as "Sicilian saffron" offers an important corrective to the assumption that *Crocus sativus* was the sole crocus species of commercial value in the ancient Mediterranean and renews attention to the economic potential and utility of an indigenous southern Italian species overlooked in classical and later scholarship.

Keywords: Ancient medicine, Pliny, Dioscorides, *Crocus sativus*, *Crocus longiflorus*, Ecophysiology, Ethnomedicine, Ethnobotany

Introduction: Saffron in the Ancient Mediterranean

With few exceptions, classical scholars and botanists have long held that the saffron crocus in widespread use throughout the ancient Mediterranean was *Crocus sativus* L. (Iridaceae), a domesticated triploid descendant of the wild *Crocus cartwrightianus* Herb. endemic to the central and Eastern Mediterranean. Translators of ancient Roman and Greek medical, scientific, and natural historical texts as far back as the seventeenth century have consistently connected the classical terms for this flower and its stigma (Lat. crocus, Grk. κρόκος) with the autumn-blooming *Crocus sativus*, as the use of this species in antiquity is well-documented in archeological, iconographic, and botanical sources (Day 2013; Dewan 2015; Martinez 2022; Rehak 2004; Riddle 2013) and now also in phylogenetic studies (Kazemi-Shahandashti et al. 2022; Nemati et al. 2019).

The use of crocus for medicinal, aromatic, and cultic purposes has been known far back as Bronze Age Crete (ca 1600 B.C.), where it seems to have been a pervasive element in religious iconography as well as a recurring motif on seals, wall paintings, ceramics, and clothing across the Minoan world (Fig. 1A). It is perhaps best known from frescoes on the Cycladic island

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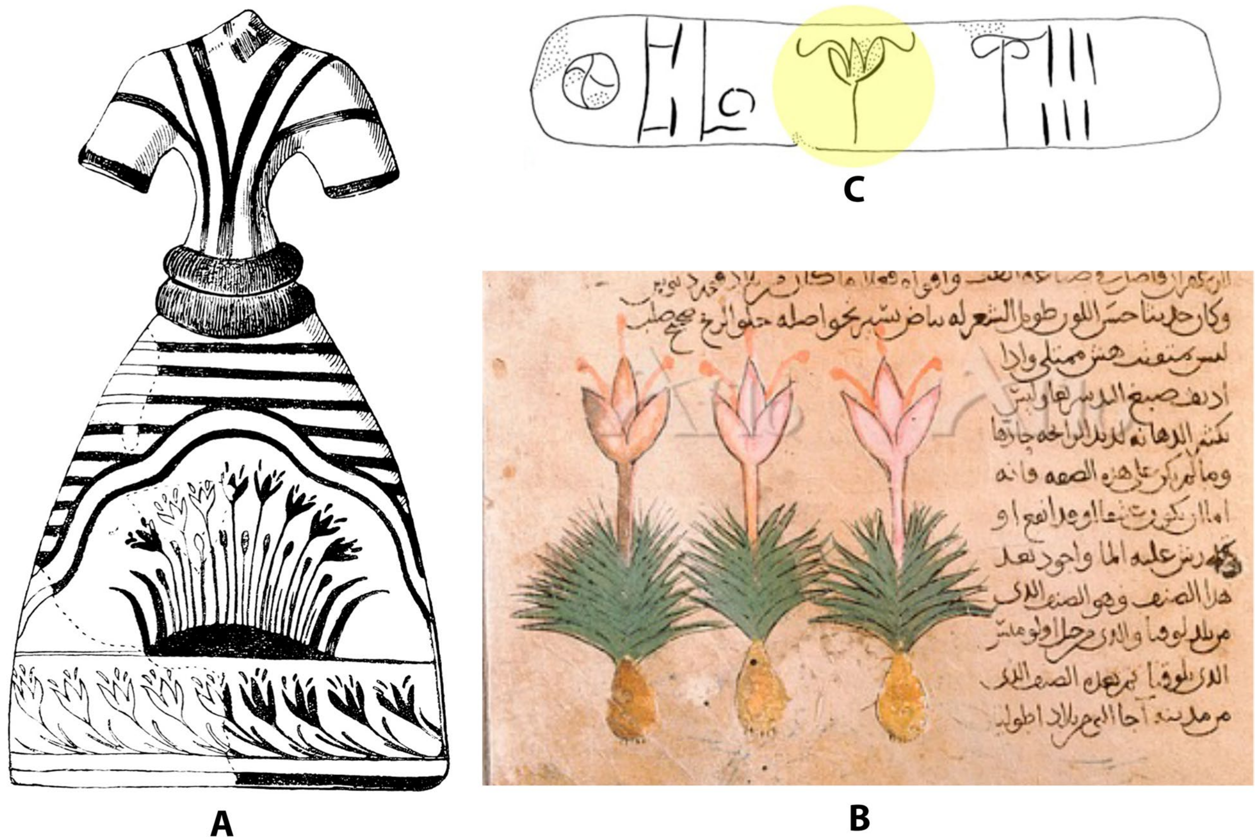

Fig. 1. **A** Minoan Faience dress plaque, Knossos, ca 1600 B.C. (from Day 2011: Fig. 10). **B** *Crocus sativus*, Folio 14r, Arabic edition of Dioscorides *De Materia Medica,* 13th c. A.D. **C** Mycenaean Linear B ideogram for crocus. Knossos Np85, (after Day 2011: Fig. 2)

of Akrotiri, in which women gather the flowers in rocky terrain and present them to a seated throned goddess. In the Linear B economic tablets from the Minoan palaces (ca 1400 B.C.), while other spices are recorded by volume, saffron crocus had its own ideogram (Fig. 1B), and saffron was recorded by mass, using the same weight standards employed for transactions in gold (Day 2011).

Both in Minoan iconography and subsequently in Bronze Age Mycenaean Linear B glyphs (which record the earliest known version of the Greek language), crocus flowers are typically shown with a characteristic morphology, the most distinctive element of which are elongated reddish stigmas extending out far out over three petals (see Fig. 1A–C and Chadwick 1986). This longer stigma is a trait recognized as characteristic of the cultivated *sativus* species, rather than of its wild predecessor *Crocus cartwrightianus* Herb., which has shorter petals and shorter and lighter colored stigmas than those of *Crocus sativus* (Amigues 1988; Day 2011; Day 2013; Mathew 1980, 1982; Mobius 1933; Warren 2000). Unlike *Crocus cartwrightianus*, *Crocus sativus* is sterile and must be corm-propagated, and as such requires human hands to thrive, a practice documented by the Greek ecologist Theophrastus by the late 4th c. B.C. Phylogenetic analysis of Mediterranean crocus species has confirmed that the transition from the wild *Crocus cartwrightianus* to the cultivated sterile *Crocus sativus* occurred in the Mediterranean and indicates that the transition took place in the area of southern Attica or the island of Kea in Greece, an area where a major Minoan center had flourished during the Late Bronze Age (Nemati et al. 2019). The timing of the transition is uncertain: the standardization of crocus imagery with the elongated stigmas has led some to argue that the Bronze Age imagery offers the first concrete evidence of the transition to the domesticated *Crocus sativus* (Kazemi-Shahandashti et al. 2022; Nemati et al. 2019, though *contra* Amigues 1988; Sarpaki 2000). Certainly, Theophrastus' fourth century description of corm cultivation demonstrates that the transition to *Crocus sativus*, propagated for its commercial value, must have occurred prior to this time. Where they can be clearly seen, illustrations of crocus in later Byzantine, medieval, and Renaissance manuscripts of Disocorides' book on pharmacology *De Materia Medica* (hereafter *DMM*), such as the *Codex Neapolitanus*, or the thirteenth century Arabic *folio 14r*, inter alia, likewise tend to exhibit the long-stigma morphology, color, and habit of *sativus* (e.g., Fig. 1C). The blended textual, art historical, and phylogenetic record thus documents a rich history of use of saffron from *Crocus sativus* across many centuries, within and beyond the Mediterranean (Dewan 2015; Kazemi-Shahndashti et al. 2022; Negbi et al. 1999).

Phytochemistry and Applications

In the classical and Byzantine periods, the medicinal and aromatic use of saffron is described by contemporary physicians (Hippocrates, Dioscorides, Galen, Marcellus Empiricus) as well as by natural historians (Theophrastus, Pliny). Beyond its role as a spice, saffron was utilized in antiquity as a dyeing agent, an aromatic, sprinkled dry onto the stages to perfume Roman theaters, blended into fragrant oils, or even prescribed as a cure for hangover (when added to wine). It was widely known for its medicinal applications, best documented by the Roman physician Dioscorides in the first century A.D., who credits saffron with digestive, astringent, and emollient properties when ingested. He describes it as an effective anti-inflammatory agent when topically applied for dermatitis or ear infections, a treatment for nausea when mixed with grape syrup, and an essential component of poultices for the uterus (*DMM* I.26). Indeed, saffron has had a long connection with gynelogical or obstetric ailments: long before Dioscorides, Assyrian sources described the use of saffron (*Azupiranu)* as a treatment for difficulties in childbirth and menstruation (Campbell Thompson 1924). These connections have led some scholars to propose that the Bronze Age Minoan frescoes depicting the gathering of crocus flowers by young women may be scenes of coming-of-age rituals (Kopaka 2009; Marinatos 1984; contra Day 2011). In classical antiquity, saffron was especially prevalent as an ingredient in unguents for eye ailments (including cataracts), prescriptions for which can be found well into the medieval period, and for which use it continues today (Cardone 2020; Fernandez-Albarral et al. 2020; Mahdi 2021).

While saffron contains a range of volatile components that contribute to these aromatic, culinary, and medicinal properties, three are key to its utility: crocin, picrocrocin, and safranal. Today, concentrations and proportions of these three compounds are measured by the International Standards Organization and used as metrics for saffron quality and purity (ISO 3632 2014). All three are apocarotenoids from the carotenoid zeaxanthin, itself derived from β-carotene. They are the products of two separate, though sometimes recursive, pathways that depend upon the site of zeaxanthin cleavage (see Fig. 2): crocetin and crocins (the components responsible for saffron color and its use as a dye) are formed from a C20 cleavage product of the carotenoid zeaxanthin (crocetin dialdehyde), which is oxidized and then glycosylated to form crocin (Alavizadeh and Hosseinzadeh 2014). Picrocrocin and safranal are products of the C10 cleavage product 3-OH-β-cycocitral, which is then converted to picrocrocin via UDPG-glucosyltransferase and hydrolyzes to form safranal (Sereshti et al. 2018; Yeats and Nagel 2018). Picrocrocin, as its etymology implies (*pikros* is Greek for "bitter"), is responsible for the slightly bitter taste associated with the spice, while safranal gives the spice its distinctive aroma and flavor. Given that all three are apocarotenoids, any increase in total zeaxanthin concentration has the potential to increase their overall quantity. The mechanisms of biosynthesis are not yet fully understood in detail (Carmona et al. 2006; Cid Perez 2021), but the existence of the dual pathways (C10 and C20) makes it possible that certain conditions could

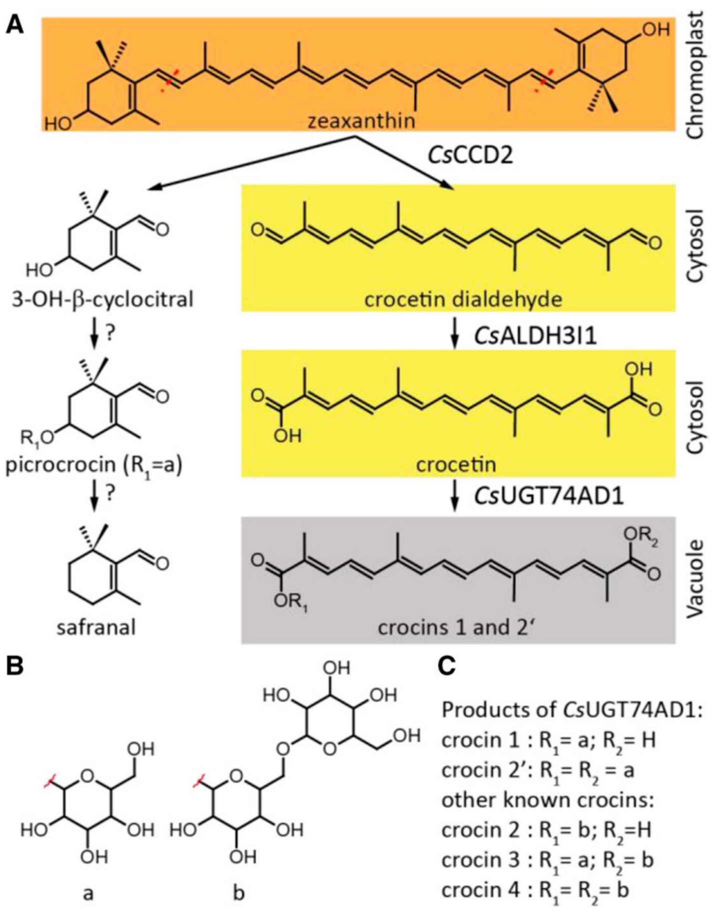

Fig. 2. C20 (right) and C10 (left) formation pathways for crocin, picrocrocin, and safranal (Yeats and Nagel 2018: Fig. 1)

drive production towards one or the other outcome. All three compounds have been demonstrated to be medicinally active, several for the specific applications described by classical authors (Ferrence and Bendersky 2004).

Whence the "Best" Crocus? Classical Authors and Medicinal Microclimates

Greek and Roman authors regularly observed variability in the potency of key medicinal species grown around the Mediterranean and often ranked their "best" and "worst" growing regions on this basis. Such rankings are a recurring feature in ecological and medicinal texts, such as those of Theophrastus, Hippocrates, Dioscorides, and Galen, but are echoed also in classical histories and travelogues, such as those of Pseudo-Scylax (4th c. B.C.), Strabo (ca 63 B.C.–24 A.D.) and Pliny (late 1st c. A.D.); the regional reputations of these plants are also hailed in poetry. There is, moreover, a striking degree of agreement among these classical authors in the identification of the "best" regions for key medicinal plants (Hardy and Totelin 2016). For example, the geographic area identified by the physician Dioscorides as the best source of medicinal iris (*Iris germanica* L. or the closely related *Iris pallida* Lam. or *Iris florentina* L.; cf. Andre 2010) is Illyria, specifically the region of what is now the Neretva River valley in modern Croatia. Illyria retained its status as the best iris producer for over 500 years, from the fourth century B.C. to at least the end of the first century A.D., a reputation spanning several empires and surviving a significant political and economic reorganization of the Mediterranean (Theoph. *Enq* IV. 5.2, IX.7.2 (4th c. B.C.); Nicander *Theriaca* 607 (2nd c. B.C.); Pliny *Naturalis Historia* 21.19; Dioscorides *DMM* 1.1.1 (both 1st A.D.); Pseudo-Galen, *Alphabet* (4th c. A.D.)

The continuity in lists of "best" growing regions for key plants was not simply an artifact of scribal tradition, with later authors blindly copying fixed formulae from earlier texts. Ranking orders were sometimes shuffled (though the top tiers tended to include the same regional contenders), and lists of favored regions were also updated, with previous favorites sidelined. In his *Naturalis Historia* (Natural History, hereafter *NH*) from the first century A.D., for example, Pliny notes that Elis and Leukas (in northwest Greece) "used to" produce the best iris oil (*NH* 21.19). And indeed, textual, archeological, and environmental data demonstrate that Elis and Leukas were damaged and depopulated during the Roman civil wars fought on Greek soil in the first century B.C., before Pliny's time, clashes which had a devastating and long-lasting impact on the agricultural hinterlands, as documented in both textual and archeological sources (Pausanias *Geography* 6.22.5–7; see also Karambinis 2018; Vött 2006). Major changes to the "best region" lists were, however, generally rare. They appear to reflect only extreme circumstances, as when a territory was conquered, abandoned, or agriculturally depleted. The consistent identification of the same areas as the "best" growing regions for key medicinal species suggests that they may have been highlighted for *longue durée* traits, such as their environmental suitability and traditional cultivation practices—recognition of their value as "medicinal microclimates"—rather than for fluctuating fortunes of commerce or ephemeral market trends.

Crocus was one such species frequently described and ranked by its growing region. Table 1 gives a representative sampling of Roman authors and crocus production areas of high repute. From such sources, we learn that the best saffron crocus in the Roman ancient Mediterranean was grown along the coastal regions of what is now southwestern Turkey. By cross-referencing the works of Dioscorides, Pliny, and Strabo together with the later Roman historian Pomponius Mela, it is possible to zero in on the geographic parameters of these regions in antiquity: Mt. Olympus is in the region of Lycia in southwestern Turkey (Fig. 3A). "Corycian" saffron is that grown in the coastal promontories to the east of the region of Lycia in which both the harbor city Corycus and Mt. Corycus are located (Strabo *Geography* 14.3.8, 14.5.5) (Fig. 3B). Both are situated on the Turkish coast, west of the modern day city of Antalya. Cilicia (Fig. 3C) is a reference to "Rough Cilicia," the coastal promontories east of Lycia and west of Mersin. From the geographer Strabo, who describes the region in detail, we learn that the crocus in Rough Cilicia is grown in two large depressions on these promontories near the Cilician coast,

Table 1. The best growing regions for *Crocus* as identified by Roman authors

Author	Text	Date	Best growing regions	Modern territory
Virgil	*Culex* (401)	1st c. B.C	Corycus	Turkey
Ovid	*Ibis* (2090)	Late 1st c. B.C.–early 1st A.D	Corycus	Turkey
Strabo	*Geographia* (14.5.5)	Late 1st c. B.C.–early 1st.A.D	Corycian grotto in Cilicia	Turkey
Pomponius Mela	*De Situ Orbis* (I.13.73–5)	Mid–1st c. A.D	Corcyrian grotto in Cilicia	Turkey
Quintus Rufus	*History of Alexander* (III.4.10)	Mid–late 1st c. A.D	Cilicia Mt. Corycus	Turkey
Dioscorides	*De Materia Medica* (1.26)	Mid–late 1st c. A.D. (ca 40-90AD)	Corycus Olympus in Lycia Aigai Centuripa	Turkey Turkey Greece: central Macedonian or Aitolian district Sicily
Pliny	*Natural History* (21.19)	Mid–late 1st c. A.D. (ca 23-79AD)	Corycus Olympus in Lycia Centuripa	Turkey Turkey Sicily

which have since been identified with Çennet and Çehennem, two famous dolines (sinkholes) in karstic formations at high elevation in the Taurus mountains along the coast. *Crocus sativus* continues to be grown in Rough Cilicia: the archeologist James Theodore Bent documented *Crocus sativus* growing on the mountains nearby these dolines (Bent 1891).

A long history of cultivation and renewed interest in saffron's economic potential for smallholder farmers have yielded numerous ecophysiological and agronomic studies that have identified the environmental conditions most likely to yield crocus with stigmas rich in the concentrations of the three compounds which provide the plant with its medicinal and commercial properties. These include low summer rainfall, well-drained calcareous soil, high elevation, and high UV exposure (Kumar et al. 2009; Rezvani-Moghaddam 2020). Well-drained soil and low rainfall prior to fall flowering are essential, as drought conditions have been shown to increase safranal, picrocrocin, and crocin contents in stigmas (Aboueshagi et al. 2023; Koochecki and Seyyedi 2016). In calcareous, well-drained soils, particularly limestone, calcium carbonate competes with potassium, limiting uptake of this mineral by the plants; this is beneficial as potassium levels have been shown to correlate negatively with safranal production (Rezvani-Moghaddam 2020). Calcareous soils also tend to maintain high amounts of organic matter (Gresta et al. 2009; Kafi et al. 2006; Lage and Cantrell 2009). The importance of organic matter in the cultivation of crocus has been determined by several modern studies (Chaouqui et al. 2023; Tammaro 1999) but was also recognized in antiquity: the Roman writer Mucianus, author of a (now lost) natural history cited by Pliny, describes the necessity of transplanting crocus into new ground every 7–8 years to ensure that the plant had access to replenished soils and that the corms remained uncrowded (cf. Pliny I.21; Kumar 2009).

Among all such studies, the one abiotic stressor that appears to correlate most strongly with concentrations of saffron's bioactive compounds is altitude, although this still requires systematic study. In research carried out on *Crocus sativus* grown across 13 sites in Morocco, Lage and Cantrell (2009) demonstrated a strong correlation between altitude and crocin concentration ($R^2 = 0.84$), with nearly twice the concentration of crocins occurring in plants grown in the high-altitude plots. In separate experimental studies, concentrations of all three apocarotenoids (crocin, picrocrocin, and safranal) have been shown to be higher in high-elevation *Crocus sativus* in other regions of the world, including Iran and

Fig. 3. "Best" growing regions for *Crocus* in classical texts. From left to right: Lycia, Mt. Corycus, Cilician grottos. Source: Google maps

the Himalayas (Kothari et al. 2021; Rikabad 2019; Zarinkamar et al. 2011), although studies of these constituents in the Italian Alps showed more variable results (Giorgi et al. 2017). Altitude may in part be a proxy for UV exposure: there is a roughly 6–10% increase in UV exposure for every 1000 ft of altitude, and UV exposure—most especially UV-B exposure—has been shown to increase the production of phenols and carotenoids in many plant species, including *Crocus sativus.* Altitude also subjects plants to slightly colder temperatures, which enhances carotenoid biosynthesis (Zarinkamar et al. 2011; Zidorn 2005). As such, altitude provides two potential triggers for enhancing the commercial value of *Crocus sativus*, each of which are independently capable of catalyzing production of bioactive secondary metabolites by increasing total carotenoid concentration.

There are few regions where the suite of environmental traits most favorable to saffron cultivation converges; indeed, some agronomists have described saffron as a "niche" crop for this reason (Rezvani-Moghaddam 2020). Yet reconstruction of the ancient climate and environments of Cilicia and Lycia during the Roman period indicates that the climate, geomorphology, and topography of these regions were (and remain) particularly well-suited to the cultivation of potent *Crocus sativus.* Environmental studies have demonstrated that the Roman Empire flourished in a climatic period termed the Roman Climatic optimum (Christiansen and Ljungqvist 2012), a stretch of stability bookended by two periods of more severe drought and temperature changes. Within this window, reconstructed temperature, solar activity, and precipitation patterns are understood to be more or less in keeping with the present day, absent very recent changes due to global warming (Harper 2018; Harper and McCormick 2018; Millar 2021). The saffron-producing regions of southern Turkey identified in classical sources have very low summer rainfall (0–11 mm), and they exhibit seasonal temperature ranges (from 12.9/13.8–25.3 °C) in the established preferred range for *Crocus sativus* (Molina et al. 2005). They are moreover uniformly characterized by well-drained, calcareous, friable, karstic soils. Of particular importance for medicinal viability is the high elevation of these areas; the region of Corycus spans 1800–3000 m above sea level; Mt. Olympus reaches 2337 m. Assessment of global horizontal irradiation and UV index across the region shows that these areas lie in a band of particularly high exposure (ca 1700–1850 kWh/m^2) relative to surrounding territory**.** There is thus a strong ecophysiological basis to support the reputation of Lycia, Corycus, and Rough Cilicia as producers of the best medicinal saffron in the ancient Mediterranean.

The Dispute over Sicilian Saffron

While classical authors were in robust agreement over the value of Corycian, Cilician, and Lycian crocus, the sources in Table 1 also document a rare point of disagreement. In his *Natural History*, Pliny the Elder describes Centuripe in Sicily as one of the top-tier producers of crocus—a third-place finisher after Corycos and Lycia (*NH* 21.17). Centuripe is a city in the region of Catania near Mt. Etna, described by Strabo (*Geog.* 6.2.7) and which has retained its name to the present day. Yet his near-contemporary, the physician Dioscorides disagrees, and to no small degree. Far from proposing a mere reshuffling of the top tier ranks (which would be more typical in classical sources), Dioscorides instead offers a scathing critique of Sicilian crocuses, calling them weak with respect to their medicinal properties, and completely "vegetable-like" (*DMM* I.26.1), although he acknowledges their popular use as a dye. The term "vegetable-like" (λαχανώδεις) from Dioscorides is particularly dismissive. The word is used to demarcate the group of garden-grown, domesticated vegetables as a separate category from medicinal plants, which were naturally considered in antiquity to be medicinally weaker than their wilder counterparts (Theoph., *Enq. 1.6.11* and *De Causis* 6.13.5; cf. also Hardy and Totelin 2016).

What is it about Sicilian saffron that could spark such discord? We may consider three possibilities.

A first impulse might be to examine the potential impact of post-harvest treatment and preparation of saffron, as Dioscorides and Pliny appear to describe two different processes in their works. Dioscorides advocates that saffron be "dried in the sun in a warm clay vessel," while Pliny suggests that it should be dried in the shade. Agricultural and ethnobotanical studies on saffron quality have indeed showed that concentrations of crocetin/crocin and safranal can be significantly altered by the application of different drying methods after harvest, as they exhibit an inverse relationship—perhaps reflecting the two pathways of zeaxanthin cleavage noted above (Arapcheska 2020; Cid-Perez 2021; Sereshti 2018). The difficulty, however, is that the drying processes each ancient author promotes would have resulted in saffron with qualities opposite to those they describe. Harvested stigmas of Moroccan *Crocus sativus* dried in the shade were shown to lose over 50% of their crocin content, while safranal content increased (Chaouqi et al. 2023; similar results were obtained by Sereshti 2018). By contrast, stigmas dried by heating—whether in the sun, over fire, or in an oven—saw a sudden boost in crocin formation, and therein dyeing potential, but also a degradation of flavor and aroma (Aghaei et al. 2019, Arapcheska et al. 2020, Cid-Perez 2021). The addition of heat facilitates breakage of the chromoplasts thus facilitating the release of crocins, while breaking down picrocrocin and safranal (Carmona et al. 2005; Tong 2015); indeed, degradation studies have shown a nearly 50% degradation of safranal into 2,3 dimethoxybenzoic acid and trimethoxybenzaldehyde within days of heat exposure (pers. obs., Birney Lab.). Thus, with these methods, Pliny's shade-dried saffron should have become more powerfully scented and a poorer dyeing agent, the opposite of Dioscorides' description; Disocorides' sun-dried saffron should have been a better dyeing agent but far less fragrant and not at all pungent. As weaker smell was thought to mark weaker medicine in antiquity (Hardy and Totelin 2016; Scarborough 1986; Totelin 2015), diminished pungency would have likely rendered the sun-dried saffron a poorer medicine in the opinion of classical physicians. Post-harvest treatment thus does not offer adequate explanation for the different opinions of the two authors.

When viewed through the lens of "medicinal microclimates" above, it is clear that the region of Centuripe is not as well-suited to the production of high potency saffron as the sources in the mountains of Turkey. Though it shares many of the same features (calcareous soils, strong UV exposure, low summer rainfall), it differs radically in altitude: Centuripe lies only 728 m above sea level, some 1000–2000 m below the elevations of Mt. Corycus, Mt. Olympus, and the Cilician production areas. Altitude, as noted above, was the single abiotic factor shown to have the greatest impact on carotenoid biosynthesis, and as such, the environments of Rough Cilicia would have been more favorable for their production than the region of Catania. A physician who prided himself on the empirical nature of his work, Dioscorides may well have observed some tangible differences in potency of saffron sourced from the two regions and conveyed this in his pharmacological recommendations. He was, moreover, certainly aware of environmentally induced variation in the quality of the *pharmaka* (medicines) he prescribed, as he explicitly addressed this concern in the preface to the *De Materia Medica*. If we presume, as most translators do that Dioscorides and Pliny are both discussing *Crocus sativus*, then ecophysiology could certainly offer a reasonable explanation for the divergence in the two opinions.

Closer scrutiny of Pliny's language, however, invites us to consider a third option, namely, that Pliny's Sicilian saffron may not be *Crocus sativus* after all, despite the fact that nearly every translation and commentary on the *Natural History* has defaulted to this assumption.

A New Candidate for "Sicilian Saffron"

Pliny's description of saffron crocus includes a number of features that differ from other classical sources, including Dioscorides (for full text see Supplementary Appendix 1). First, he is explicit in identifying wild crocus as better than the domesticated version, a detail that is a clear deviation from earlier sources he often cites (Wellman 1889). The domesticated species, he notes, offers a low yield of saffron, must be cultivated from the corm, and is all flash and no substance (literally, prettier but "multo lenius," much weaker). These latter two statements on cultivation and efficacy draw from the works of the ecologist Theophrastus and promote the opinion—one usually shared by Dioscorides—that wild species are more medically potent than cultivated ones, an ancient view today supported by ethnobotanical studies in some species (Diosc. *DMM* 1.6., Guarrera 2013, Li et al. 2023, Máthé 2015, Schippmann et al. 2006, Theoph., *Enq.* 3.1.3–4). After praising wild crocus, Pliny then offers a list of desirable morphological traits that seem to contradict Discorides' description of preferred habit and character, a key feature of which is that the crocus stigma should not be long, as Dioscorides suggests, but instead short and stubby ("pinguissimum et brevis capilli"). Pinguissisimus—literally "fattest," which is often translated as "oiliest," can be deployed with the sense of fullness or heaviness, used to describe beehives or wood full of pitch. However it is also used as a term for thickness, to describe thick fertile soil, or the density of hair or foliage (e.g., "folia pinguissima," Pliny *NH* 21.9, 21.29, and 21.53). The shorter, thicker stigmas Pliny describes are a long-recognized morphological trait that can distinguish wild saffron species from cultivated *Crocus sativus.*

There is only one wild crocus species endemic to Sicily that, like *Crocus sativus*, is an autumn-blooming species: this is *Crocus longiflorus* Raf., originally referred to as *Crocus odorus* var. *longiflorus*, recognized by Rafinesque (1810), Lindley (1844), and Herbert (1847) as a wild species of crocus growing native to southern Italy and Malta. Rafinesque and Herbert note the species grows "in the meadows on the coast of Sicily, near Palermo, and in Calabria"; Bocardo (1888) specifically identifies *longiflorus* as a wild species cultivated by peasants in the province of Catania and Agira, areas which flank the Roman site of Centuripe. Phylogenetic analysis has demonstrated that *Crocus longiflorus* belongs to the group of spring-flowering crocuses *Crocus* ser *Verni* B. Mathew (Harpke et al. 2015; Mathew et al. 2009; Peterson et al. 2008), but it is unique among the *Crocus verni* in being an autumn-bloomer.

In color and morphology, *Crocus longiflorus* is very similar to *Crocus sativus* but differs from the habit of the latter in its distinctive longer flower, shorter leaves, and especially shorter stigma length relative to the stamen and the petals. Compared with *sativus*, the stigma of *longiflorus* tends to be shorter than or equal to stamen length, while that of *sativus* stigmas regularly exceed it and droop over the petals, often by a considerable margin (Herbert 1847; Kerndorff 2015; Marquez 1996; Rafinesque 1810; Siracusa 2022) (Fig. 4A, B). Stigma length relative to anther size was also determined to be a diagnostic morphological trait supported by phylogenetic classification among Italian crocuses (Harpke et al. 2015; Kerndorff 2015). The shorter stature and clustered habit of the *longiflorus* styles gives the appearance of a thicker top (Fig. 4C(11)), and thus illuminates Pliny's description of them as "stubby" and even "dense" relative to those of *sativus*. Both species prefer similar climatic conditions (e.g., well-drained sunny, calcareous, soils), and as both bloom in autumn, they would have been harvested at the same time. They are sufficiently similar that they can easily be confused by the untrained eye (Marquez 1996), and as their suites of bioactive and aromatic compounds overlap significantly (though proportions vary), they can be utilized for similar purposes (Nørbæk 2002; Siracusa 2022); Marquez has even documented modern local use of *Crocus longiflorus* as a spice and condiment (a saffron substitute) in the area around Salerno.

In a study published in *Economic Botany*, researchers at the University of Siena carried out comparative spectrophotometric analyses on *Crocus sativus* and *Crocus longiflorus* samples from Salerno, Italy, using UV–VIS for phytochemical assay and staining intensity measurements using potassium dichromate to assess dyeing potential (Marquez et al. 1996). Both methods demonstrated that *Crocus longiflorus* had higher concentrations of crocins relative to *Crocus sativus* and lower relative concentrations of picrocrocin, the latter being a precursor molecule for safranal and therefore a useful proxy for the relative quantities of safranal. The divergence in crocin and safranal content might suggest a species trait—or an environmental trigger—which helped to tip zeaxanthin cleavage towards the C20 pathway, producing more crocin, at the expense of the C10 pathway (see Fig. 2). The dyeing study, carried out using potassium dichromate, also demonstrated that *Crocus longiflorus* had greater coloring power than the Italian *Crocus sativus*, while being slightly less aromatic and flavorful. Subsequent studies have shown that while the range and concentrations of crocins have been shown to vary among *Crocus longiflorus* samples around Southern Italy, the species is particularly high in trans-crocetin esters (especially the β-D-gentiobiosyl esters) which produce the

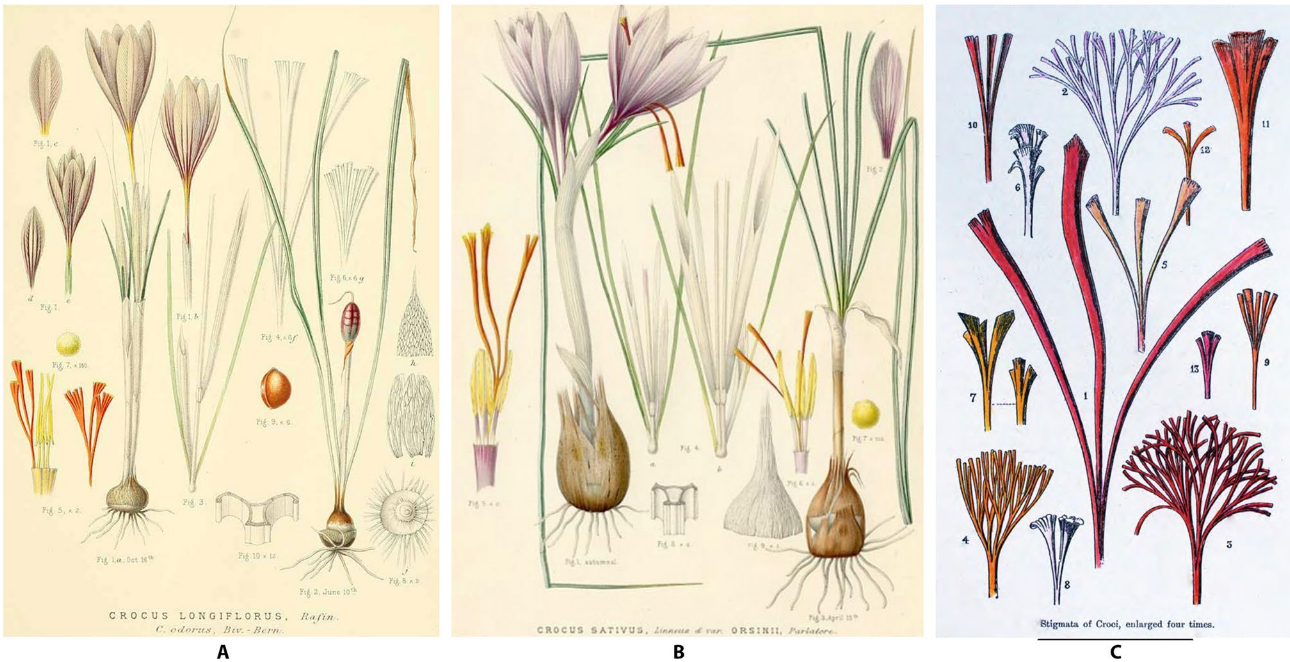

Fig. 4. **A** *Crocus longiflorus* (Maw 1886: Pl. 28). **B** *Crocus sativus* (Maw 1886, Pl. 29). **C** Comparative size and morphology of crocus styles from *Crocus sativus* (1, center) and *Crocus verni* (11, top right) (after Maw 1886: Fig. 10)

reddish-gold coloration (Siracusa 2022). The authors of the Siena study argued that the economic potential of the wild *Crocus longiflorus* species was being overlooked and undervalued given its capacity dyeing agent and spice, and particularly given its hardiness and ease of propagation.

Crocus longiflorus thus reflects the geographical distribution, morphological and functional characteristics of Sicilian saffron as described both by Pliny and Dioscorides, and seems a likely candidate for the Sicilian saffron promoted by the former and abhorred by the latter. Such an identification would explain Pliny's unusual emphasis on the importance of the wild species, even when most scholars consider the cultivated *Crocus sativus* to be the primary species of commercial value in the ancient Mediterranean. If this interpretation is correct, Dioscorides' remark that Centuripean saffron was useful as a dye, if not as a medicine, can moreover be understood in light of the Siena phytochemical study. In Pliny's time, the more subtle odor of *longiflorus* may well have been taken as a sign of reduced medicinal potency given the long association of pungency with medicinal efficacy (Hardy and Totelin 2016; Totelin 2015).

The Disappearance of Sicilian Saffron

Classical scholars have consistently maintained that Pliny's Sicilian saffron is *Crocus sativus*, even while remarking on the differences in the crocus traits he emphasizes (Bonet 2009; Morton 1986). Over centuries of commentary, only a rare few have posited alternatives, each making note of Pliny's explicit declaration that the wild species is better, while disregarding his morphological description. Opsomer (1989) proposed wild *Crocus siculus* Tineo, although this identification is untenable, as *Crocus siculus* blooms in the spring, unlike the saffron crocus which according to Theophrastus, Pliny, and others blooms in autumn. Herbert (1847), also noting the "wild" designation, proposed that Pliny might have meant *Crocus cancellatus* Herb., but the species is neither native to Sicily nor does its morphology accord with Pliny's description of the stigmas (Herbert describes them as thin or spindly). Among endemic wild species, only *Crocus longiflorus* possesses all the traits which Pliny describes.

This persistence in the identification of Pliny's crocus as *Crocus sativus* is the product of an unsurprising skepticism about Pliny's expertise. Indeed, while Disocorides is typically credited with empiricism (Riddle 1985), Pliny's botanical knowledge has been the subject of significant criticism from as early as the fifteenth century A.D. (Barbaro 1492; Leoniceni 1529). Pliny has been castigated for mistranslation, misidentification, and misperception, and the *Natural History* often treated as a product of rote compilation rather than observation or robust comprehension (Lloyd 1983; Morton1986). Yet recent scholarship has taken a more nuanced view of Pliny's aims and methods, as well as a more appreciative stance on the state of his botanical knowledge (Healy 1999; Irwin 2016; Taub 2017). Pliny's intention, laid out in his preface, is to describe for the benefit of his readers the practical exploitation of plants, and he expresses a specific desire to be exhaustive and inclusive, both in the geographic range and in the scope of what may or may not be true (Bonet 2009). His interests are not purely medical but broadly utilitarian. More importantly, Pliny's center of gravity (and that of his audience) lies in the Roman west; his are "domestic medicine books" (Bonet 2009; Carey 2003; Taub 2017). To that end, he is swift to offer western alternatives to eastern plants, and to offer insights from his own experience which naturally included greater experience with western flora (Amigues 2002; Bonet 2009; Stannard 1965). Although the *Natural History* does contain errors, many of Pliny's mistakes are now thought to be artifacts of dictation, unsuccessful attempts at analogy, or efforts (however misguided) to promote western plant species that might be cognate to favored species from the eastern Mediterranean. The work thus offers a western counterpoint to the works of Theophrastus and Dioscorides whose botanical perspectives and knowledge are rooted in the eastern Mediterranean (Stevens 2016). With those considerations in mind, a revisitation of Pliny and Dioscorides' descriptions invites us to look beyond the historical emphasis upon *Crocus sativus* and consider Pliny's language at face value—that rather than an erroneous description of *sativus*, his work instead records local knowledge and use of an indigenous Italian crocus species, *Crocus longiflorus*.

Indeed, looking beyond Pliny's work, there are clear indications that in the Roman and subsequent Byzantine periods, "Sicilian saffron" was recognized as something distinct from the Corycian or Cilician saffron crocus. Columella, a contemporary of Pliny, notes that bulbs of both Corycian and Sicilian saffron were planted in Roman gardens (*De Re Rustica*, 9.4). Physicians singled out Sicilian saffron as a key ingredient in eye salves (*collyria* or *perichristaria*) or in ointments to treat scarring, even while prescribing Cilician or Corycian saffron for other uses (e.g., Scribonius Largus, *Compositiones medicamentorum* I. 29, 30; Marcellus Empiricus, *De Medicamentis,* 8.9, 207, 108; Galen 14.151). Its reputation as a dyeing agent may even have persisted into the Middle Ages. During the late twelfth/early thirteenth century A.D., Peter of Saint Audemar, a painter of the Benedictine monastery of St. Omer in northern France, wrote *De Coloribus*, a treatise on illumination. In it, he complained of the poor quality of French saffron, which was apparently unable to produce the promised brilliant yellow coloration, and instead reports a particularly valuable variety from Sicily "with a color superior to gold" (although he mistakenly attributes the source of this information to a seventh century source, Isidore of Seville) (Merrifield 1849).

Although Sicilian saffron occupied its own role in the Roman world as a medicinal treatment, its memory and use were largely eclipsed by Corycian/Cilician saffron, whose reputation for superior medicinal value persisted far beyond the Roman Empire to become a staple of pharmacopeia in the western medical tradition (Nutton 2012). Its disappearance is likely due to the lasting influence of Dioscorides' work and the subsequent devaluation of Pliny's, whose dismissal catalyzed a general rejection of medieval plant knowledge from the fifteenth century onwards (Touwaide 2010).

Conclusion

The medicinal saffron favored by Dioscorides is likely to have been *Crocus sativus*, a commercial species cultivated in specific microclimates in the Eastern Mediterranean where the environment and soil conditions favored the production of stigmas rich with bioactive compounds. Pliny's "Sicilian crocus" is likely not *Crocus sativus*, but instead a wild species of crocus, *Crocus longiflorus*, endemic to Sicily. It was different enough in character to be recognized as distinct from the cultivated *Crocus sativus*, and prescribed separately by Roman physicians, while also being valued for different applications beyond its medicinal potential. This is the plant that drew Pliny's praise and Dioscorides' scorn.

By bringing ecophysiology and environmental science to bear on classical texts, our study thus offers a corrective to the assumption that *Crocus sativus* was the sole crocus species of commercial value in the ancient Mediterranean and renews attention to the economic potential and utility of an indigenous southern Italian species. Such a blended approach offers a new way to interrogate traditional species identifications, to find ethnobotanical plants that may have been overlooked, and to assess the impact of microclimates and cultivation strategies that could be applied to small-scale or commercial growing in the present day. There is still much to be discovered, or rediscovered, in our ancient sources.

Data Availability All data is from previously published and publicly available resources.

Code Availability N/A.

Declarations

Ethics Approval N/A.

Consent to Participate and Consent for Publication N/A

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