2nd Mediterranean Plant Conservation Week
“Conservation of Mediterranean Plant Diversity: Complementary Approaches and New Perspectives”
12-16 November 2018, La Valetta, MALTA

Recent advances in seed germination research of Mediterranean plants

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[2] Institute of Mediterranean Forest Ecosystems, Hellenic Agricultural Organization "DEMETER", Athens, GR
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CIHEAM
MAI CHANIA

ΠΡΑΣΙΝΟ ΤΑΜΕΙΟ

Seed banking not an option for many threatened plants

The Global Strategy for Plant Conservation requires 75% of threatened plant species conserved ex situ by 2020. Currently, ex situ conservation focuses on conventional seed banking, yet this method is unsuitable for many threatened species. The 75% target is unattainable without urgent investment into alternative techniques.

Sarah V. Wyse, John B. Dickie and Katherine J. Willis

NATURE PLANTS | VOL 4 | NOVEMBER 2018 | 848–850 |

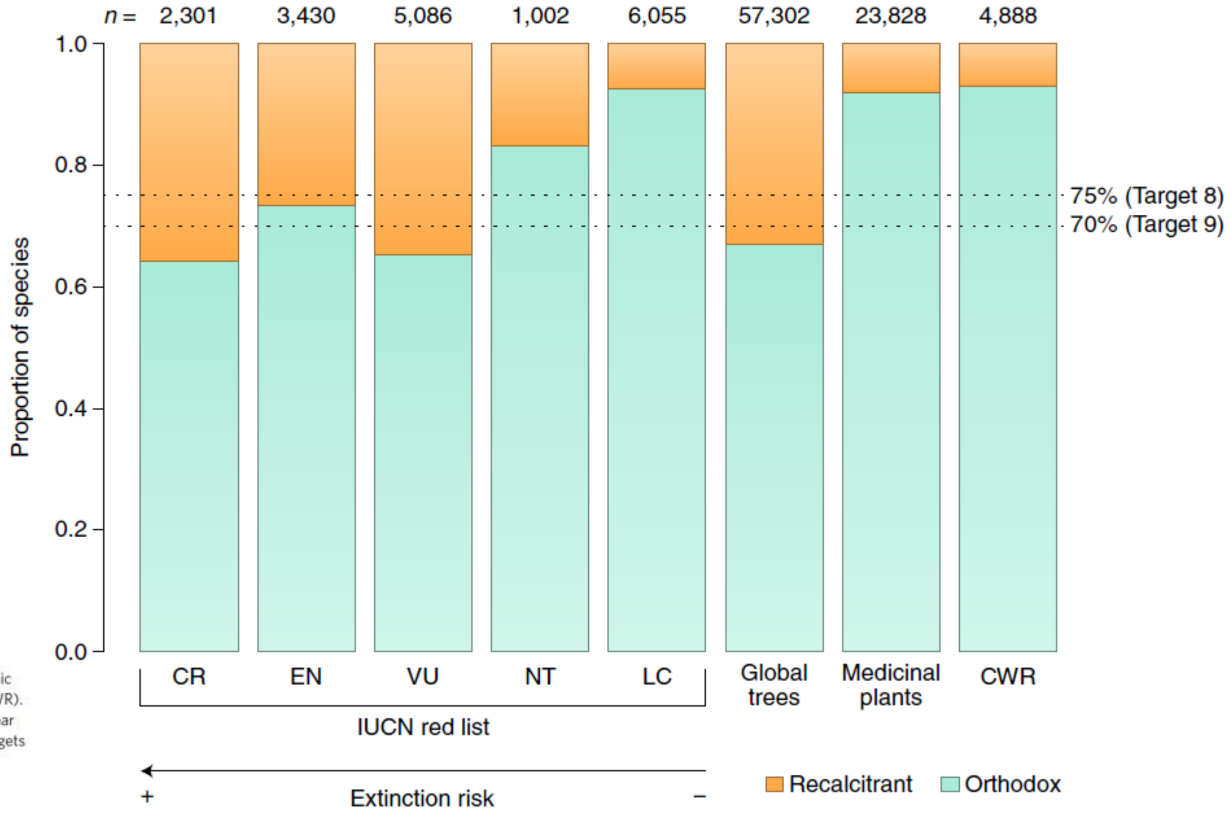
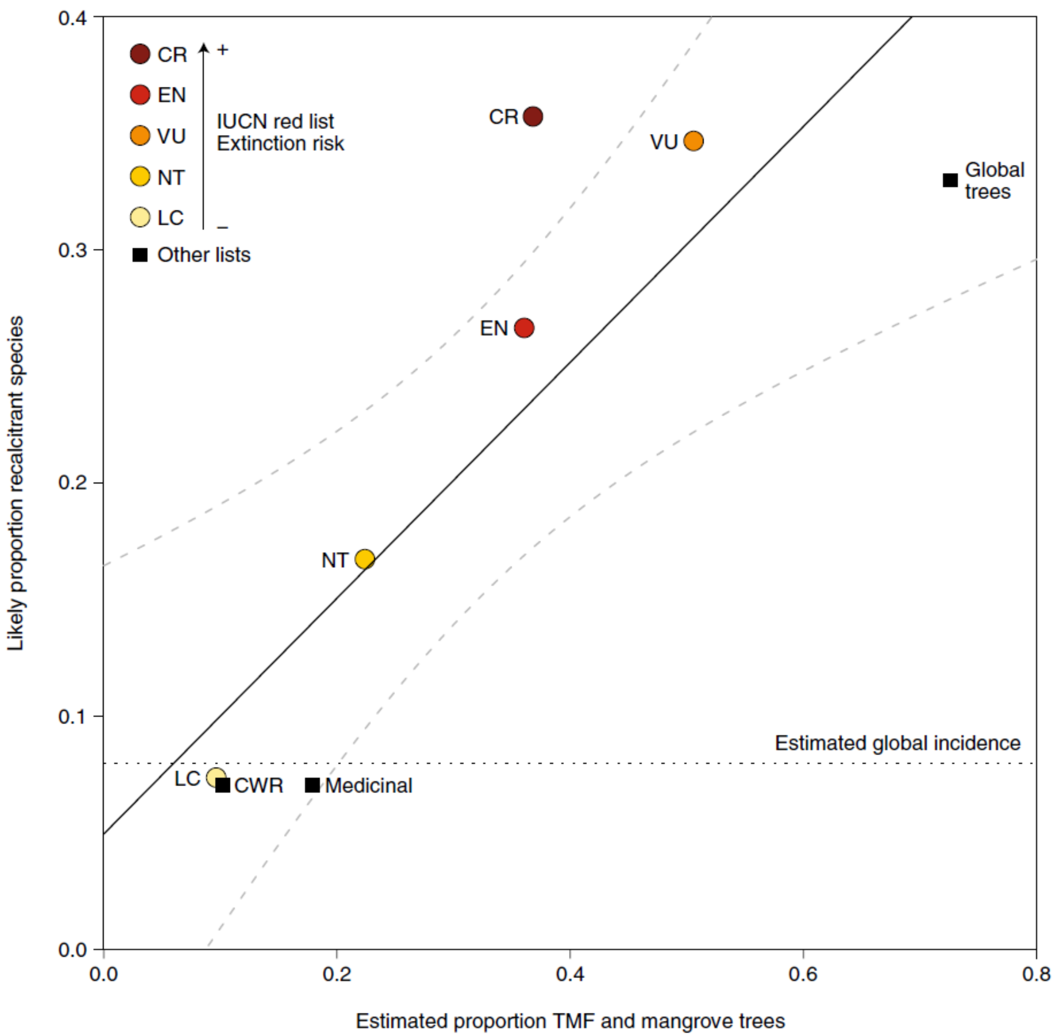


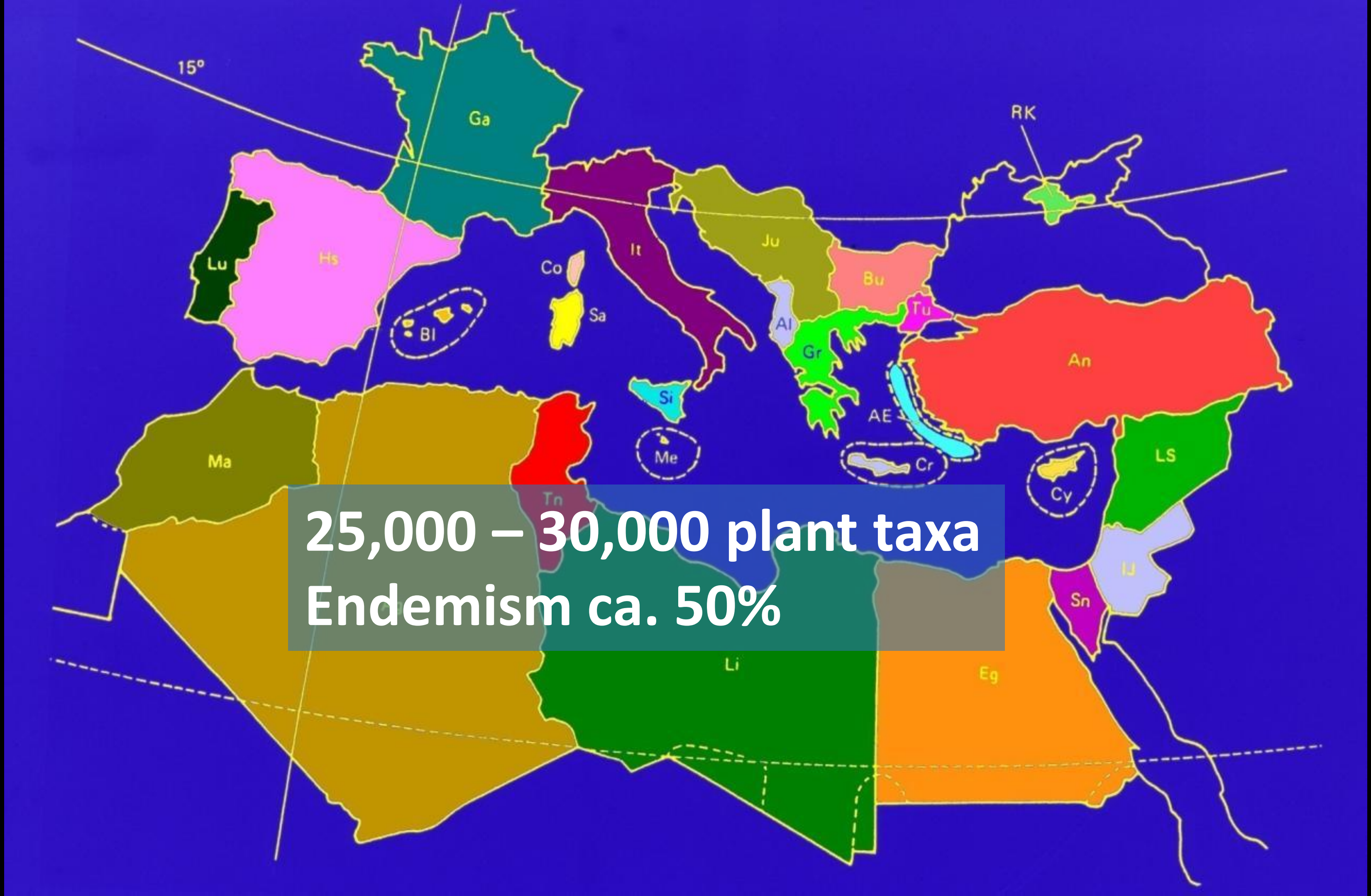
Fig. 1 | The likely proportions of seed storage behaviours across different plant lists. Species lists used are: the IUCN red list; GlobalTreeSearch, a database of all known tree species[12]; the Royal Botanic Gardens Kew's 'Medicinal plants' database; and the Crop Trust's inventory of crop wild relatives (CWR). CR, critically endangered; EN, endangered; VU, vulnerable (the three 'threatened' categories); NT, near threatened; and LC, least concern. Horizontal dotted lines denote the proportions of species that Targets 8 and 9 of the Global Strategy for Plant Conservation aim to conserve. Proportions predicted using models developed by Wyse and Dickie[11]. Target 8 aims for at least 75% of threatened plant species conserved in ex situ collections; Target 9 aims for the conservation of 70% of the genetic diversity of crops, including CWRs and other socio-economically valuable plant species.



Taxa with recalcitrant seeds constitute between 0.5-1.0% of the Greek Flora.

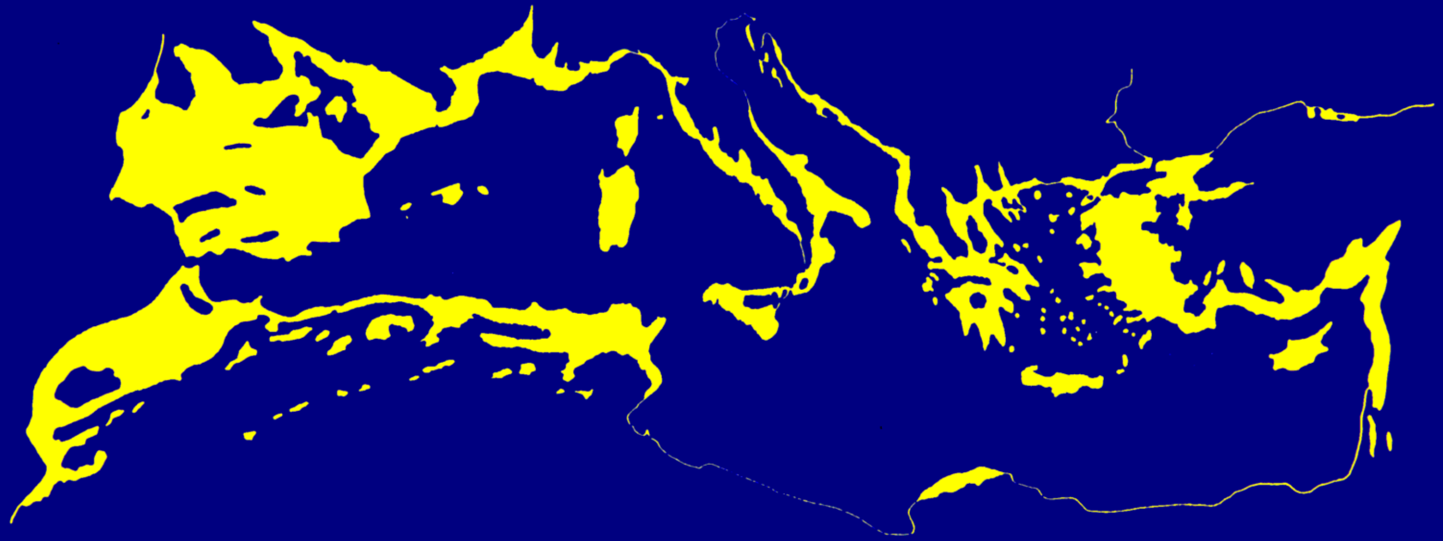
Projected value of seed recalcitrance occurrence in the flora of the Mediterranean Rim: 1-2%

Fig. 2 | The likely proportions of recalcitrant species on different plant lists in relation to the estimated proportion of the list made up of trees from tropical moist forest and mangrove habitats. Solid black line is a linear model fitted for these two variables ($r^2 = 0.73$, $P = 0.007$); dashed grey lines represent the upper and lower 95% confidence bounds. Horizontal dotted line is the estimated global incidence of recalcitrant seed plants[9], storage behaviour was predicted using models developed by Wyse and Dickie[11]. Estimated proportion of tropical moist forest (TMF) and mangrove tree species calculated using data from GlobalTreeSearch, a database of all known tree species[12], the Global Biodiversity Information Facility (GBIF; www.gbif.org) and the Terrestrial Ecoregions of the World[17]. Species lists used are: the IUCN red list; GlobalTreeSearch, a database of all known tree species[12]; the Royal Botanic Gardens Kew's 'Medicinal plants' database; and the Crop Trust's inventory of CWRs. CR, critically endangered; EN, endangered; VU, vulnerable (the three 'threatened' categories); NT, near threatened; and LC, least concern.



25,000 – 30,000 plant taxa

Endemism ca. 50%



DURING THE LAST 3 DECADES:

AN IMPRESSIVE INCREASE OF RESEARCH GROUPS WORKING ON SEED GERMINATION (AND SEED BIOLOGY IN GENERAL) AROUND THE MEDITERRANEAN.

ACCOMPANIED BY AN EXPLOSIVE SURGE OF PUBLICATIONS (RESEARCH PAPERS, REVIEWS, MSc & PhD THESES, PAMPHLETS, MANUALS, TECHNICAL REPORTS, BOOKS etc)

New Phytologist
Review

Research review

A research agenda for seed-trait functional ecology

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Received: *18 July 2018*
Accepted: *17 September 2018*

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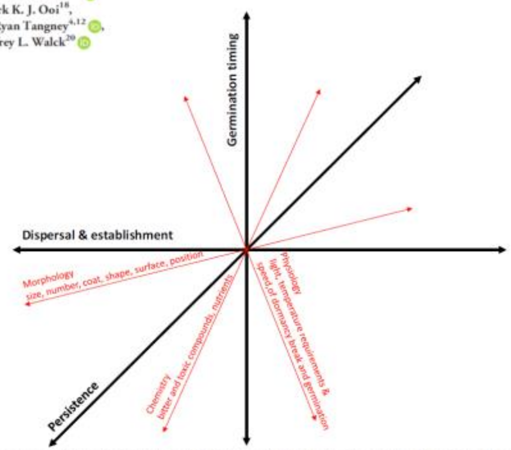


Fig 2 The seed ecological spectrum. We hypothesize that seed traits (red arrows) exhibit trade-offs and axes of covariation linked to several major functions (black arrows). Together, these spectra help to characterize key dimensions of the regeneration niche. A range of seed traits may feed into these spectra (Fig. 3), and whereas the seed size–number trade-off is a well-identified trait set underpinning dispersal and establishment functions, the axes of trait covariation that generate dormancy and germination phenology as well as persistence are still to be quantified. Note that direction and traits on axes are hypothetical.

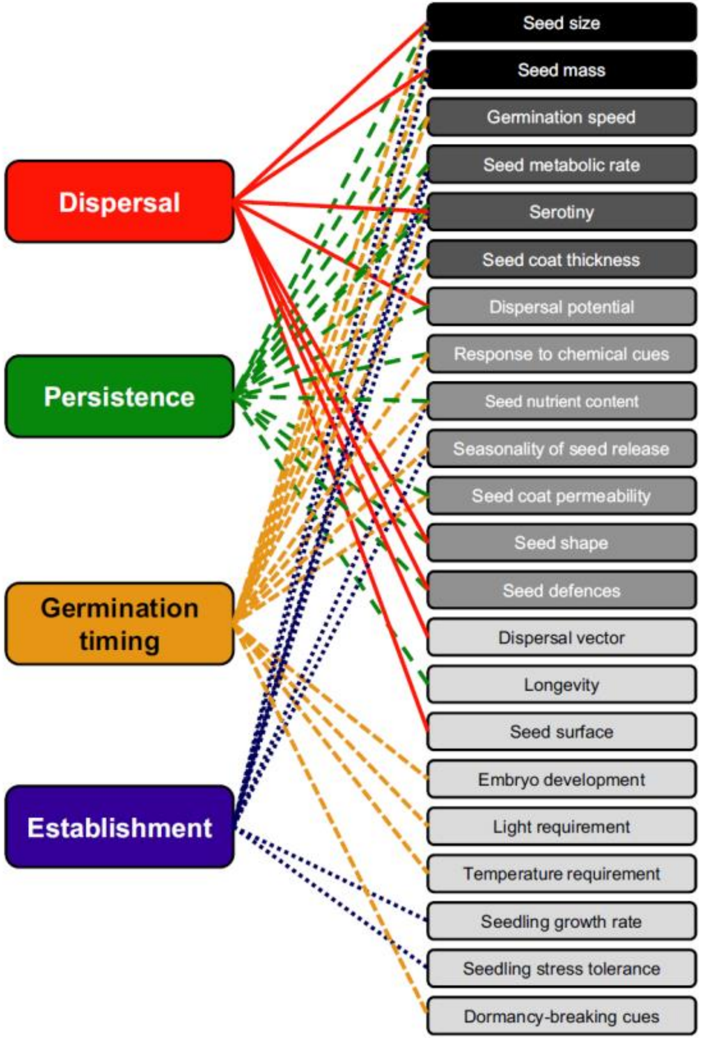


Fig. 3 Network between seed functions (left) and seed traits (right). Lines indicate direct links between traits and functions (coloured). The shading of trait boxes refers to the number of links with seed functions. Dispersal (red) is defined as the horizontal movement of diaspores away from the parent plant. Persistence (green) is the ability of seeds to remain alive in the canopy or soil seed bank and reduce granivory and fungal attack. Germination timing (orange) is the time after dispersal when germination – that is, radicle emergence – occurs; it bridges unfavourable conditions and matches seedling emergence to the optimal moments for regeneration. Seeds can schedule their emergence by dormancy traits and breaking requirements that interact with the seed environment and, once nondormant, with germination traits, such as light and temperature requirements. Establishment (blue) comprises all subsequent functions after germination (emergence, establishment) that result in the successful recruitment of individuals into a population, and also includes seedling traits. Seed traits shown here represent traits broadly (e.g. 'seed metabolic rate' is the CO_2/O_2 gas exchange of seeds under standardized conditions; 'dispersal potential' is an index based on the percentage of seeds dispersed beyond a reference distance by a specific vector; 'embryo development' includes embryo : seed size ratio and embryo growth parameters; 'seed nutrient content' represents carbon (C), nitrogen (N), and phosphorus (P) content; 'response to chemical cues' include germination response to nitrate, karrikins, etc.; 'seed surface' includes seed appendages, hairs, mucilage, etc.; 'seed defences' includes content of repellent or toxic substances in the seed coat, e.g. phenols, and mechanical resistance). We plan to publish a handbook that complements this work with detailed definitions, methods of measurements, and standardized data reporting for seed functional traits.

Dormancy types

Dormancy classification is an endless source of confusion and misunderstandings

Endogenous
Innate
Organic
Embryonic
Morphological
Physiological
Morphophysiological
Exogenous
Seed-coat imposed
Physical
Combined
Double
Chemical
Mechanical
Primary
Secondary
Induced
Photodormancy
Skotodormancy
Thermodormancy
Osmodormancy
Enforced
Imposed
Apparent
Partial
Full
Nondeep
Intermediate
Deep
Very deep

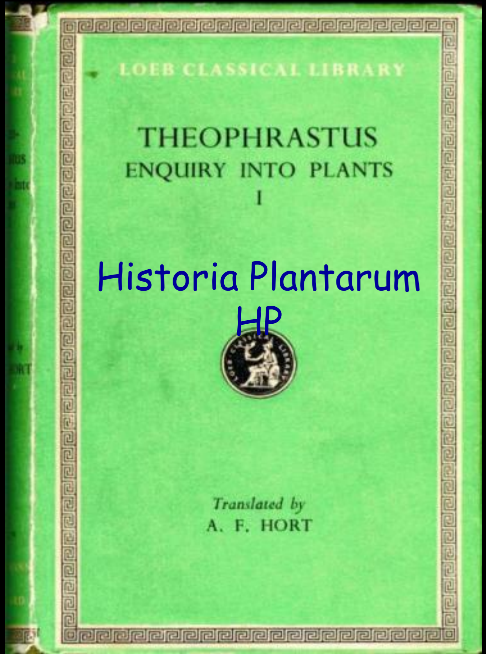
Germination Characters

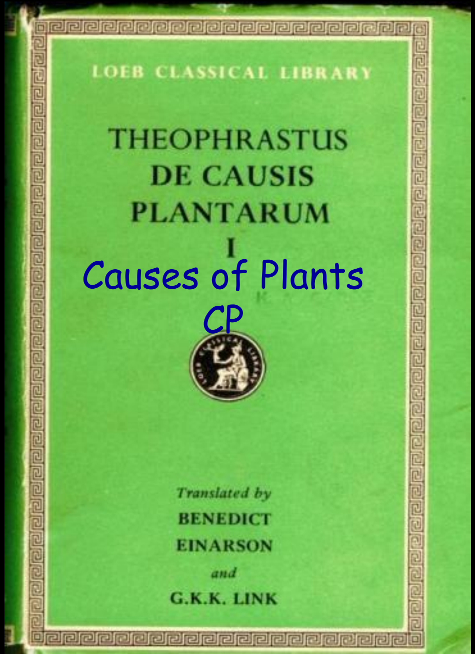
The distinctive types of germination behaviour

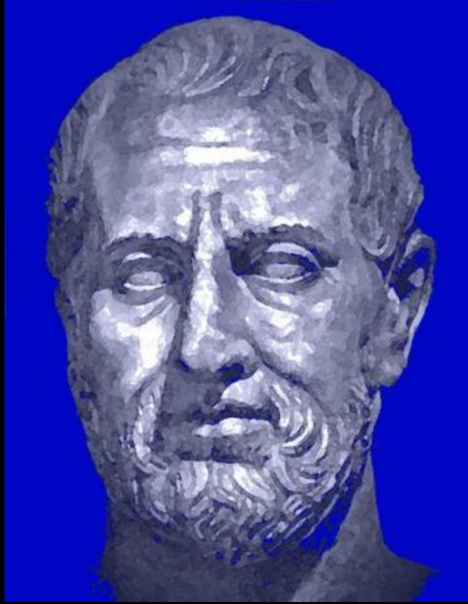
Germination Functional Types

“Theophrastus is the father of Botany”

Carl von Linnaeus
(1707-1778)







Θεόφραστος ο Ερέσιος
(371-286 πΧ)

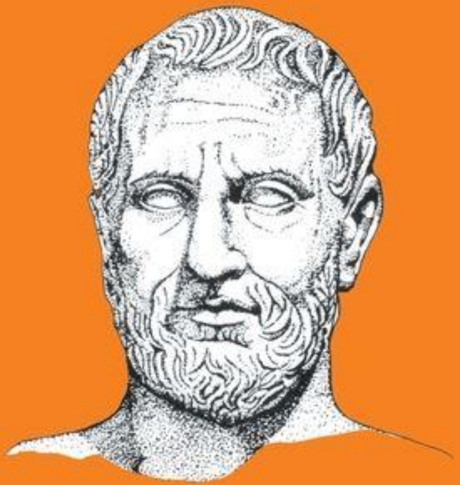
ΘΕΟΦΡΑΣΤΟΥ
ΧΑΡΑΚΤΗΡΕΣ
ΗΘΙΚΟΙ.

THEOPHRASTI
CHARACTERES
ETHICI.

EX RECENSIONE
PETRI NEEDHAM,
ET VERSIONE LATINA
ISAACI CASAUBONI.

GLASGUAE:
IN AEDIBUS ACADEMICIS
EXCUDEBANT ROBERTUS ET ANDREAS FOULIS
ACADEMIAE TYPOGRAPHI
MDCCLVIII.

THE CHARACTERS OF THEOPHRASTUS



EDITED WITH INTRODUCTION
COMMENTARY AND INDEX
BY R.G. USSHER

ΘΕΟΦΡΑϹΤΟΥ ΧΑΡΑΚΤΗΡΕϹ ΗΘΙΚΟΙ

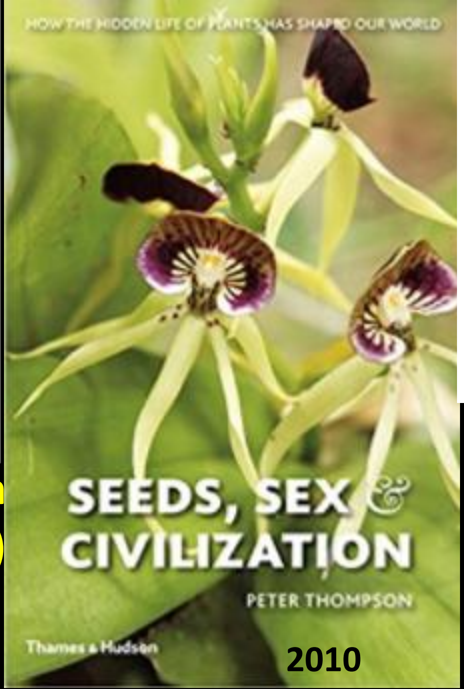
ΘΕΟΦΡΑϹΤΟΥ ΧΑΡΑΚΤΗΡΕϹ ΗΘΙΚΟΙ

εἰρωνείαϲ α΄
κολακείαϲ β΄
ἀδολεϲχίαϲ γ΄
ἀγροικίαϲ δ΄
ἀρεϲκείαϲ ε΄
ἀπονοίαϲ ϛ΄
λαλιᾶϲ ζ΄
λογοποιίαϲ η΄
ἀναιϲχυντίαϲ θ΄
μικρολογίαϲ ι΄
βδελυρίαϲ ια΄
ἀκαιρίαϲ ιβ΄
περιεργίαϲ ιγ΄
ἀναιϲθηϲίαϲ ιδ΄
αὐθαδείαϲ ιε΄
δειϲιδαιμονίαϲ ιϛ΄
μεμψιμοιρίαϲ ιζ΄
ἀπιϲτίαϲ ιη΄
δυϲχερείαϲ ιθ΄
ἀηδίαϲ κ΄
μικροφιλοτιμίαϲ κα΄
ἀνελευθερίαϲ κβ΄
ἀλαζονείαϲ κγ΄
ὑπερηφανίαϲ κδ΄
δειλίαϲ κε΄
ὀλιγαρχίαϲ κϛ΄
ὀψιμαθίαϲ κζ΄
κακολογίαϲ κη΄
φιλοπονηρίαϲ κθ΄
αἰϲχροκερδείαϲ λ΄

CHARACTERS OF THEOPHRASTUS

1. Ironical
2. Flatterer
3. Garrulous
4. Boor
5. Reckless
6. Chatty
7. Gossip
8. Shameless
9. Penurious
10. Gross
11. Unreasonable
12. Officious
13. Stupid
14. Surly
15. Superstitious
16. Grumbler
17. Distrustful
18. Offensive
19. Unpleasant
20. Of Petty Ambition
21. Mean
22. Boastful
23. Arrogant
24. Coward
25. Oligarch
26. Late Learner
27. Slanderer
28. Patron of Rascals
29. Avaricious
30. Shabby Profiteer

Peter Thompson (P.A. Thompson) died Dec. 2008



2010

Pioneer of germination ecophysiology (& seed banking)

Ann. Bot. 39, 1–19, 1975

QUALITY CONTROL MARK

Characterization of the Germination Responses of *Silene dioica* (L.) Clairv., Populations from Europe

P. A. THOMPSON

Royal Botanic Gardens, Wakehurst Place, Ardingly, Sussex

Received: 11 March 1974

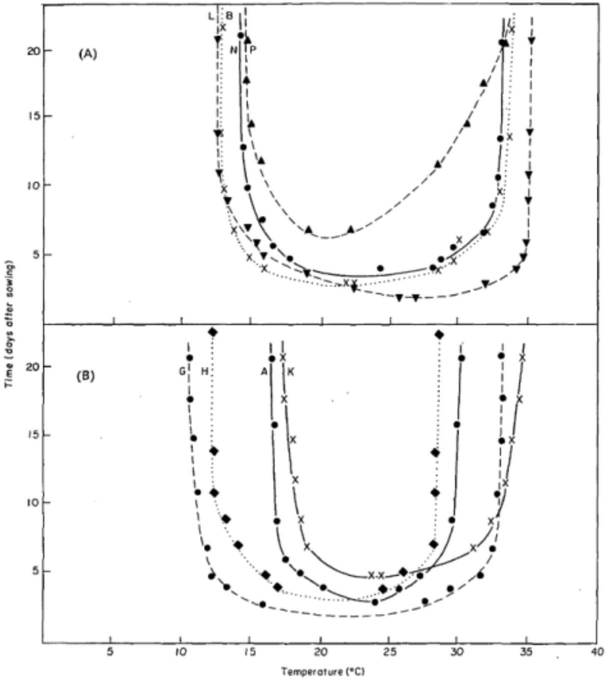


FIG. 3. Germination character curves of populations of *Silene dioica* plotted as maximum and minimum temperatures on successive days which resulted in 50 per cent of final maximum germination rates.

(A) Seed collected from populations growing in Germany (L); Finland (B); Czechoslovakia (N); and Poland (P).

(B) Seed collected from populations growing in England (G and H); Norway (A) and Switzerland (K).

Journal of Ecology, Vol. 58, No. 3 (Nov., 1970), pp. 699-711

A COMPARISON OF THE GERMINATION CHARACTER OF SPECIES OF CARYOPHYLLACEAE COLLECTED IN CENTRAL GERMANY

BY P. A. THOMPSON

Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey

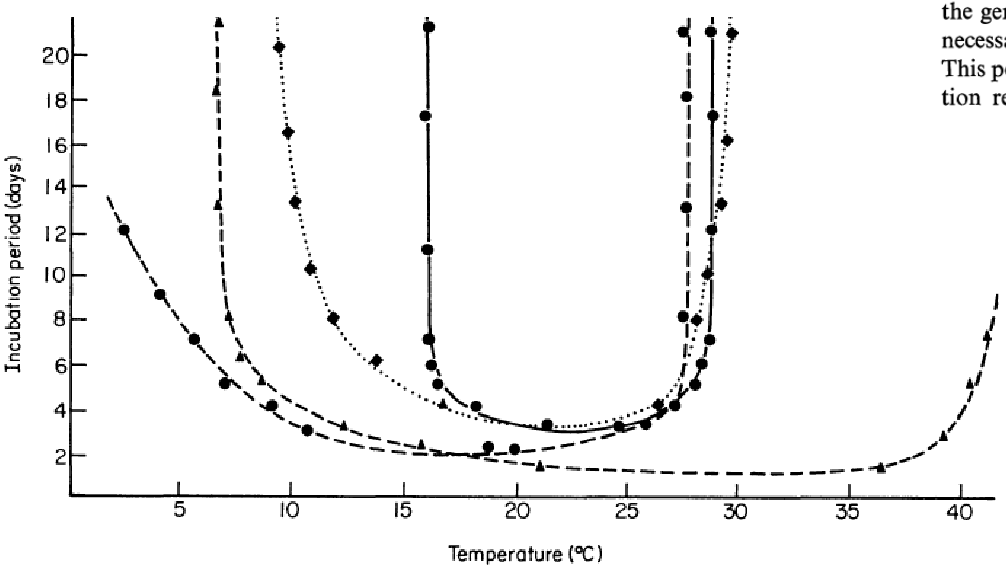


FIG. 5. Germination response curves for maximum and minimum temperatures providing a 50% germination rate on successive days. Tests were made, for four species, on thermo-gradient bars set to cover the range 2–42°C. *Agrostemma githago* (– – ● – –); *Silene dichotoma* (▲); *Lychnis viscaria* (♦); *Silene noctiflora* (— ● —).

[redacted]

of the other species, and minima lower than any apart from *Agrostemma githago*. It could be argued that these three species, which have already been identified as possible adventives within the region, each possessed germination characters which were outside the normal range found for those species considered to be typical of deciduous woodland zones of Europe. More information on the correlations existing between geographical distribution and germination character is presented elsewhere (Thompson 1970a, b).

The preservation within a species of an alien character, as implied here, suggests that the germination responses of adventives, in this case well established as weeds, may not necessarily show obvious signs of adaptation in response to a changed environment. This point was examined in more detail for these three species by comparing the germination responses of populations of seed obtained from different parts of Europe. Two

[redacted]

This implies that the fundamental germination character of a species may not necessarily change on transposition by man, even when the species has been maintained for a lengthy period in an alien environment, as is the case with *A. githago*. This interpretation must be accepted with reservation in view of a conflict of evidence on the point arising from the results of other workers. Thus Stearns & Olson (1958), McNaughton (1966), McWilliams, Landers & Mahlstede (1968) working with *Tsuga canadensis*, *Typha* species and *Amaranthus retroflexus* respectively have reported differences in the germination responses of populations from different parts of North America, and Harper (1965) notes that the germination requirement of a species may differ markedly over its geographical range, although Lauer (1953) found few differences in the responses of *Agrostemma githago* and *Datura stramonium* collected in various parts of Europe.

However, ecotypic variations in the physiological responses of European species are well authenticated with respect to plant height and flowering time (e.g. Turesson 1930) and a recent review by Hiesey & Milner (1965) has spotlighted the wide range of adaptive responses found in natural populations to variations in nutrient status, photoperiod, temperature and rates of photosynthesis and respiration. These examples of physiological adaptations to environment prevent an easy acceptance of the suggestion that the physiological responses involved in germination may be relatively non-plastic. But it is suggested that the examination of this problem depends largely on a concise, simple method of making comparisons of germination responses to different conditions such as the one described in this paper.

5 Germination Characters

Postdevelopers

Hardcoaters

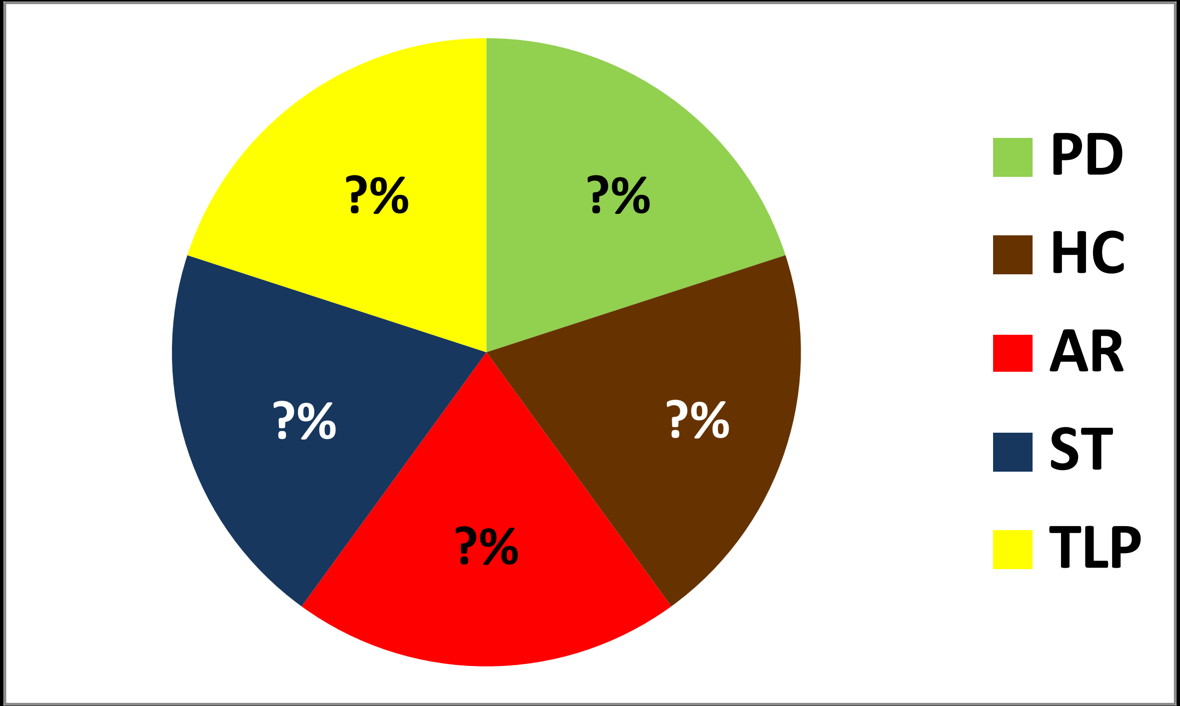
Afterripeners

Stratificationers

Temperature(and light)-probers

5 Germination Characters

IN THE MEDITERRANEAN

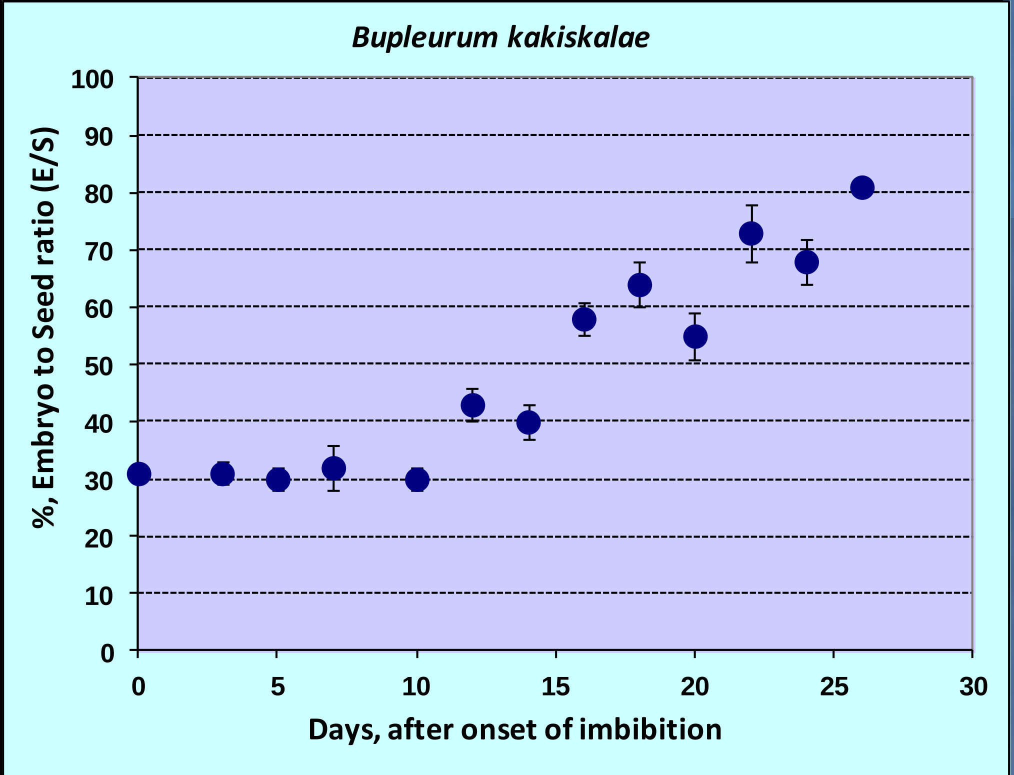


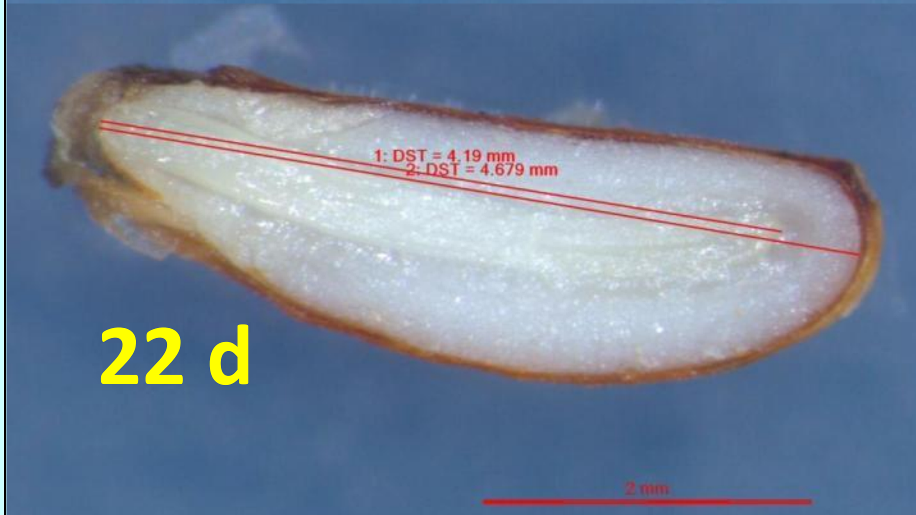
Postdevelopers

Seeds with underdeveloped or undifferentiated embryos

Bupleurum kakiskalae
(Apiaceae)

Bupleurum kakiskalae (Apiaceae)





Fournaraki 2010

Postdevelopers

37 Families / 200

Considerably determined by phylogeny

Plus the undifferentiated embryos:
Orchidaceae c. 500 spp.
Orobanchaceae c. 150 spp.

c. 5-10% of the Mediterranean Flora

Seeds with underdeveloped or undifferentiated embryos are associated with delayed, WINTER or SPRING germination

Apiaceae	52
Asparagaceae	10
Campanulaceae	13
Gentianaceae	15
Liliaceae	11
Papaveraceae	12
Ranunculaceae	45
	158
total number	209

Hardcoaters

Seeds with water impermeable seed coats

Int. J. Wildland Fire 6(2): 77-82, 1996
© IAWF. Printed in U.S.A.

Legumes in the Fire-Prone Mediterranean Regions: an Example From Greece*

Margarita Arianoutsou[1] and Costas A. Thanos[2]

The frequency of LEGUMES tends to increase along decreasing altitudinal and latitudinal gradients.
In drier Mediterranean environments, therophytes (and among them annual papilionoid legumes) dominate the local floras

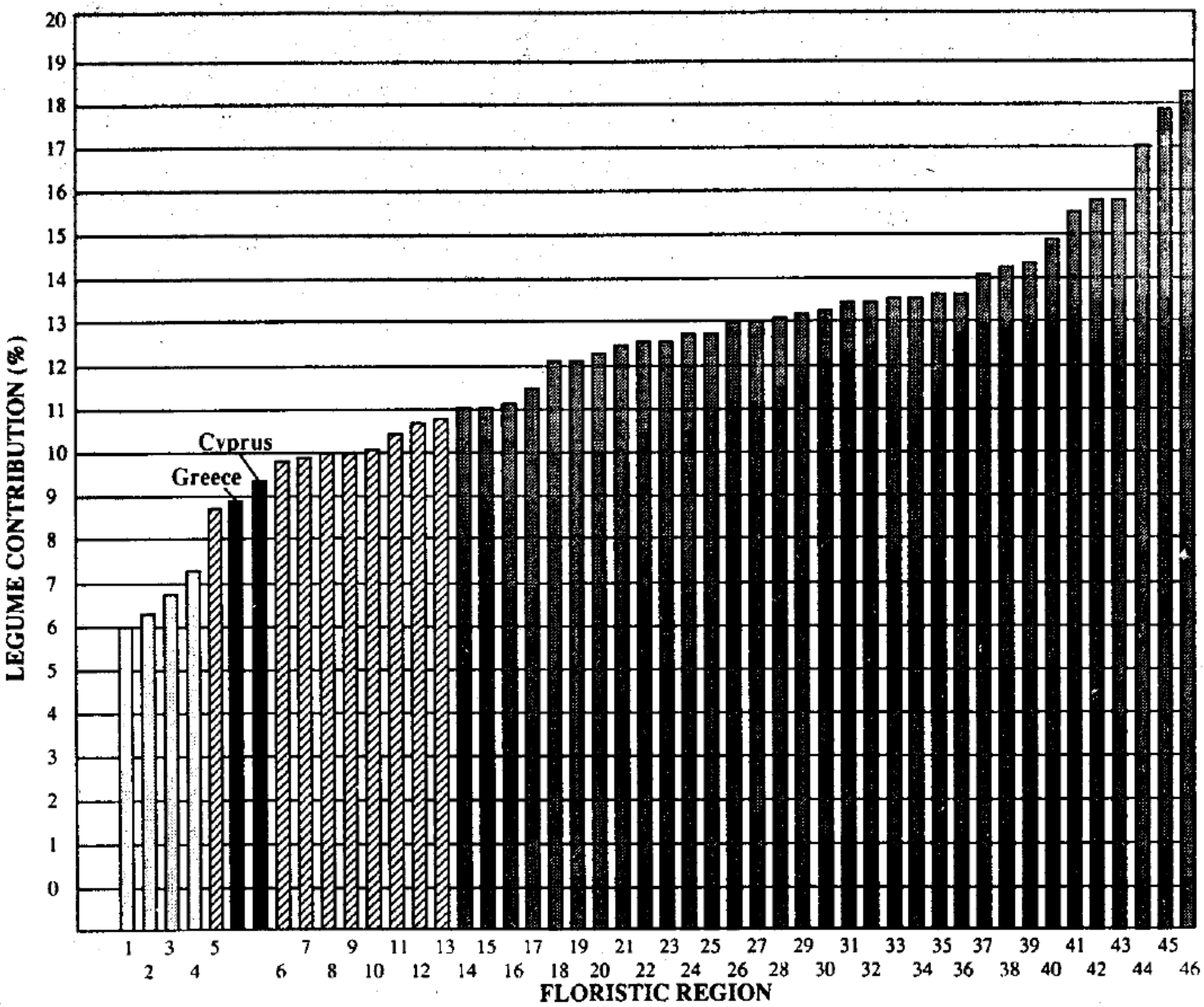
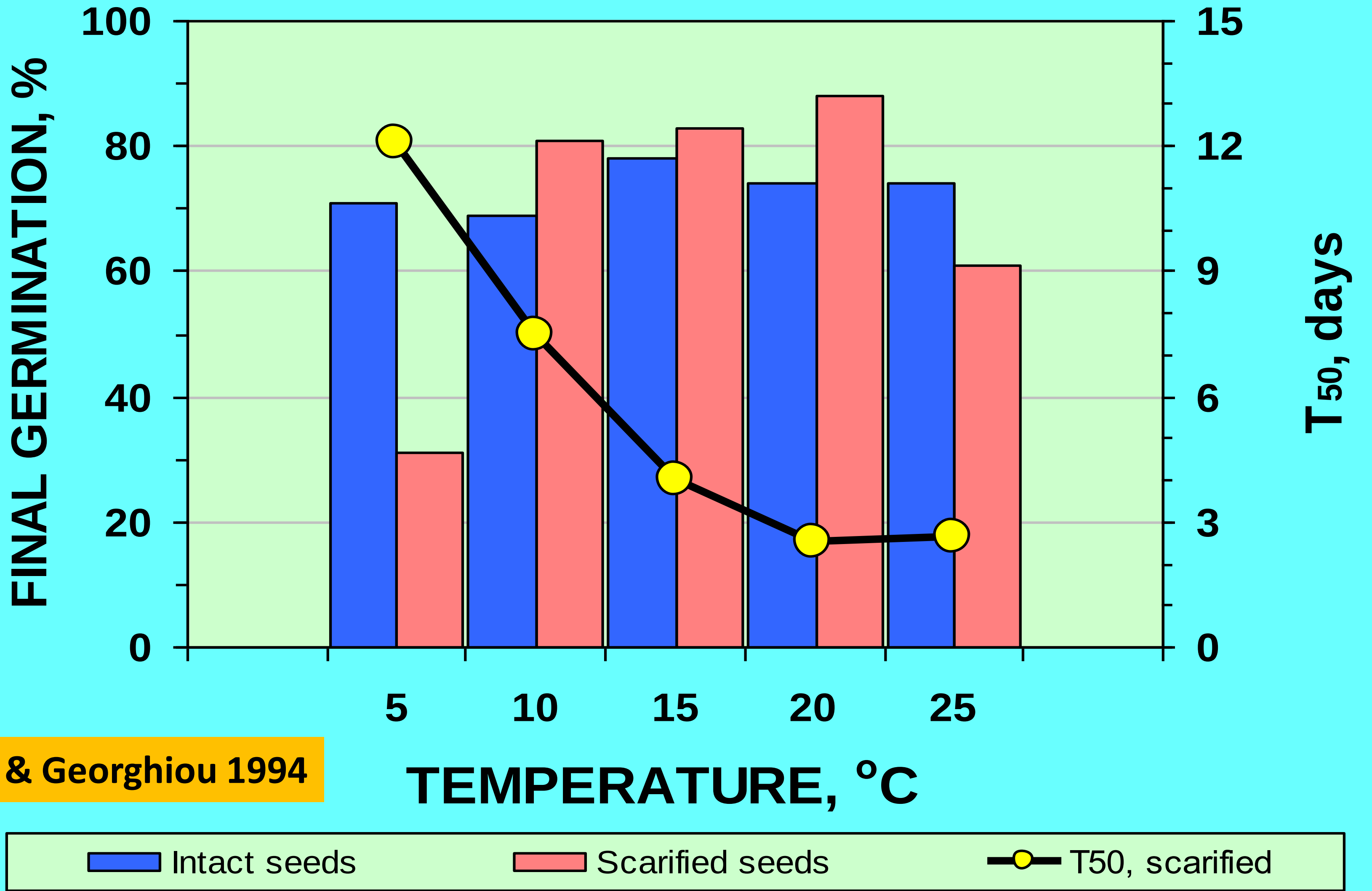


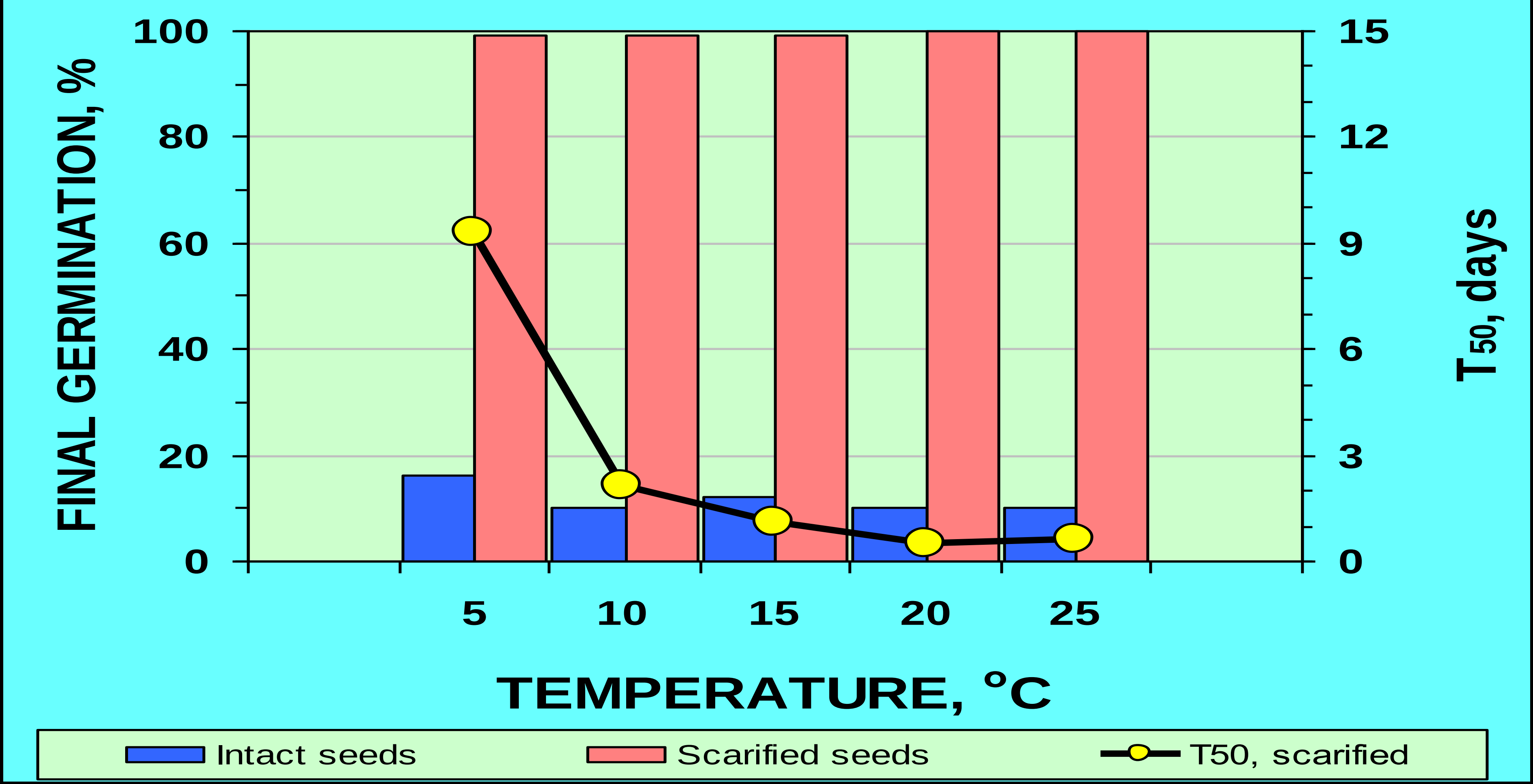
Figure 1. Contribution of legumes to the total flora of various geographic regions of Greece (in the cases marked with * the contribution has been estimated on a species plus subspecies basis). 1 Mountains of Greece * (Strid 1991) 2 Lailias Mt. (Voliotis 1977) 3 Macedonian Mts (Quezel and Contandriopoulos 1968) 4 Prespas Lakes Nat. Park (Pavlidis 1985) 5 Psathura Isl. (Snogerup et al. 1980) 6 Cholomon Mt. (Voliotis 1967) 7 Crete Isl. (Barclay 1986) 8 Lesbos Isl. (Cantargy 1889) 9 Euboea Isl. (Rechinger 1961) 10 Vertiscos Mt. range (Pavlidis 1982) 11 Strofilia hydrobiotope (Georgiadis et al. 1990) 12 Cephallonia Isl. (Phitos and Damboldt 1985) 13 Central Euboea Isl. (Phitos 1960) 14 Yioura Isl. (Kamari et al. 1988) 15 Armathia Isl. and 15 islets (Raus 1989) 16 Corfu Isl. (Georgiou 1988) 17 Syros Isl. (Sarlis 1994) 18 Skopelos Isl. (Economidou 1973) 19 Hymettus Mt. (Zerlendis 1973) 20 Ag. Evstratios Isl. (Snogerup 1991) 21 Schinias pine forest (Brofas and Karetsos 1991) 22 Yiaros Isl. (Tzanoudakis 1981) 23 Skiathos Isl. (Economidou 1969) 24 Cythera Isl. (Yannitsaros 1969) 25 Mt. Paikon grazelands (Drossos and Athanassiadis 1989) 26 Kira Panagia Isl. (Snogerup et al. 1991) 27 Aetoloacarnanian lakes (Koumpli-Sovantzi 1983) 28 Cassandra Peninsula (Lavrentiadis 1961) 29 Dionysades Isls (Christodoulakis et al. 1990) 30 Chios Isl. * (Meikle 1954) 31 Santorini Isls (Hansen 1971) 32 Sithonia Peninsula (Pavlidis 1976) 33 Samos Isl. (Christodoulakis 1986) 34 Kos-Kalymnos-Pserimos-Telendos Isls (Hansen 1980) 35 Spetses Isl. (Nikolaidou and Yannitsaros 1992) 36 S. Euboeic Gulf islands (Sarlis 1981) 37 Elaphonesos Isl. (Yannitsaros 1971) 38 Piperi Isl. (Tsimburla and Yannitsaros 1992) 39 Skantzoura Isl. (Gustaffson and Snogerup 1974) 40 Nisyros Isl. (Papatsou 1975) 41 Paxi Isl. (Georgiadis et al. 1986) 42 Kassandra pine forests* (Tsitsoni and Karagiannakidou 1987) 43 Seven islets of N. Dodecanesus (Panitsa and Tzanoudakis 1991) 44 Kastellorizo Isl. (Greuter 1979) 45 Psara Isl. (Greuter 1976) 46 Oinousses Isls (Panitsa et al. 1994).

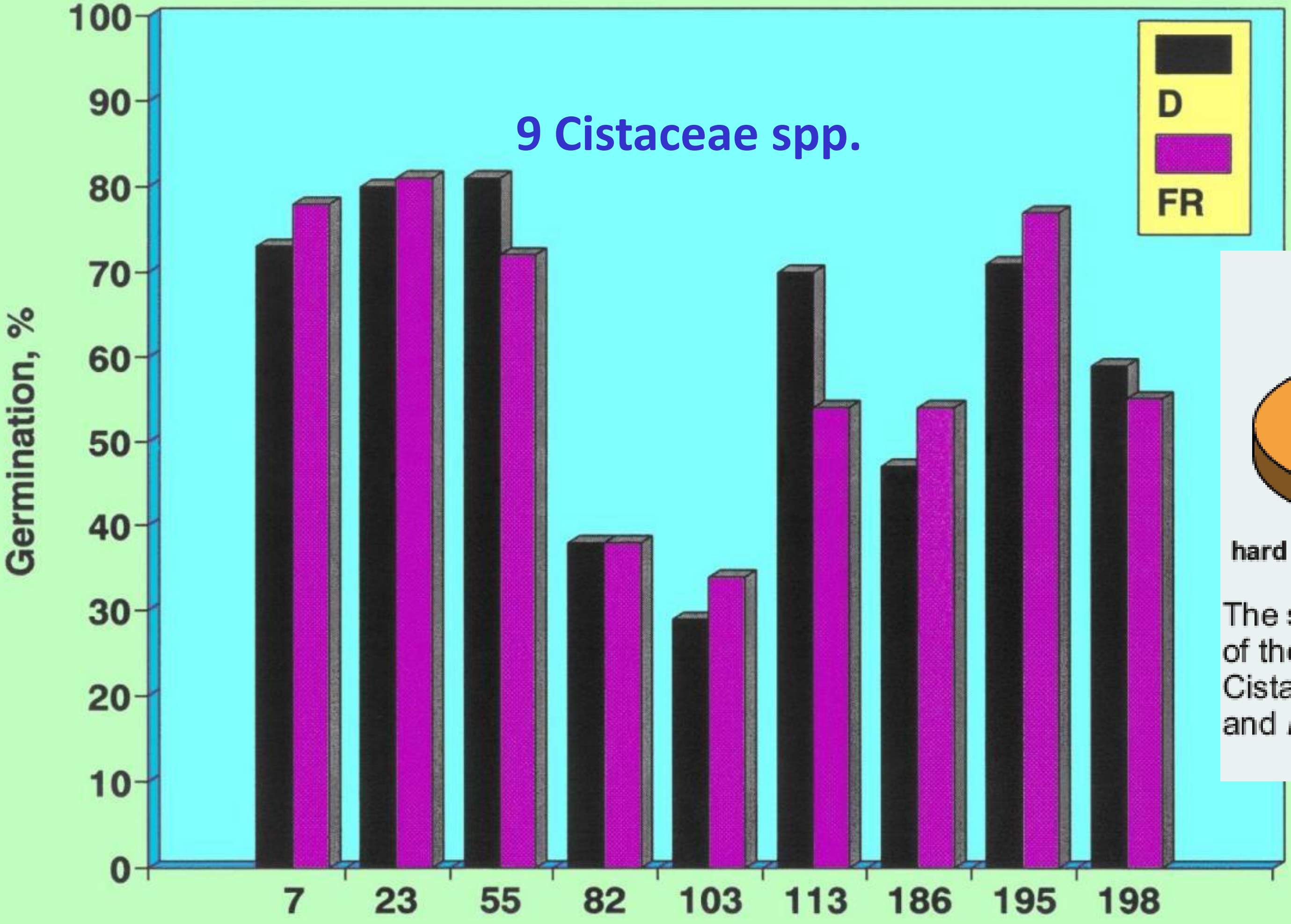


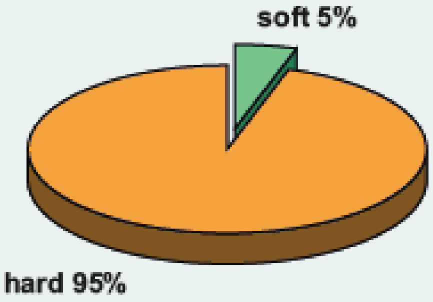
Doussi & Georghiou 1994

Doussi & Georghiou 1994

Ebenus sibthorpii







The soft- and hard-coated portions of the seed population for two Cistaceous species: *Cistus creticus* and *Fumana arabica*

Thanos et al. 1992

Hardcoaters

9 Families / 200

Strongly determined by phylogeny

10.4% of the Greek Flora

c. 11% of the Mediterranean Flora

Hard (water-impermeable) coats are affiliated to:
EPISODIC (postfire) or
ERRATIC germination (after animal consumption, drought, freezing/thawing, weathering …)

USUALLY indifferent to temperature and light

	GREECE
Anacardiaceae	5
Biebersteiniaceae	1
Bixaceae	
Cannaceae	
Cistaceae	28
Convolvulaceae	41
Cucurbitaceae	
Dipterocarpaceae	
Fabaceae	441
Geraniaceae	43
Malvaceae	28
Nelumbonaceae	
Rhamnaceae	1
Sapindaceae	
Sarcolaenaceae	
Sphaerosepalaceae	
Surianaceae	
	588

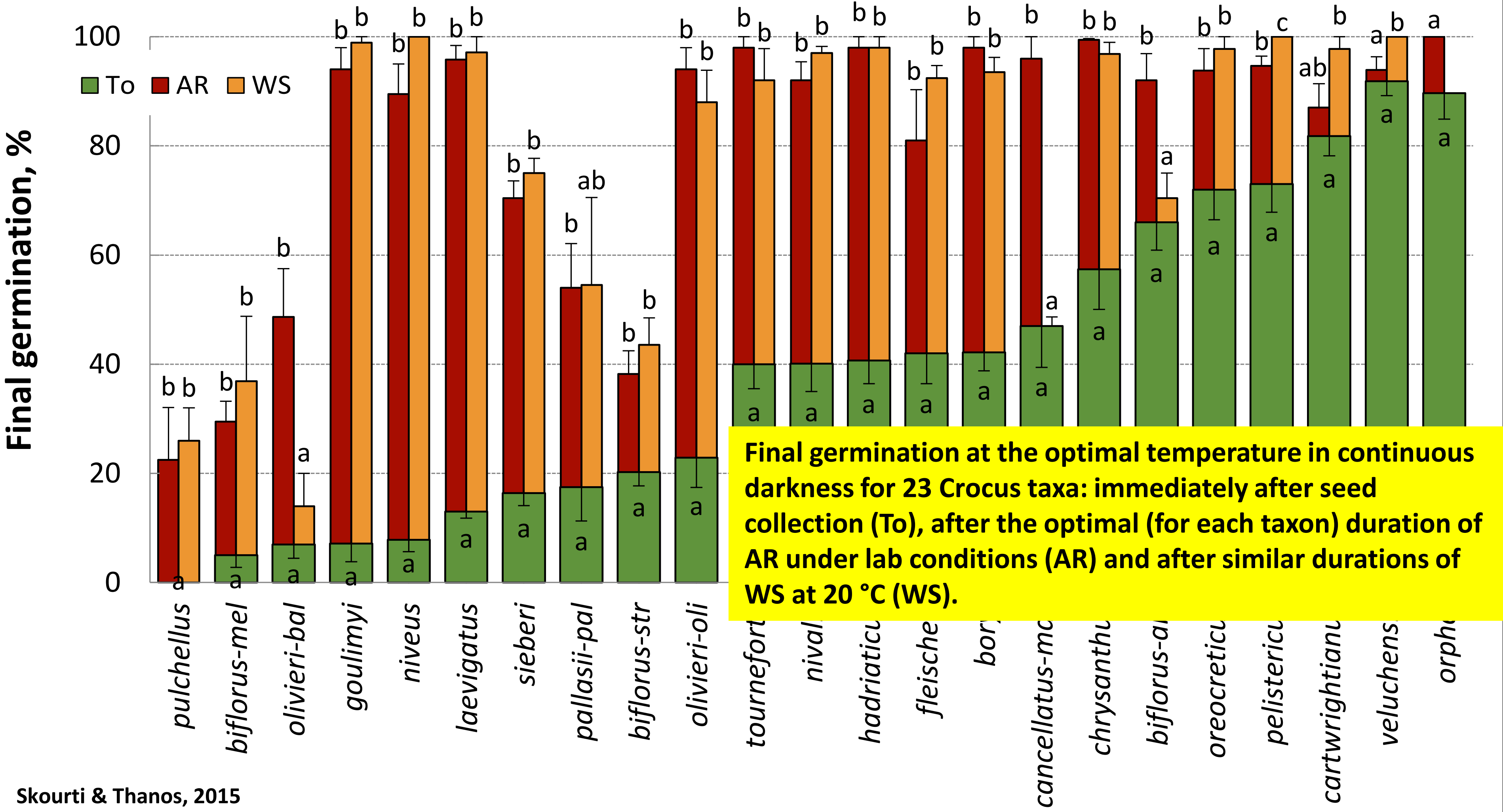
Afterripeners

Seeds require a few months at dry, warm conditions

C. chrysanthus

C. biflorus subsp. *nubigena*

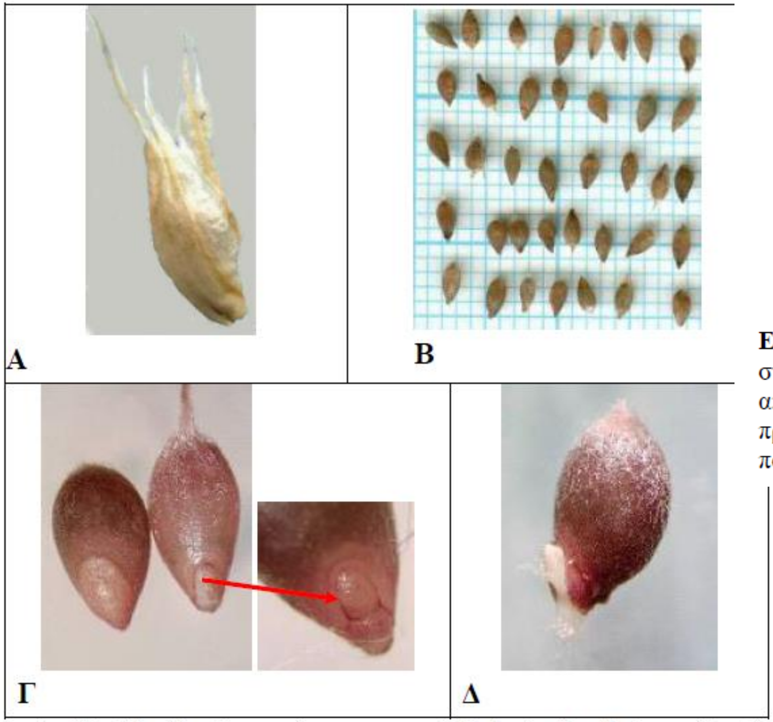
C. cartwrightianus



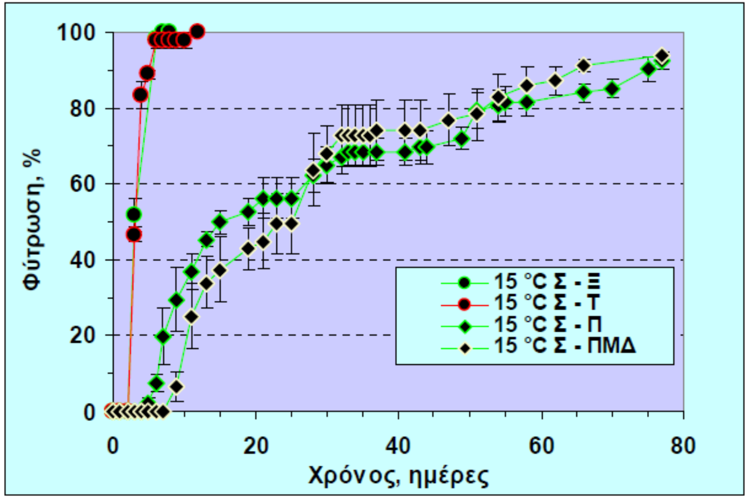
Final germination at the optimal temperature in continuous darkness for 23 Crocus taxa: immediately after seed collection (To), after the optimal (for each taxon) duration of AR under lab conditions (AR) and after similar durations of WS at 20 °C (WS).

Skourti & Thanos, 2015

Sesleria doerfleri (Poaceae)



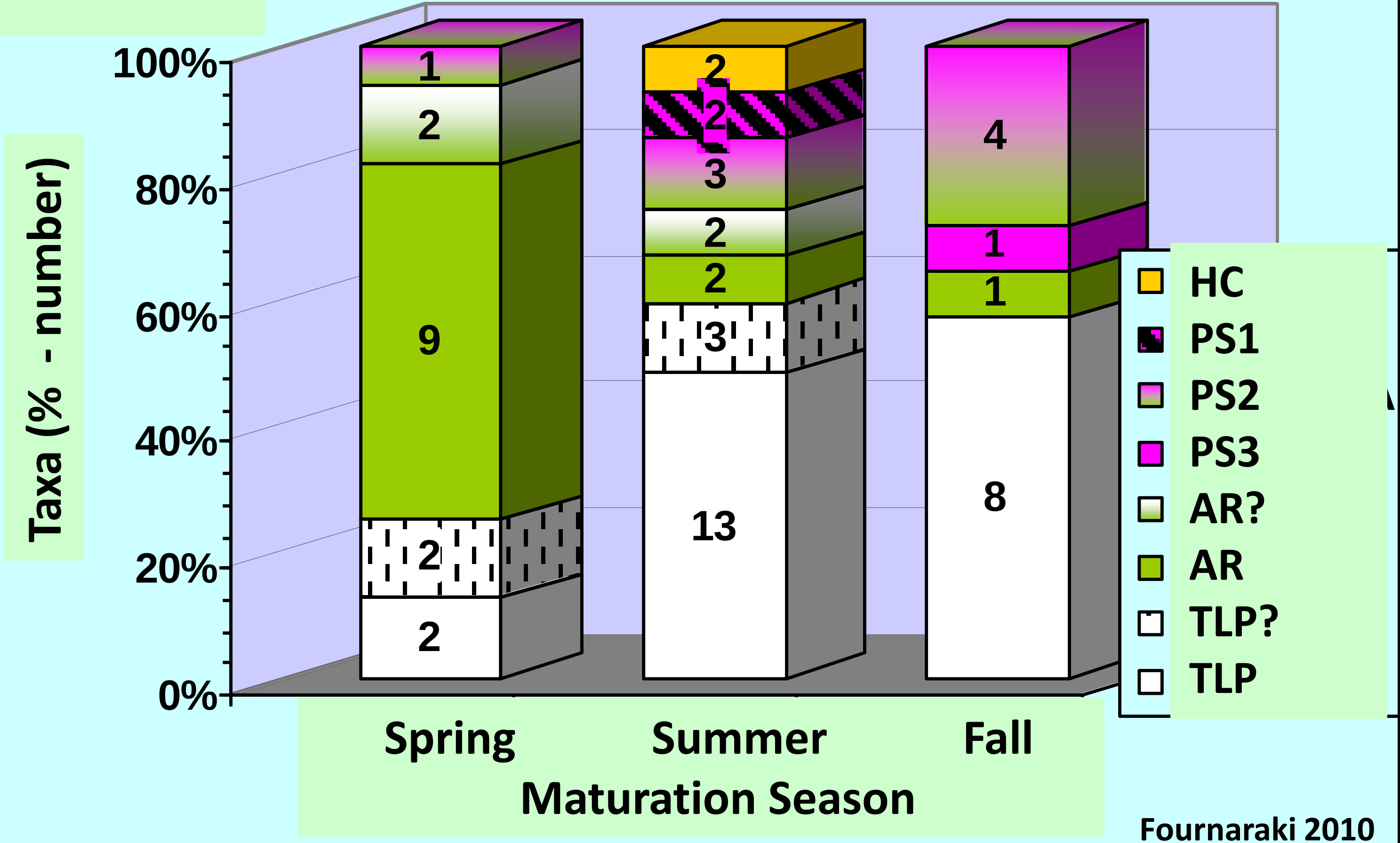
Φωτογραφία 71. Μονάδα διασποράς και καρποί *Sesleria doerfleri*: μονάδα διασποράς (καρύοψη που περιβάλλεται από τις λεπίδες) (**A**), καρποί (**B**), καρποί στη βάση των οποίων διακρίνεται το έμβρυο (**Γ**), φυτρωμένος καρπός (**Δ**).



Εικόνα 138. Χρονική πορεία της φύτρωσης σπερμάτων *Sesleria doerfleri* στους 15 °C, σε συνεχές σκοτάδι (Σ). Ξ: Σπέρματα που παρέμειναν στο ξηραντήριο 22 μήνες, Τ: σπέρματα που αποθηκεύτηκαν στην Τράπεζα Σπερμάτων για περίπου 4 μήνες, Π: σπέρματα που συλλέχθηκαν πρόσφατα (πραγματοποίηση πειράματος την επομένη της συλλογής), ΠΜΔ: μονάδες διασποράς που συλλέχθηκαν πρόσφατα. Οι κατακόρυφες γραμμές αντιστοιχούν στο ± τυπικό σφάλμα.

Fournaraki 2010

Threatened plants of Crete



Fournaraki 2010

Afterripeners

27 Families / 200

Considerably determined by phylogeny (very INCOMPLETE data)

c. ??% of the Mediterranean Flora

Usually manifested by plants with ‘early seed maturation’. AR is believed to safeguard seeds from untimely summer/early autumn germination.

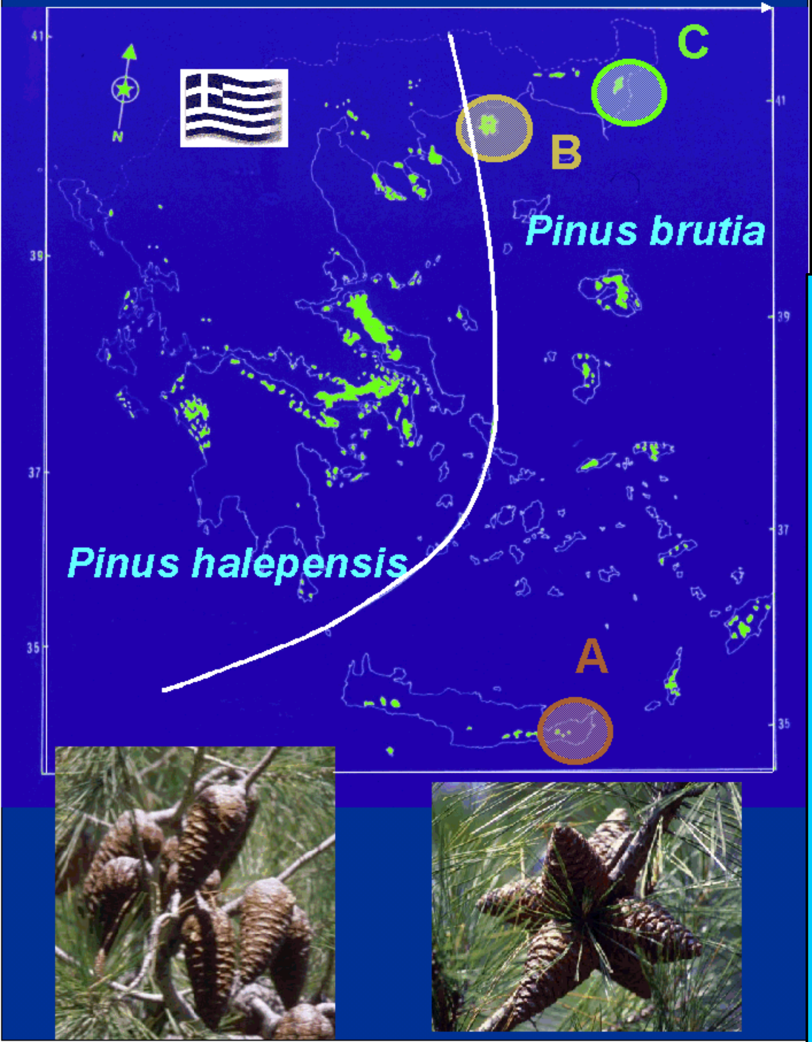
Quite common in the south of Europe.

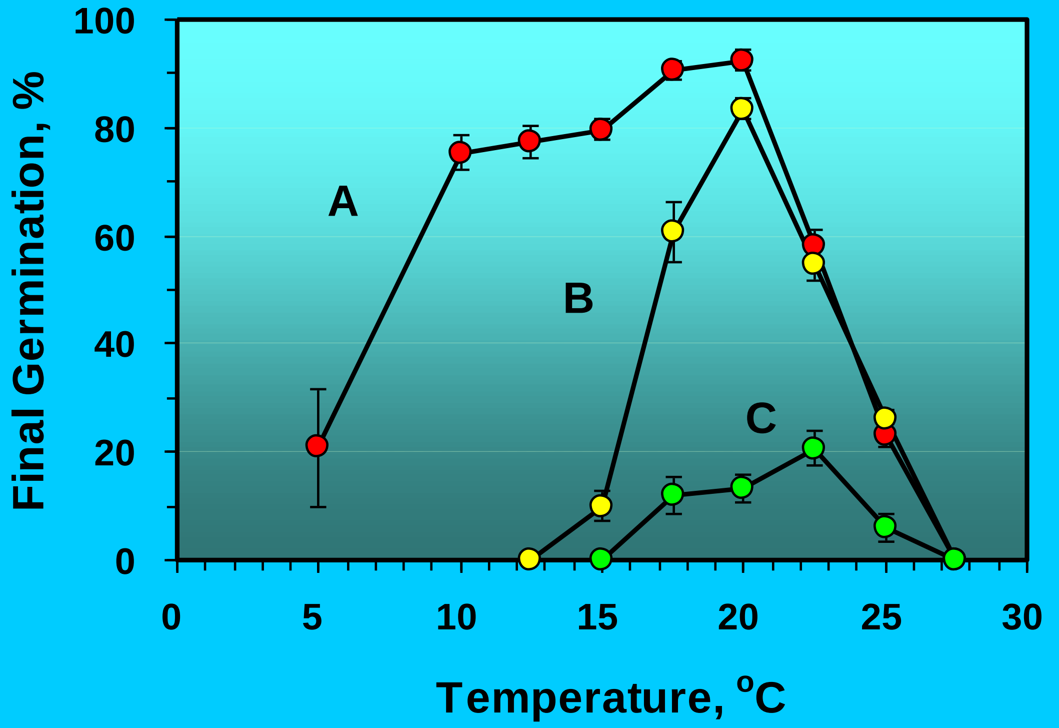
Asteraceae	11
Brassicaceae	32
Caryophyllaceae	20
Iridaceae	37
Poaceae	48
	148
total number	194

Stratificationers

Seeds require a period of weeks or months at wet, cold conditions

Germinability (in the Dark) of seeds from 3 Greek *Pinus brutia* provenances






Aesculus hippocastanum
CRITICALLY ENDANGERED (CR)

Aesculus hippocastanum

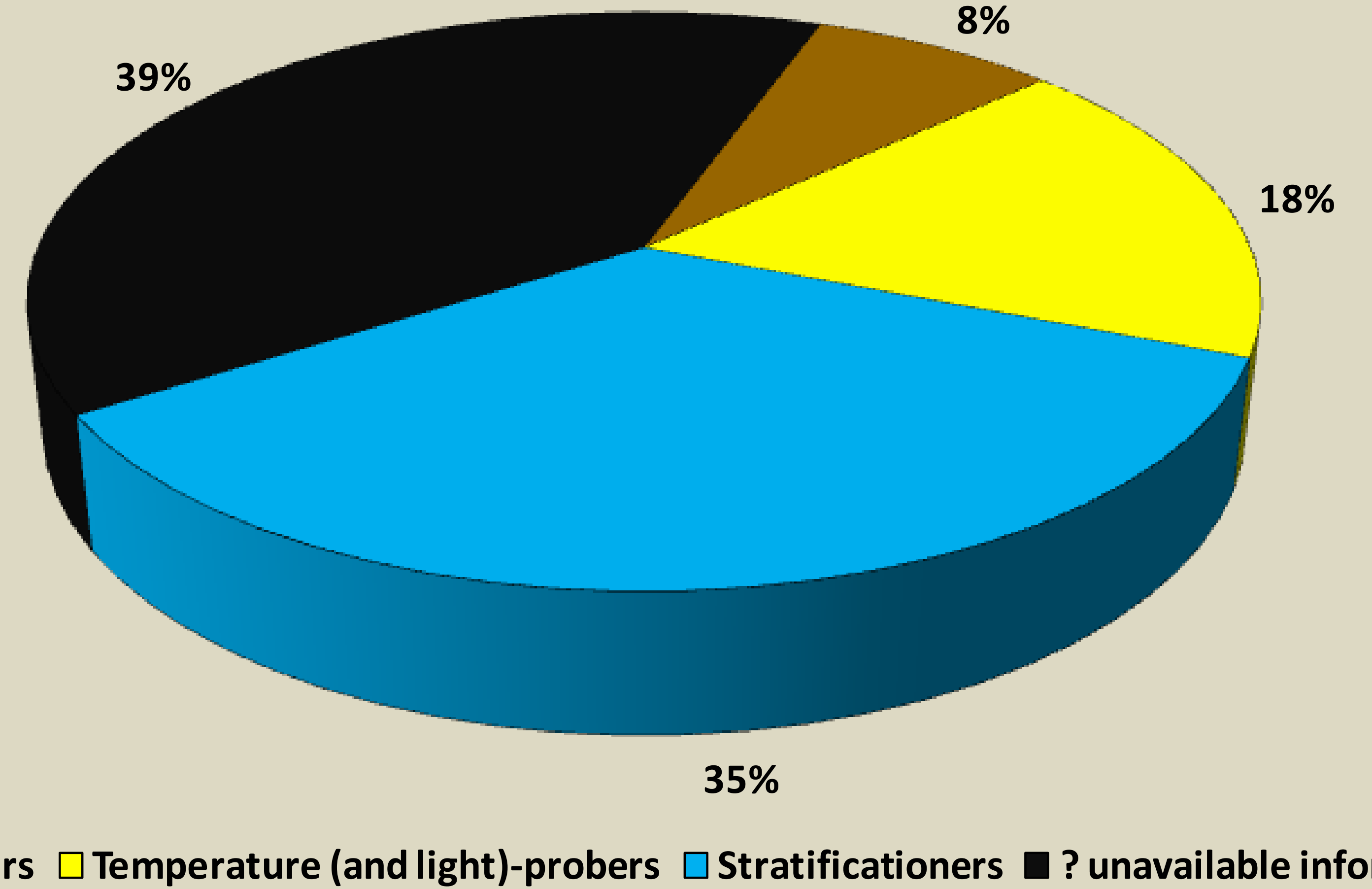
Germination in the Lab

Dormancy is fully released after a period of 4-5 months of stratification at 5 °C

Germination characters

169 TREES OF THE GREEK FLORA

Daskalakou et al. 2018



Stratificationers

65 Families / 200

Weakly determined by phylogeny

c. ??% of the Mediterranean Flora

A requirement of cold stratification is associated with:
LATE WINTER or
SPRING germination

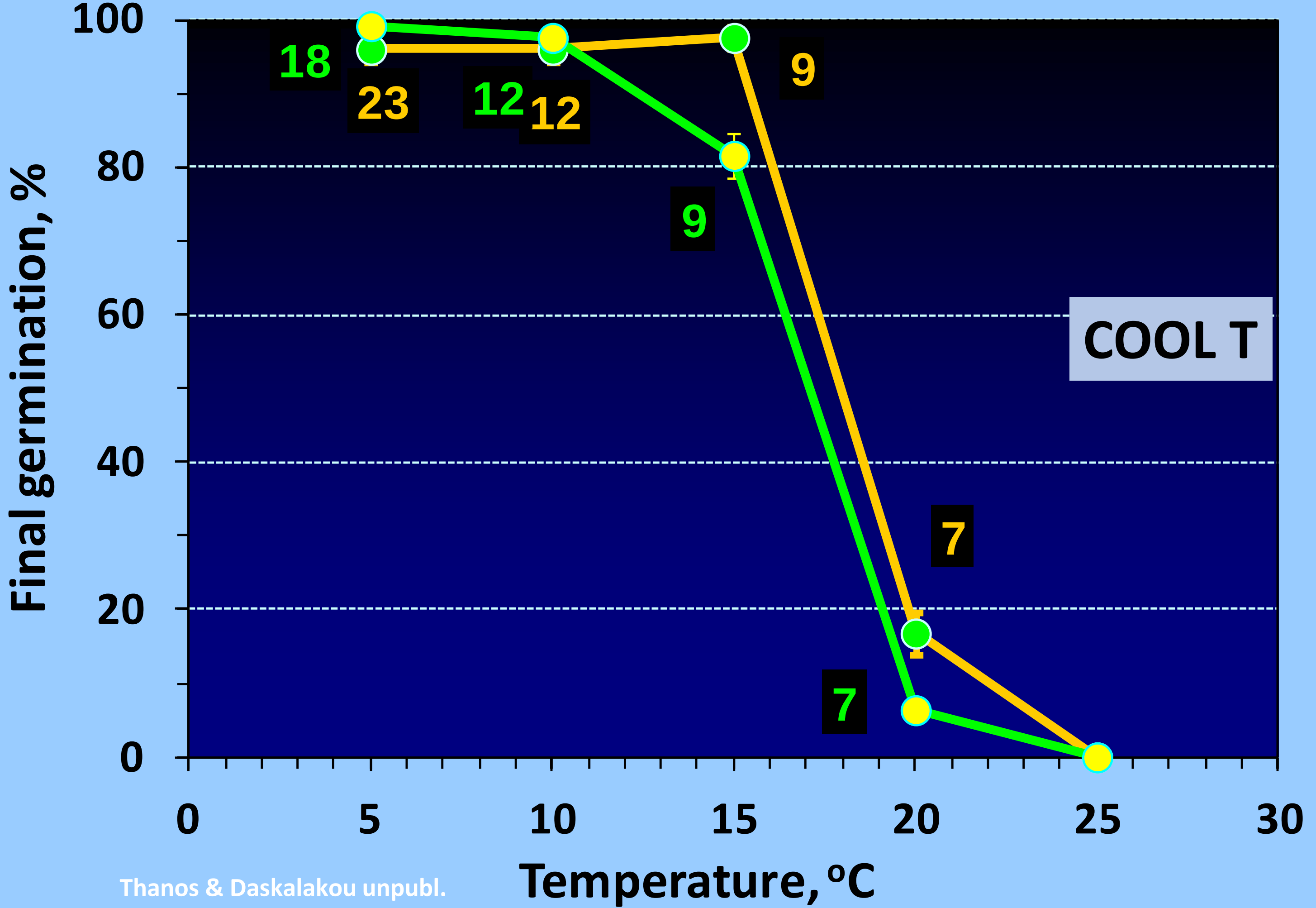
Increasingly more common with increasing altitude and latitude

Amaranthaceae	19
Asteraceae	76
Betulaceae	10
Boraginaceae	12
Brassicaceae	39
Caryophyllaceae	27
Cyperaceae	46
Ericaceae	28
Lamiaceae	42
Orobanchaceae	10
Plantaginaceae	14
Poaceae	39
Polygonaceae	14
Rosaceae	69
	445
total number	605

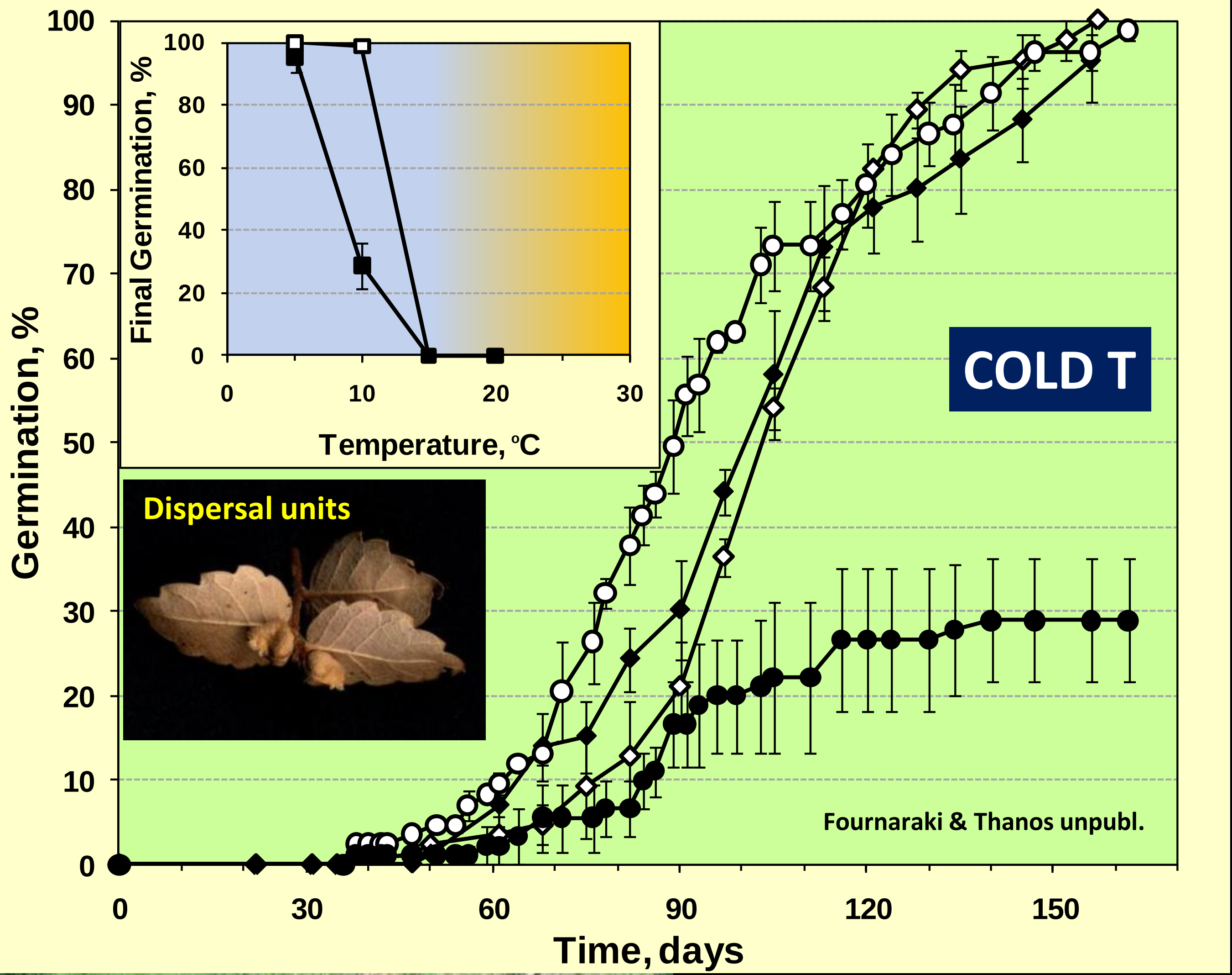
Temperature/light-probers

Seeds germinate under specific, optimal conditions of temperature and/or light

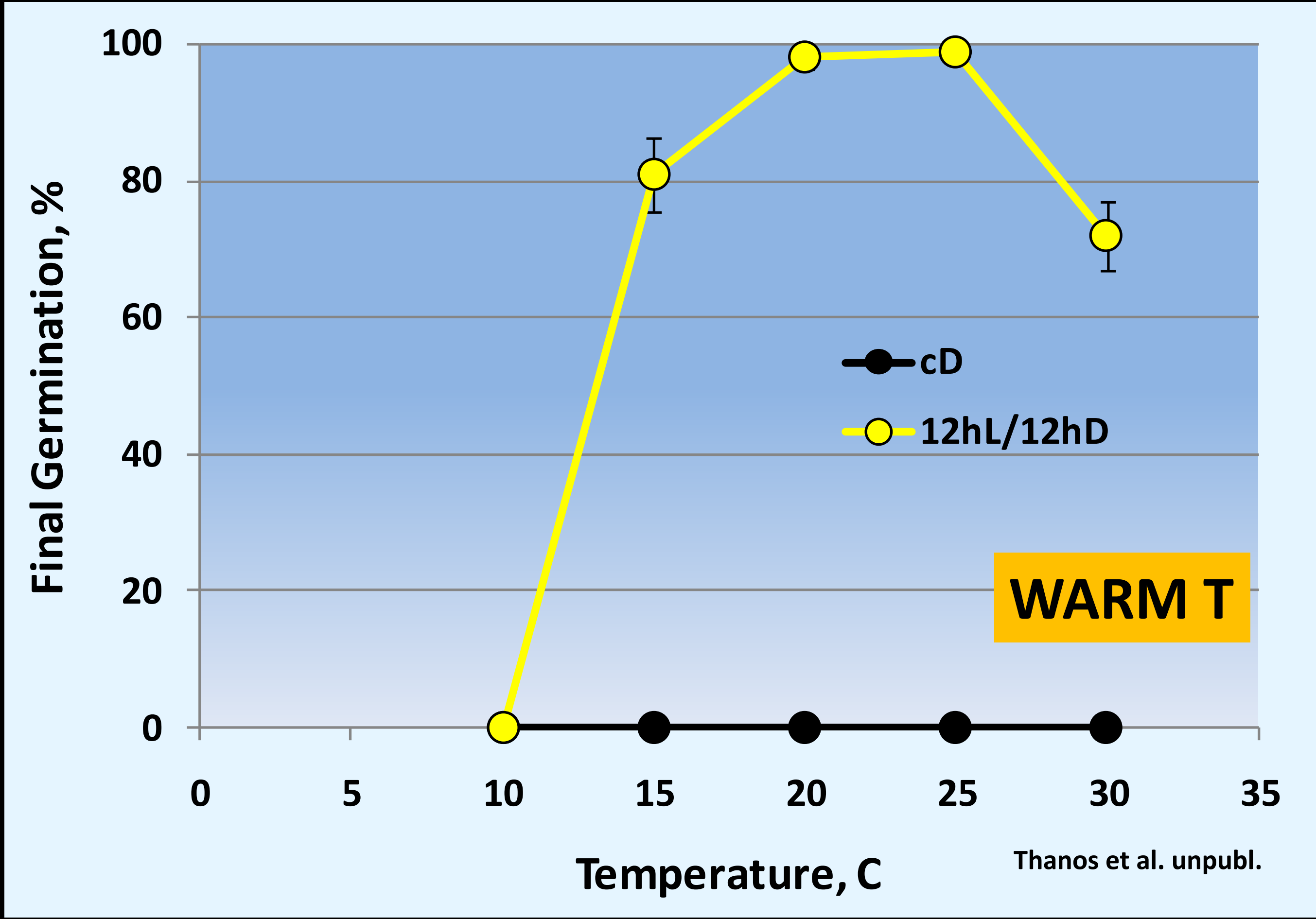
Consolida ajacis



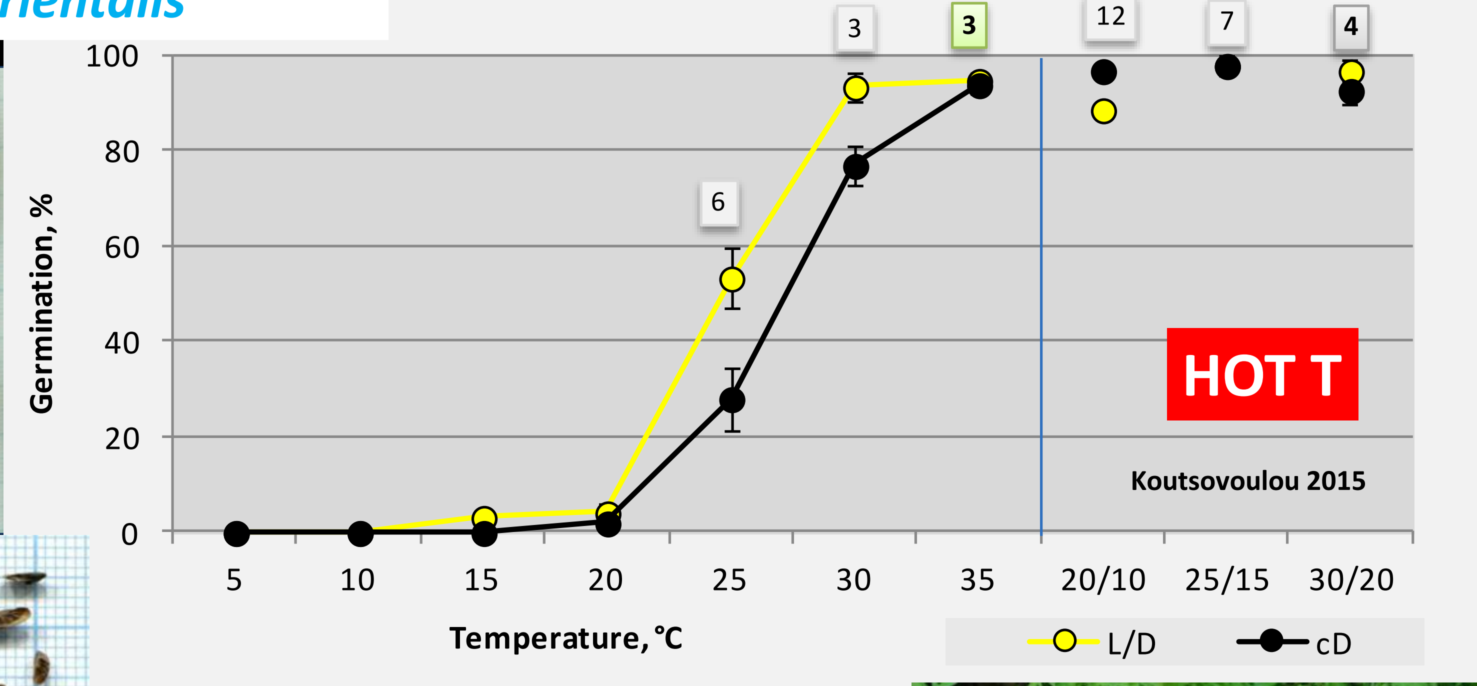

Zelkova abelicea


Germination, %
Time, days
Final Germination, %
Temperature, ºC
Dispersal units
COLD T
Fournaraki & Thanos unpubl.

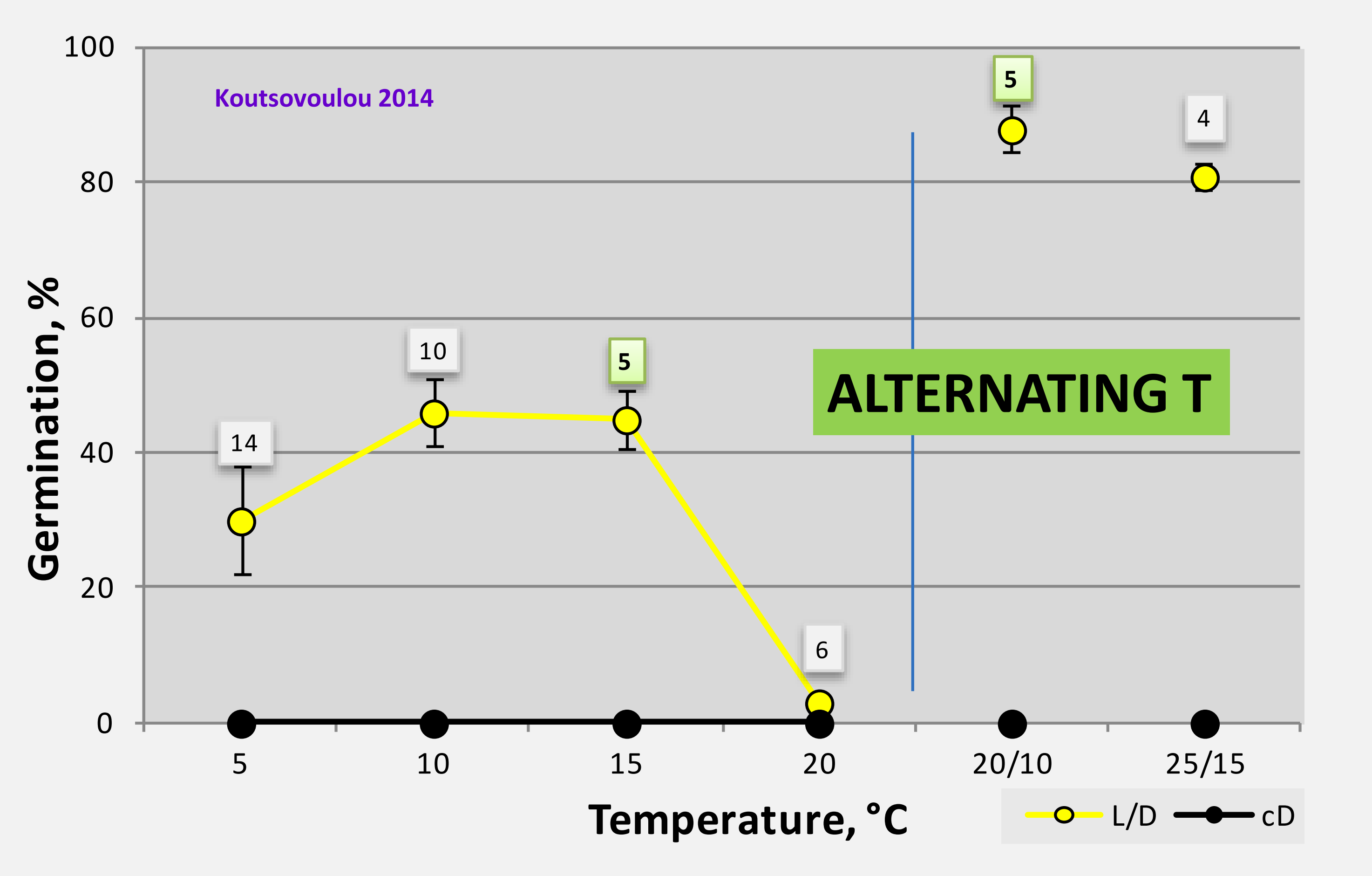
Nepeta sphaciotica
2300 m a.s.l.



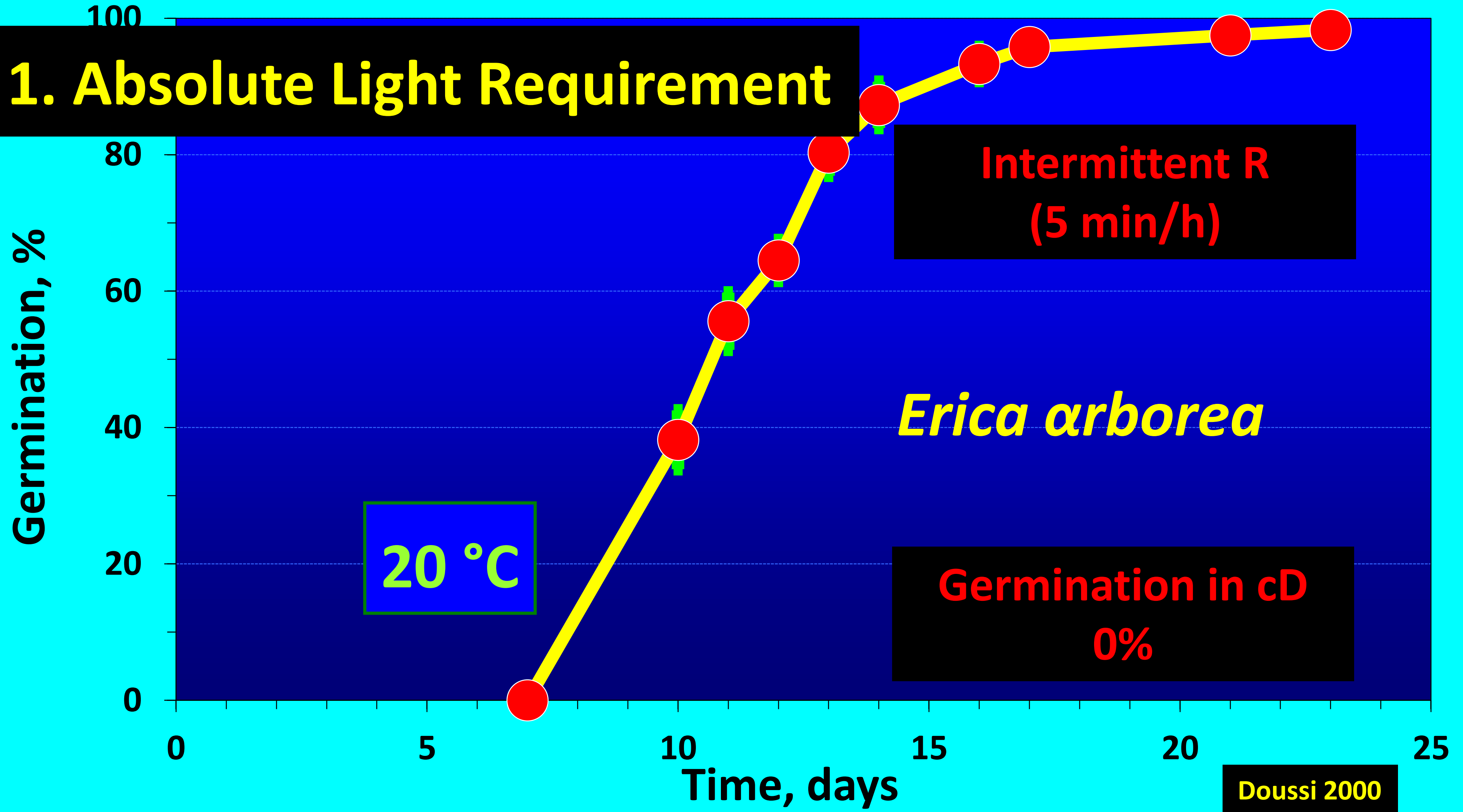
Liquidambar orientalis



Campanula creutzburgii



1. Absolute Light Requirement



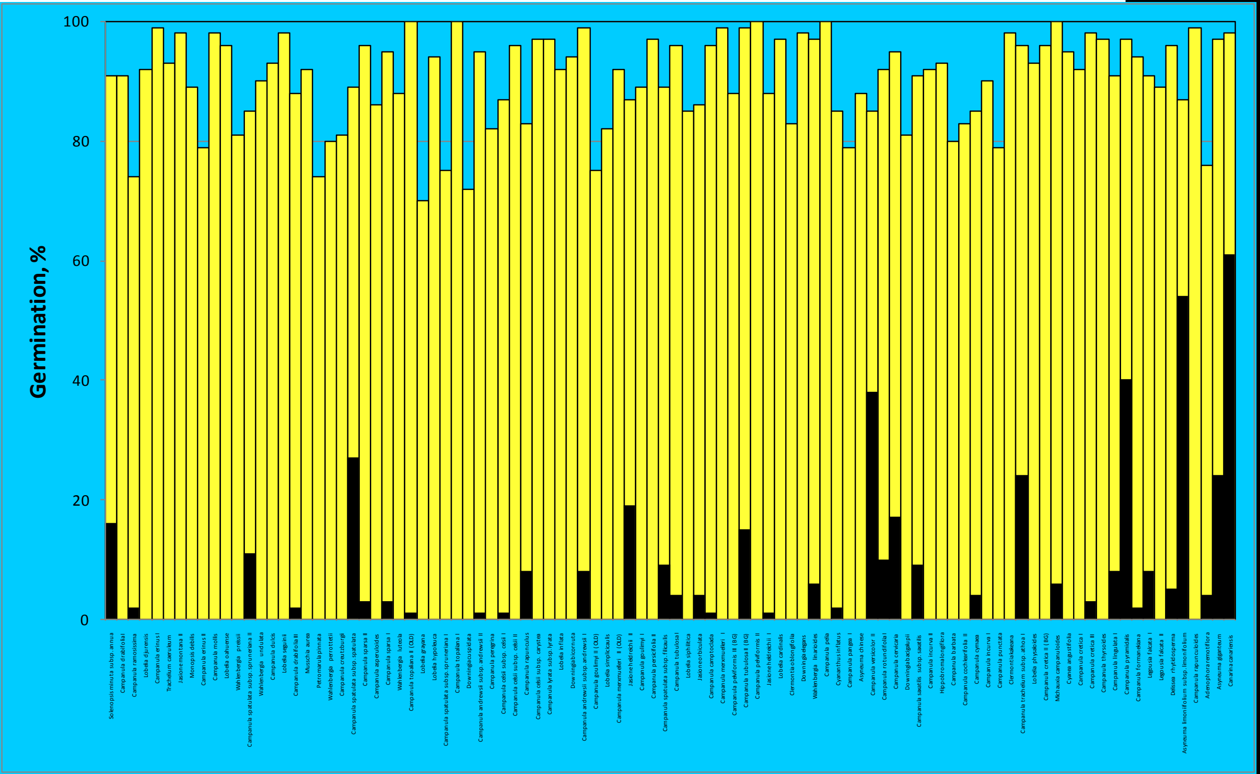
Annals of Botany **113**: 135–143, 2014
doi:10.1093/aob/mct250, available online at www.aob.oxfordjournals.org

ANNALS OF BOTANY
Founded 1887

Campanulaceae: a family with small seeds that require light for germination

Katerina Koutsovoulou[1], Matthew I. Daws[2,3] and Costas A. Thanos[1,*]

[1]*Department of Botany, Faculty of Biology, National and Kapodistrian University of Athens, Panepistimiopolis, Athens 15784, Greece,* [2]*Alcoa of Australia Ltd, Pinjarra, Western Australia, Australia and* [3]*Seed Conservation Department, Royal Botanic Gardens, Kew, UK*



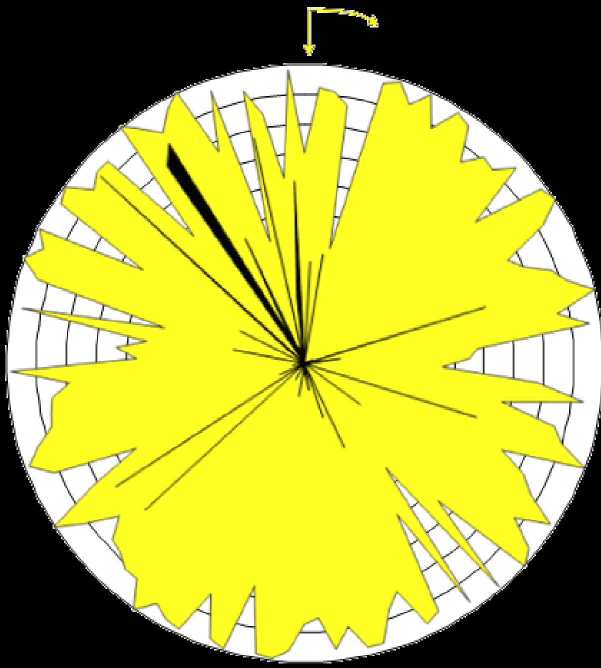
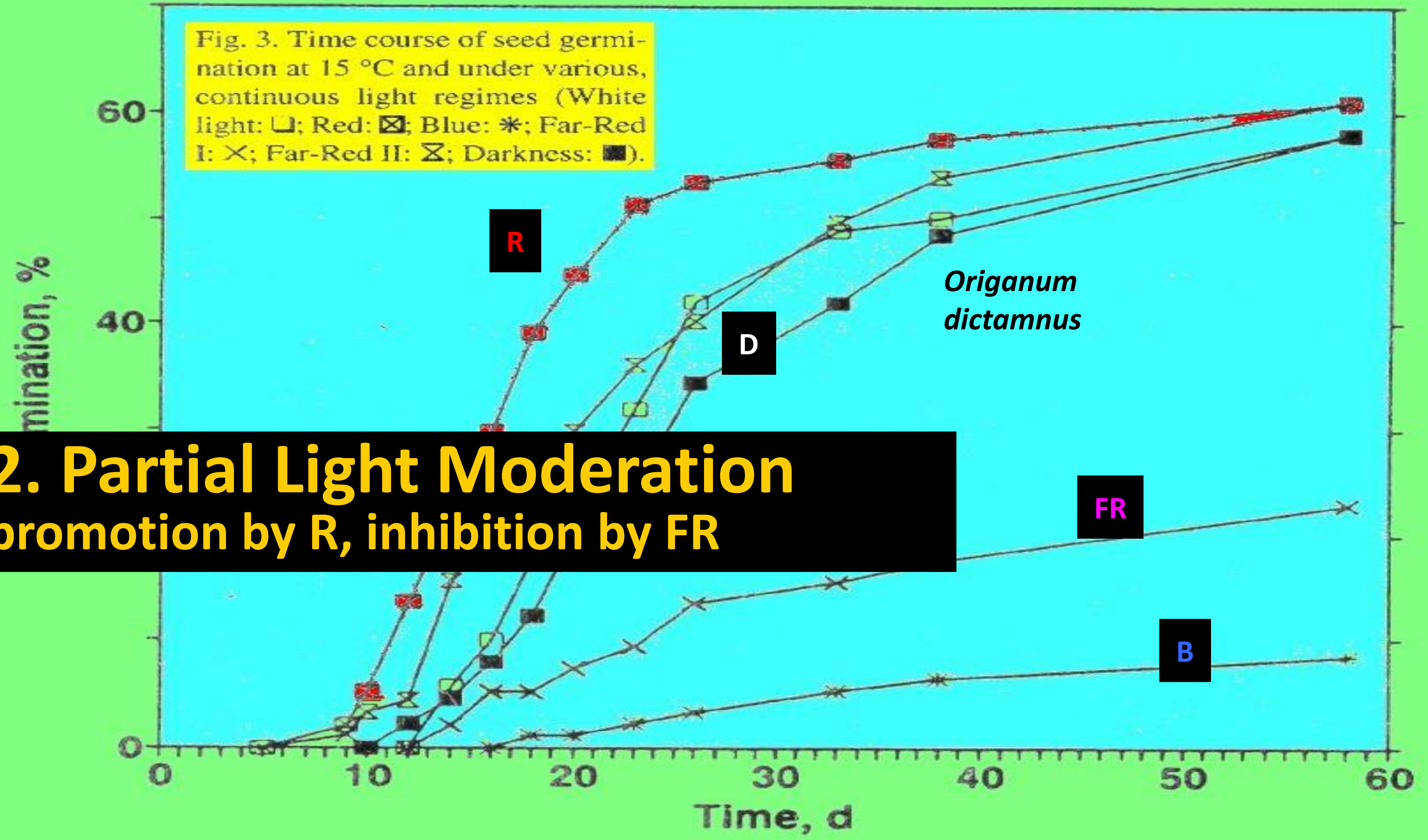


FIG. 1. Final germination percentage in the light (white) and dark (black) in the temperature regime with the highest germination for 114 taxa ($F_G \geq 30$ %). The outer circle corresponds to 100 % and the circle interval is set at 10 %. Taxa are arranged in order of increasing seed mass (clockwise from the starting point, vertical arrow).

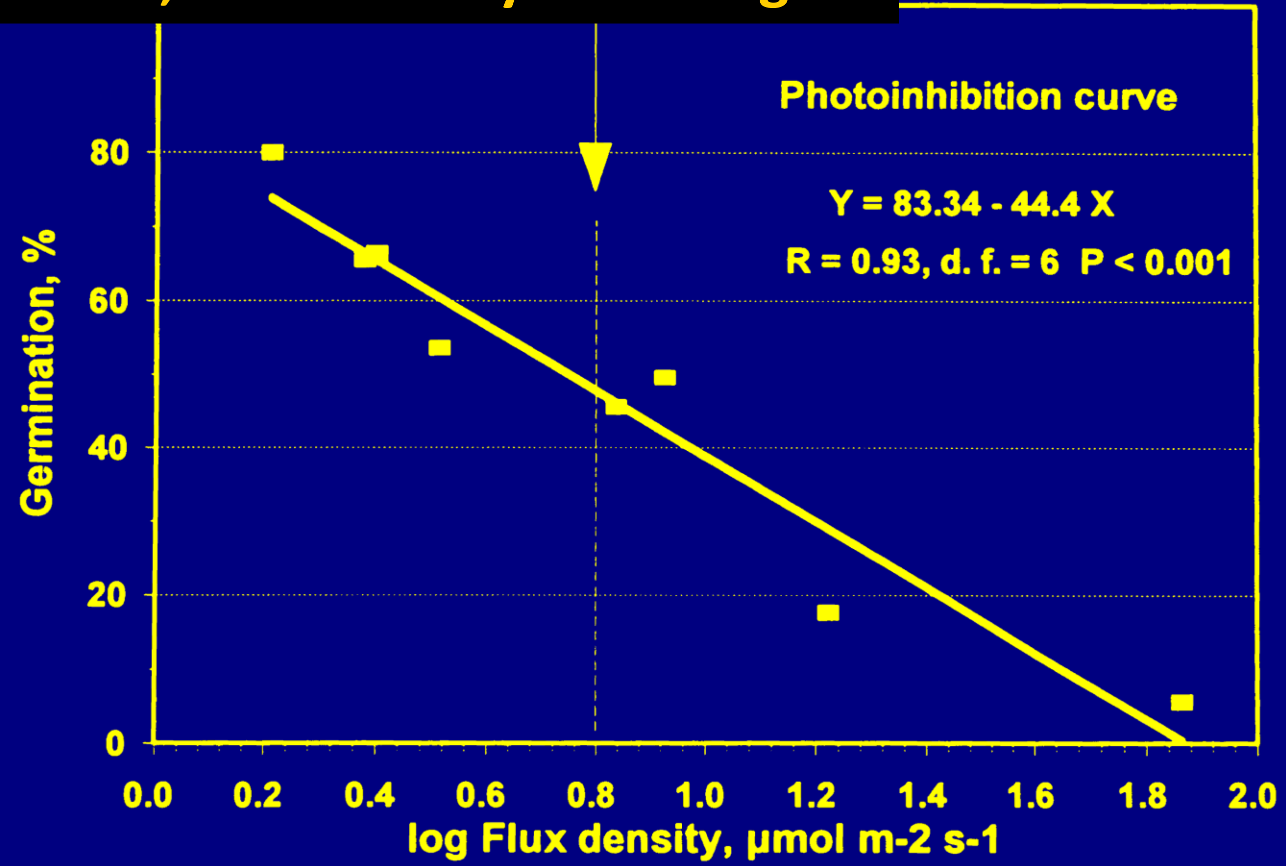


2. Partial Light Moderation

promotion by R, inhibition by FR

Thanos & Doussi 1995

3. Photoinhibition
germination in D, inhibition by White Light



Thanos & Daskalakou unpub.

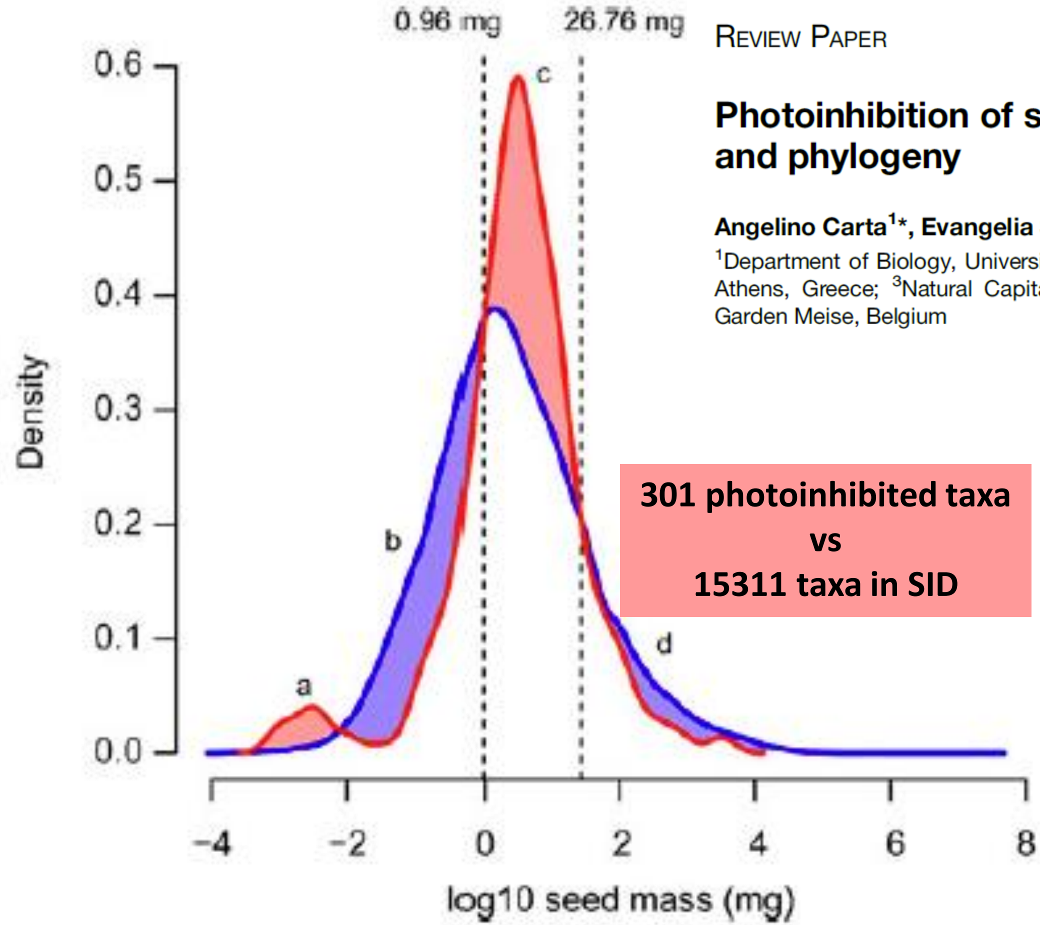
Seed Science Research (2017) **27**, 131–153
doi:10.1017/S0960258517000137

Review Paper

Photoinhibition of seed germination: occurrence, ecology and phylogeny

Angelino Carta[1]*, Evangelia Skourti[2], Efisio Mattana[3], Filip Vandelook[4] and Costas A. Thanos[2]

[1]Department of Biology, University of Pisa, Italy; [2]Department of Botany, National and Kapodistrian University of Athens, Greece; [3]Natural Capital and Plant Health Department, Royal Botanic Gardens, Kew, UK; [4]Botanic Garden Meise, Belgium



An estimated 2% of the World Flora show PHOTOINHIBITED SEED GERMINATION 4-5% in the Mediterranean Rim

Figure 1. Kernel density estimates of seed mass for the world flora (blue line; Royal Botanic Gardens Kew, 2016) and for the photoinhibited flora (red line; present study). Both distributions are significantly different ($P < 0.001$ based on Kolmogorov–Smirnov two sample test). The vertical dashed lines correspond to seed mass thresholds separating seeds whose germination is light stimulated (<0.96 mg), photoinhibited (>0.96 and <26.76 mg) and indifferent to light (>26.76 mg). The red peak, coinciding approximately with 0.002 mg, corresponds to Orchidaceae and Orobanchaceae taxa. Red areas correspond to seed mass ranges where there is a higher representation of photoinhibited taxa than of the world flora, and blue areas to those where photoinhibited taxa are less represented.

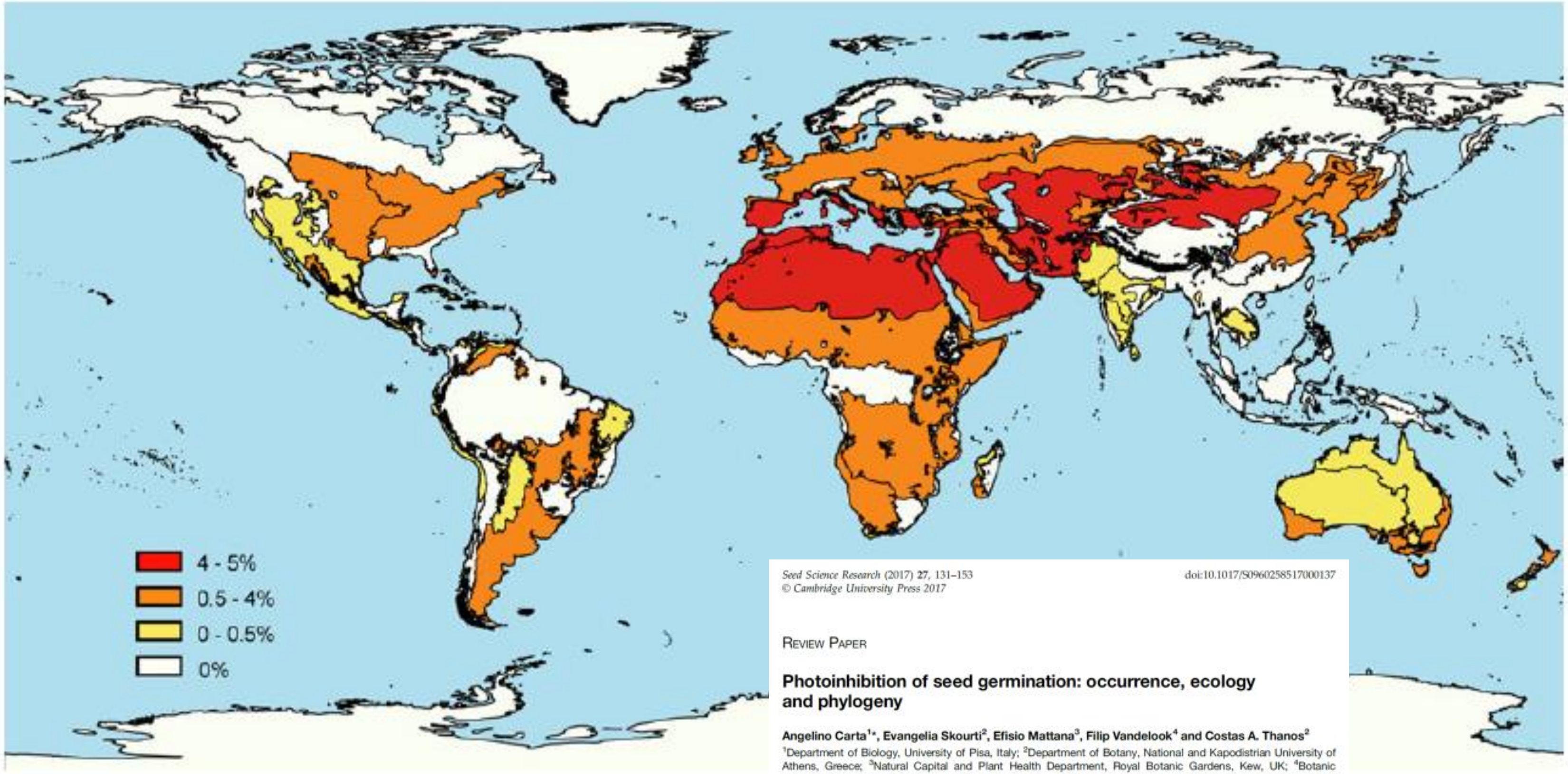


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Figure 4. Percentage of photoinhibited taxa in each climatic region within each biogeographical realm (terrestrial ecoregions of the world; see Olson *et al.*, 2001) calculated based on plant richness estimates from Kier *et al.* (2005). Realms: Australasia, Antarctic, Afrotropics, IndoMalay, Nearctic, Neotropics, Oceania, Palearctic. Climatic regions: tropical humid, tropical dry, temperate humid, temperate montane, cold, tropical semi-arid, temperate semi-arid, montane, polar, mediterranean, arid.

Temperature/light-probers

31 Families / 200

Weakly determined by phylogeny (INCOMPLETE data)

c. ??% of the Mediterranean Flora

Temperature (and light) detecting mechanisms are associated with TIMING OF GERMINATION in:

Autumn (cool T, mediterranean)

Winter (cold T, temperate and mountainous)

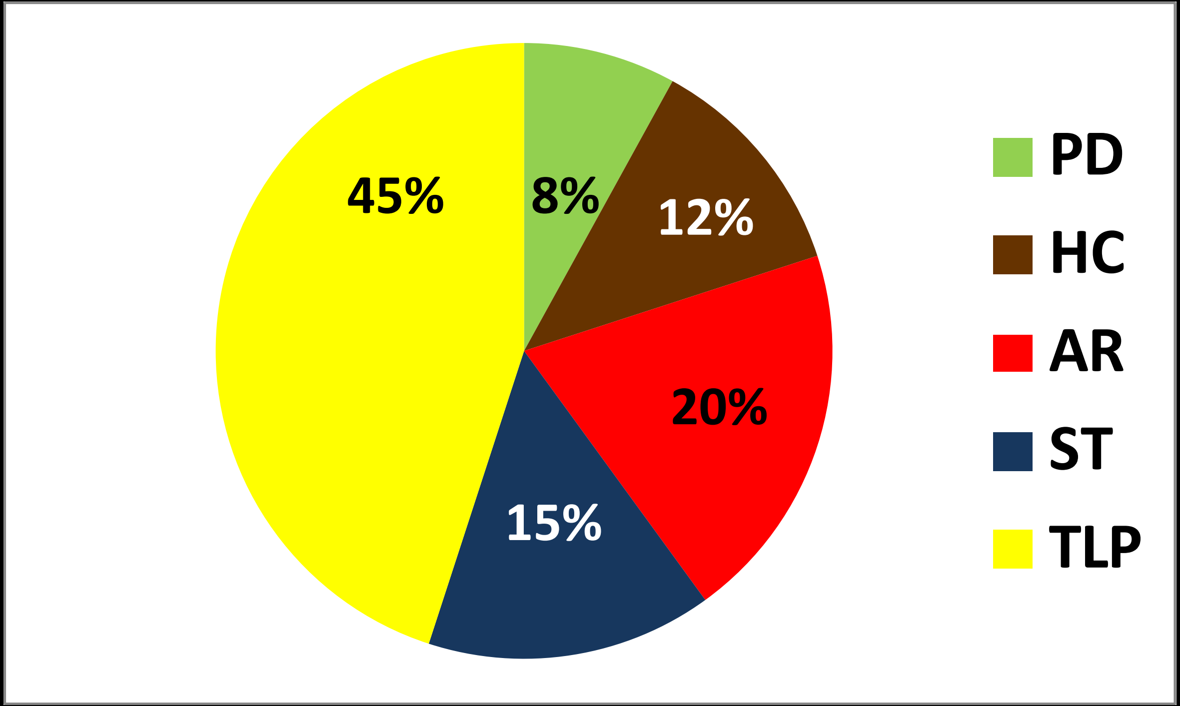
Spring (warm T, alpine and arctic)

Summer (hot T, mostly immigrants)

Amaranthaceae	7
Asteraceae	37
Fagaceae	8
Pinaceae	9
Poaceae	15
Polygonaceae	7
Salicaceae	16
	99
total number	155

5 Germination Characters

Estimate for the MEDITERRANEAN



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MAI CHANIA

ΠΡΑΣΙΝΟ ΤΑΜΕΙΟ