An overview of seed functional ecology: focusing on accelerating progress in the tropics

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Trends in
Plant Science

Opinion

Seeds as natural capital

Efisio Mattana [1,*] Tiziana Ulian [1] and Hugh W. Pritchard [1,2,*]

Existence value	Use value		
	Direct use value	Indirect use value	Option value
• Seed traits; • Wild species / populations / ecotypes / landraces perpetuation through seed dispersal, germination and persistence in the soil; • Maintenance of species functional role(s) in the ecosystem(s); • Adaptation to climate change.	• Economic, nutritional, medicinal and cultural value of seeds; • Perpetuation of current major crops / commercial crop varieties / landraces.	• Economic, nutritional, medicinal and cultural value of products from seeds and plants.	• Potential economic, nutritional, medicinal and cultural value of unexplored seeds and seed traits; • Potential economic, nutritional, medicinal and cultural value of products derived from unexplored seeds and seed traits; • Potential new crop varieties.

Trends in Plant Science

Dimension	Agriculture	Ecology
Goals	Productivity, yield, efficiency, domestication	Understanding and managing biodiversity, interactions, and ecosystem processes
Study species	Crops, crop wild relatives	Wild, threatened, endemic, non-native species
Driver of selection	Humans (artificial selection)	Nature (natural selection)
Preferred traits	Uniformity, rapid germination, high vigor, synchronized development	Trait diversity, dormancy variation, variable germination time
Dormancy	Often undesirable because it reduces crop establishment	Adaptive mechanism for spreading risk in time and space
Genetics	Breeding for uniform genotypes	Maintenance of genetic diversity

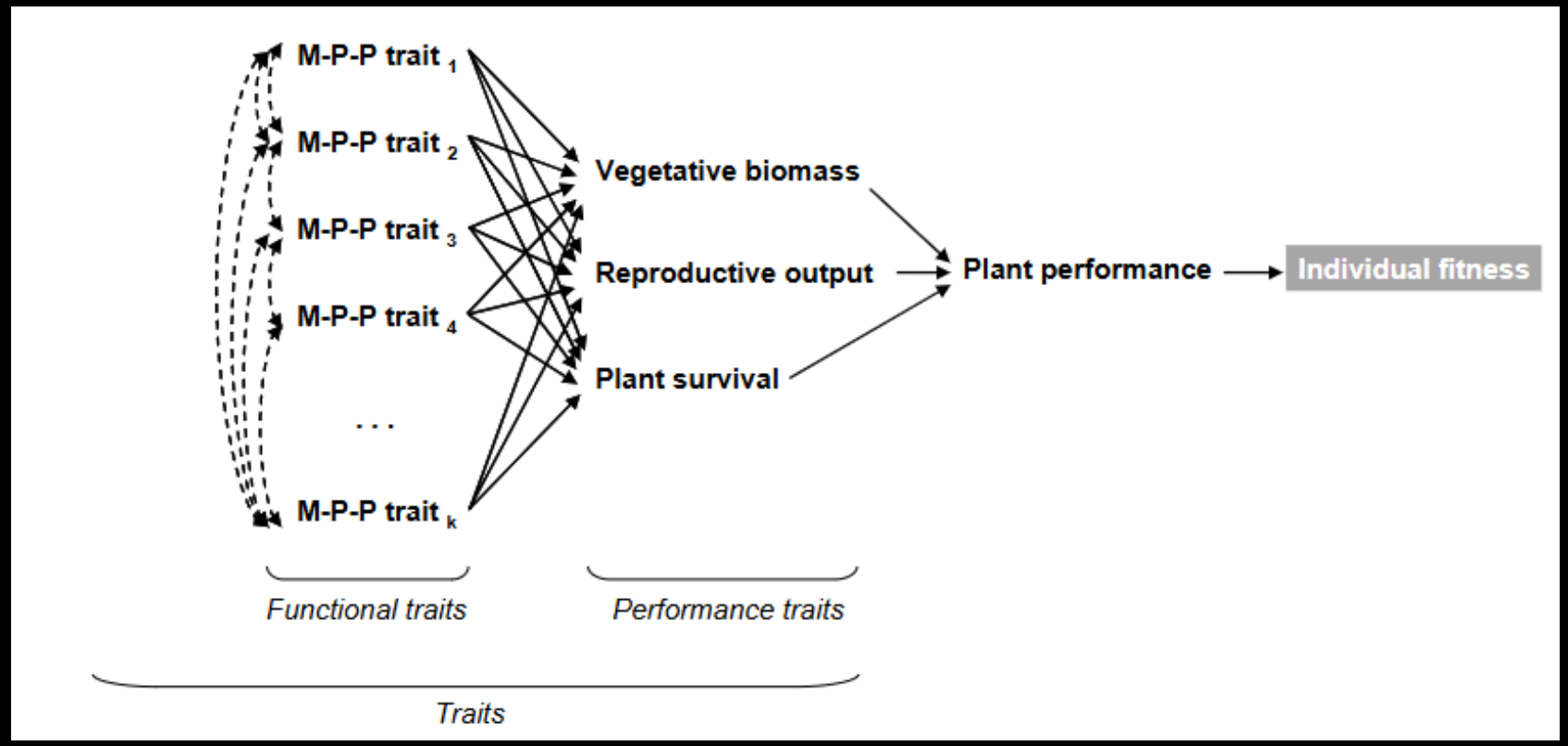
Forum

Oikos 116: 882–892, 2007
doi: 10.1111/j.2007.0030-1299.15559.x,

Subject Editor: Pia Mutikainen, Accepted 8 January 2007

Let the concept of trait be functional!

Cyrille Violle, Marie-Laure Navas, Denis Vile, Elena Kazakou, Claire Fortunel, Irène Hummel and Eric Garnier



Journal of Vegetation Science 27 (2016) 637–645

FORUM

Seed germination traits can contribute better to plant community ecology

Borja Jiménez-Alfaro, Fernando A.O. Silveira, Alessandra Fidelis, Peter Poschlod & Lucy E. Commander

Table 1. Main seed traits with potential to improve predictability in vegetation ecology and examples of their functional significance across different ecosystems. Classification in morphological, biophysical and germination traits is based on biological properties as well as requirements for measurement (see details in the text). Note that many traits may be correlated with each other. The term 'seed' can refer to the whole dispersal unit, i.e. the seed together with attached fruit structures.

Seed Trait	Units	Functional Significance
Morphological Traits		
Seed Surface Structure	Categorical	Colonization capacity, dispersal mode, plant–animal interactions
Embryo Type	Categorical	Position and structure of the embryo in the seed (linked to dormancy)
Embryo:Seed Ratio	Ratio	Size of the embryo relative to the seed (linked to dormancy and plant life evolution)
Seed Coat Thickness	Ratio	Fire tolerance, persistence in soil, resistance to pathogens and predators
Seed Mass	mg	Dispersal distance, persistence in soil, predation likelihood
Seed Shape	Quantitative but dimensionless	Burial and persistence in soil
Seed Size	mm	Dispersal potential, reproductive output
Biophysical Traits		
Buoyancy	Time or rate	Floating capacity, dispersal ability by water (linked to seed structure)
Coat Chemical Content	Categorical	Defence against pathogens
Coat Water Permeability	Percentage	Fire tolerance, defence against predators (linked to physical dormancy)
Desiccation Tolerance	Categorical	Persistence and ageing in different climates and habitats (e.g. aquatic, terrestrial, grasslands, forests)
Oil Content	Percentage	Energy provision for seedlings, water relations with the environment
Reserve Type	Categorical	Nutritional value, persistence in soil
Terminal Velocity	$m \cdot s^{-1}$	Dispersal distance, dispersal potential
Water Content	Percentage	Seed survival, longevity in soil
Germination Traits		
After-Ripening	Weeks, months; percentage	Climate adaptation, seasonal germination niche (linked to dormancy)
Dormancy	Categorical, quantitative	Delay of germination until embryo is completely developed (morphological, MD) or a given environmental factor affects embryo growth potential (physiological, PD) or specialized structures in the seed coat (physical, PY), or combinations of the above (MPD, PD+PY), or no delay in germination – non-dormant (ND) (linked to other traits)
Germinability	Percentage	Colonization capacity, seed vigour and viability (generally result of influence of other traits)

Review

New Phytologist

Research review

A research agenda for seed-trait functional ecology

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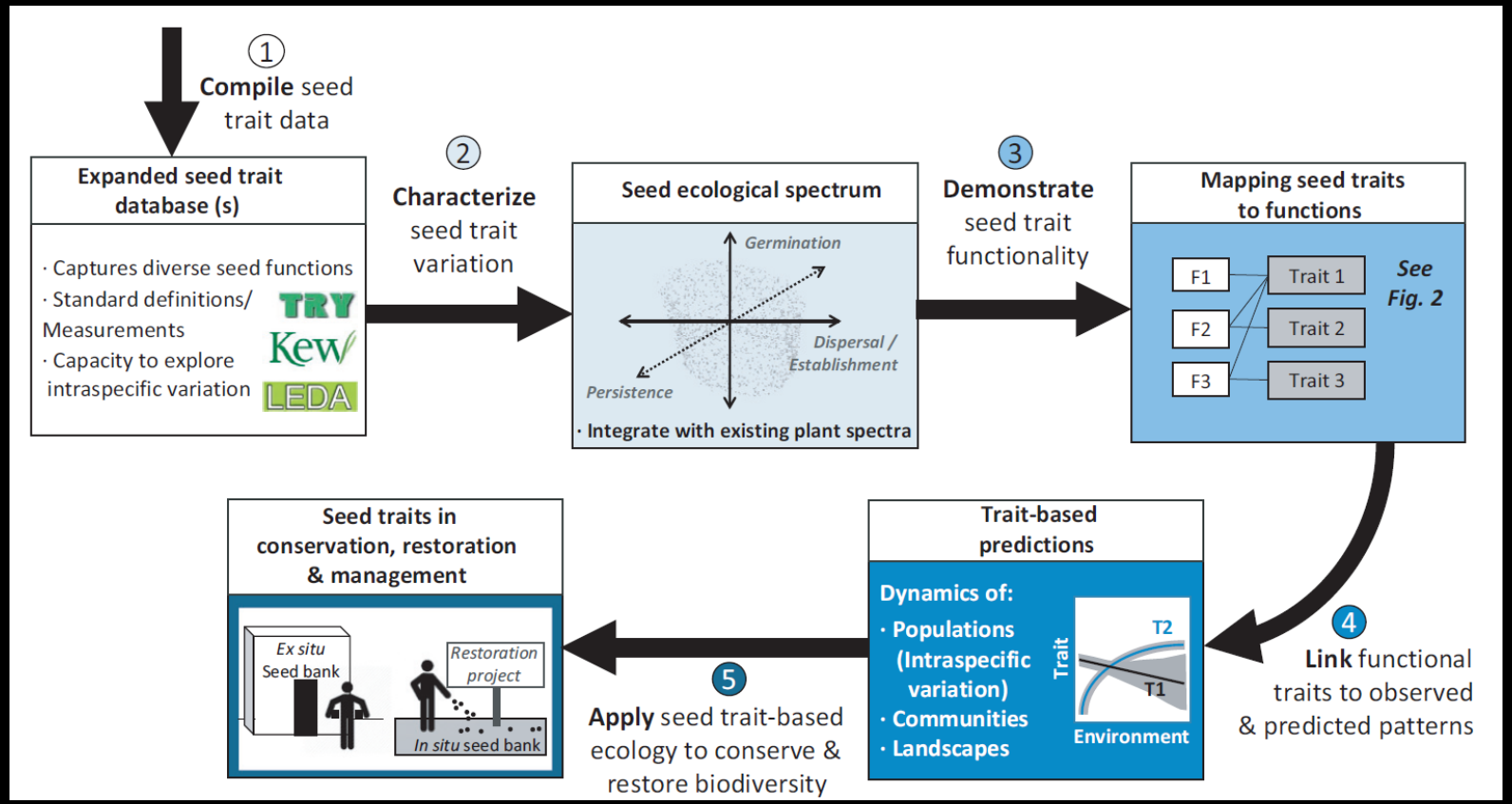

JOURNAL ARTICLE

Seed ecology of European mesic meadows

Eduardo Fernández-Pascual, Madalena Vaz, Beatriz Morais, Ramón Reiné, Joaquín Ascaso, Elías Afif Khouri, Angelino Carta

Annals of Botany, Volume 129, Issue 2, 1 February 2022, Pages 121–134,
https://doi.org/10.1093/aob/mcab135
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JOURNAL ARTICLE

Regeneration from seed in herbaceous understorey of ancient woodlands of temperate Europe

Cristina Blandino, Eduardo Fernández-Pascual, Rosemary J Newton, Hugh W Pritchard

Annals of Botany, Volume 129, Issue 7, 18 June 2022, Pages 761–774,
https://doi.org/10.1093/aob/mcac003

JOURNAL ARTICLE

Climate shapes the seed germination niche of temperate flowering plants: a meta-analysis of European seed conservation data

Angelino Carta, Eduardo Fernández-Pascual, Margherita Gioria, Jonas V Müller, Stéphane Rivière, Sergey Rosbakh, Arne Saatkamp, Filip Vandelook, Efisio Mattana

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https://doi.org/10.1093/aob/mcac037

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Journal of Vegetation Science
Advances in plant community ecology
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ANNALS OF BOTANY
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VIEWPOINT

Low availability of functional seed trait data from the tropics could negatively affect global macroecological studies, predictive models and plant conservation

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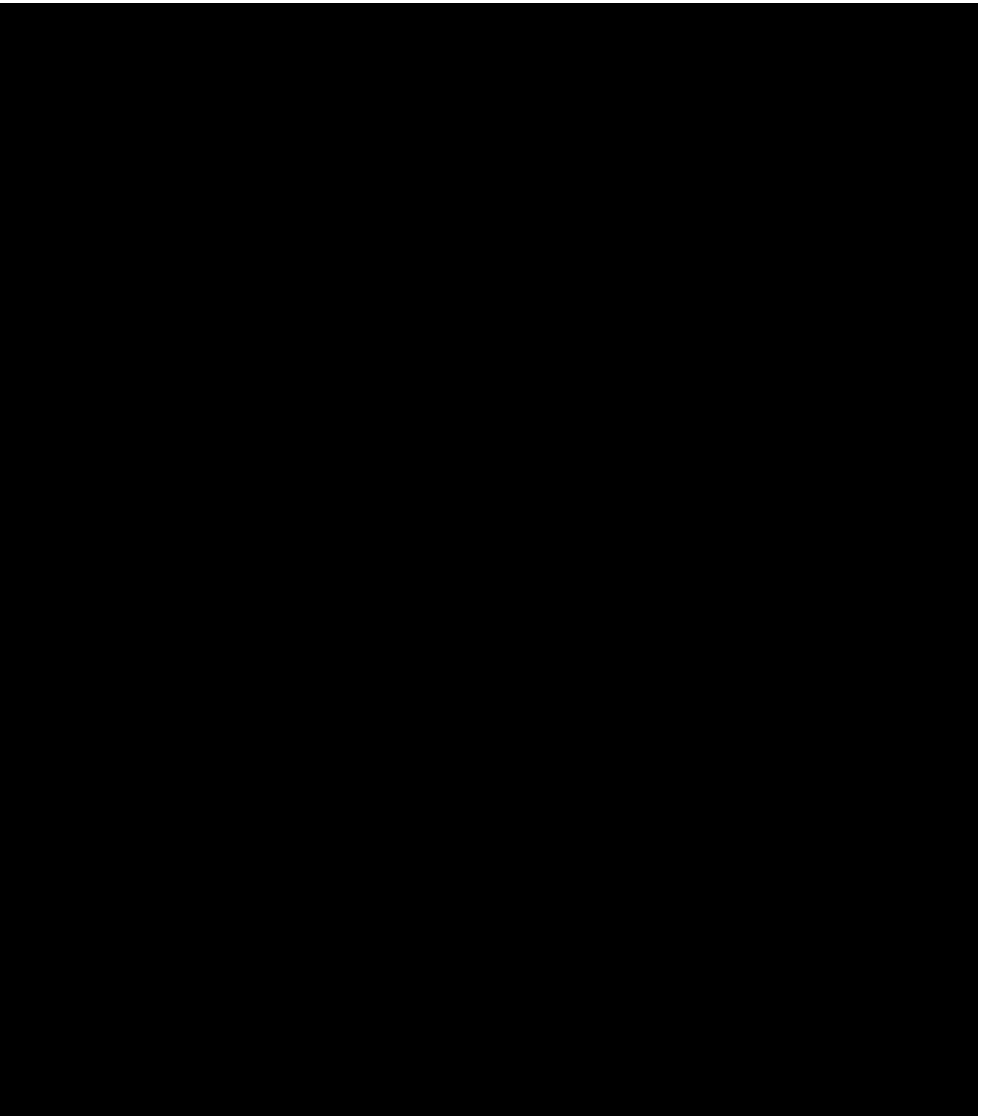
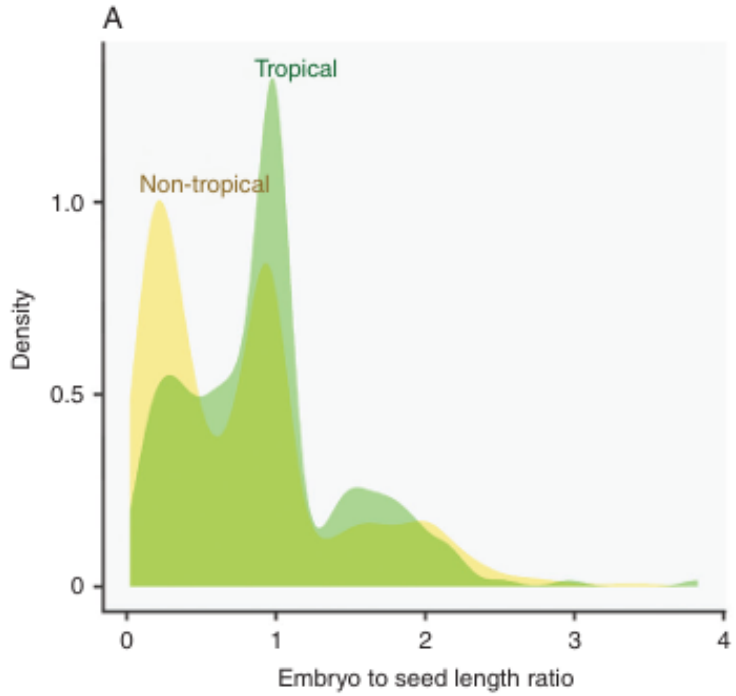
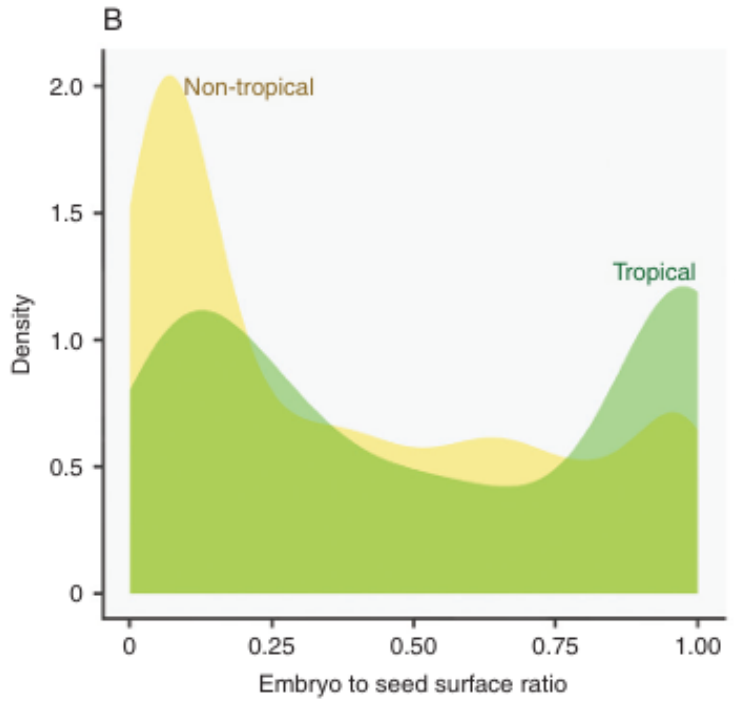
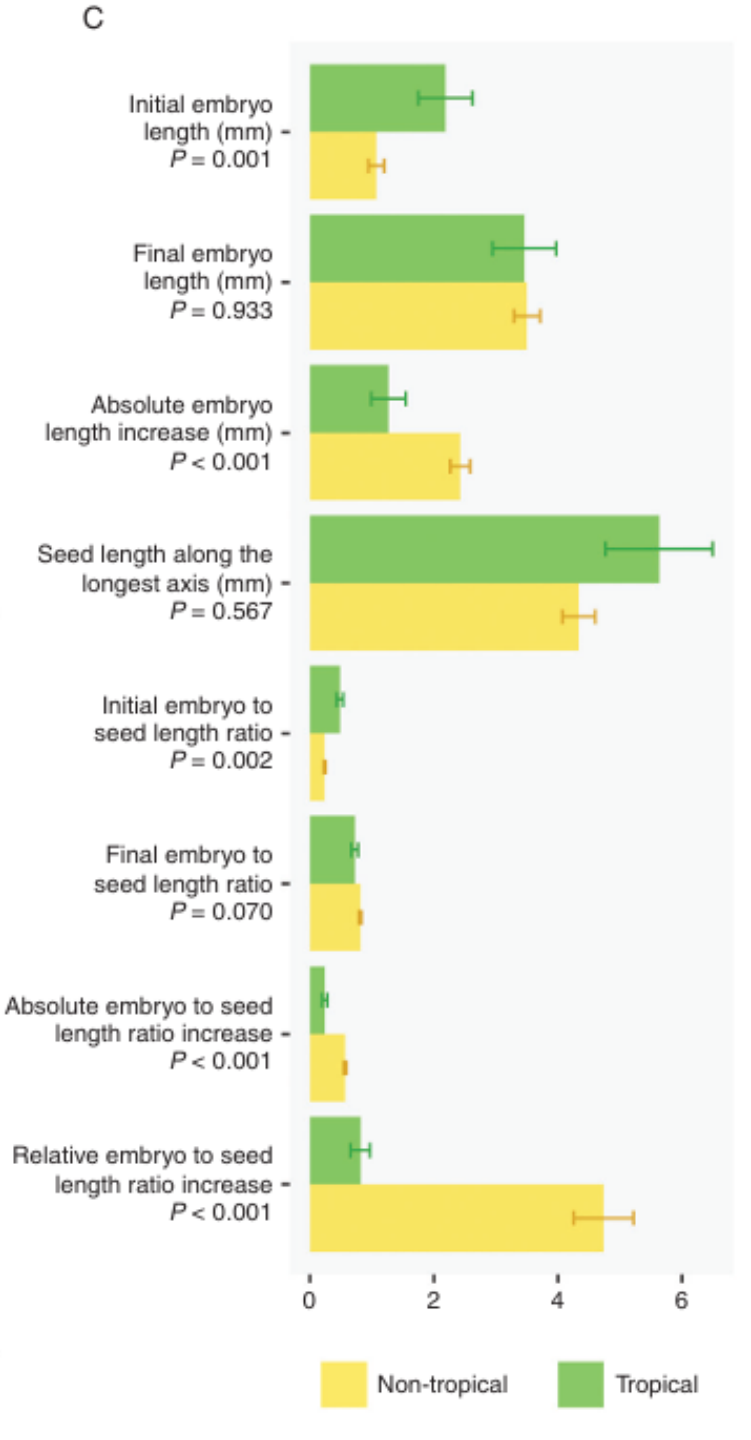
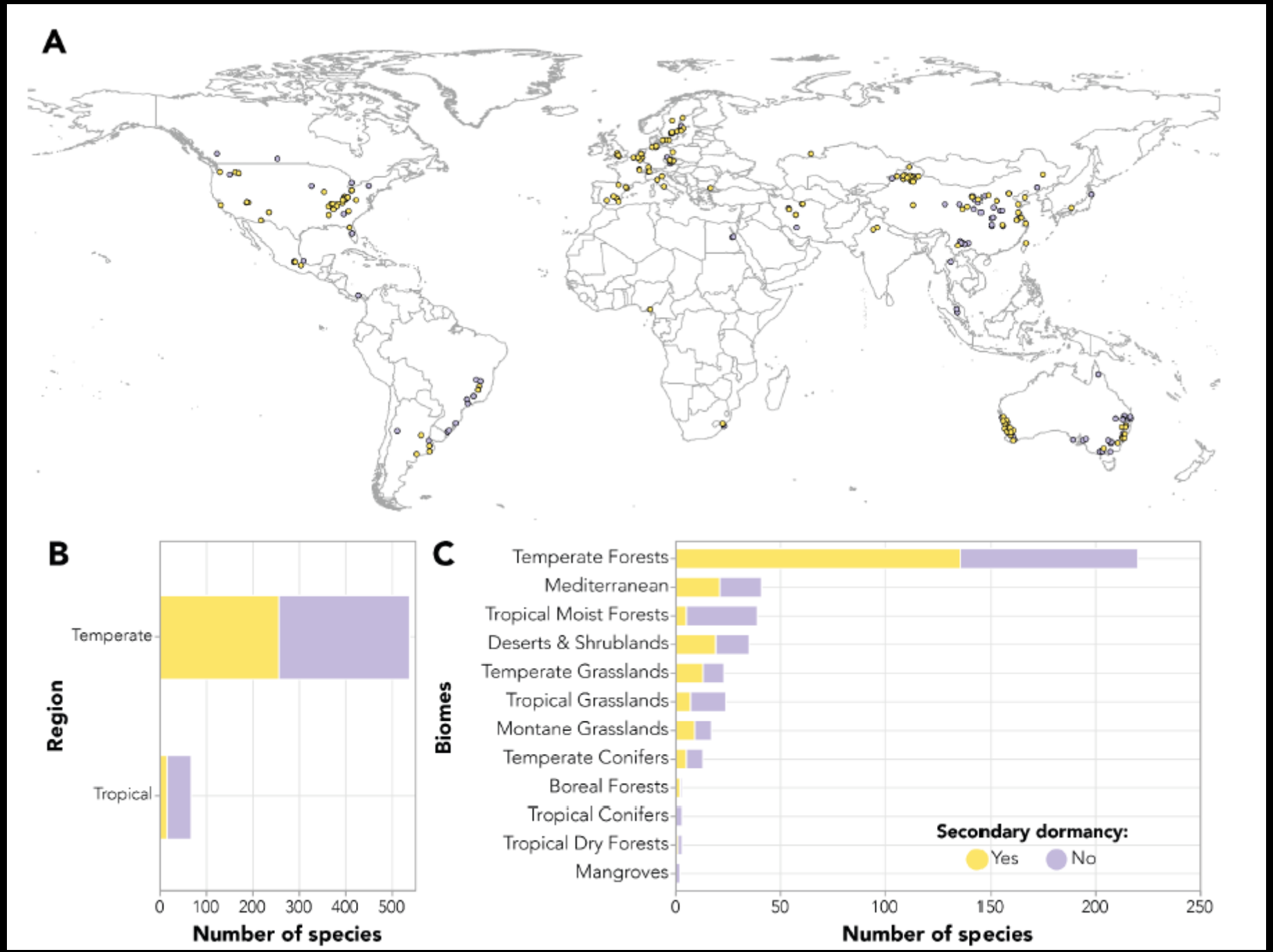









A
B
Region
Temperate
Tropical
0
100
200
300
400
500
Number of species
C
Biomes
Temperate Forests
Mediterranean
Tropical Moist Forests
Deserts & Shrublands
Temperate Grasslands
Tropical Grasslands
Montane Grasslands
Temperate Conifers
Boreal Forests
Tropical Conifers
Tropical Dry Forests
Mangroves
Secondary dormancy:
Yes
No
0
50
100
150
200
250
Number of species

Miconia (Melastomataceae)
~1500 sp

Ficus (Moraceae) ~900 sp

Piper (Piperaceae) ~2,400 sp

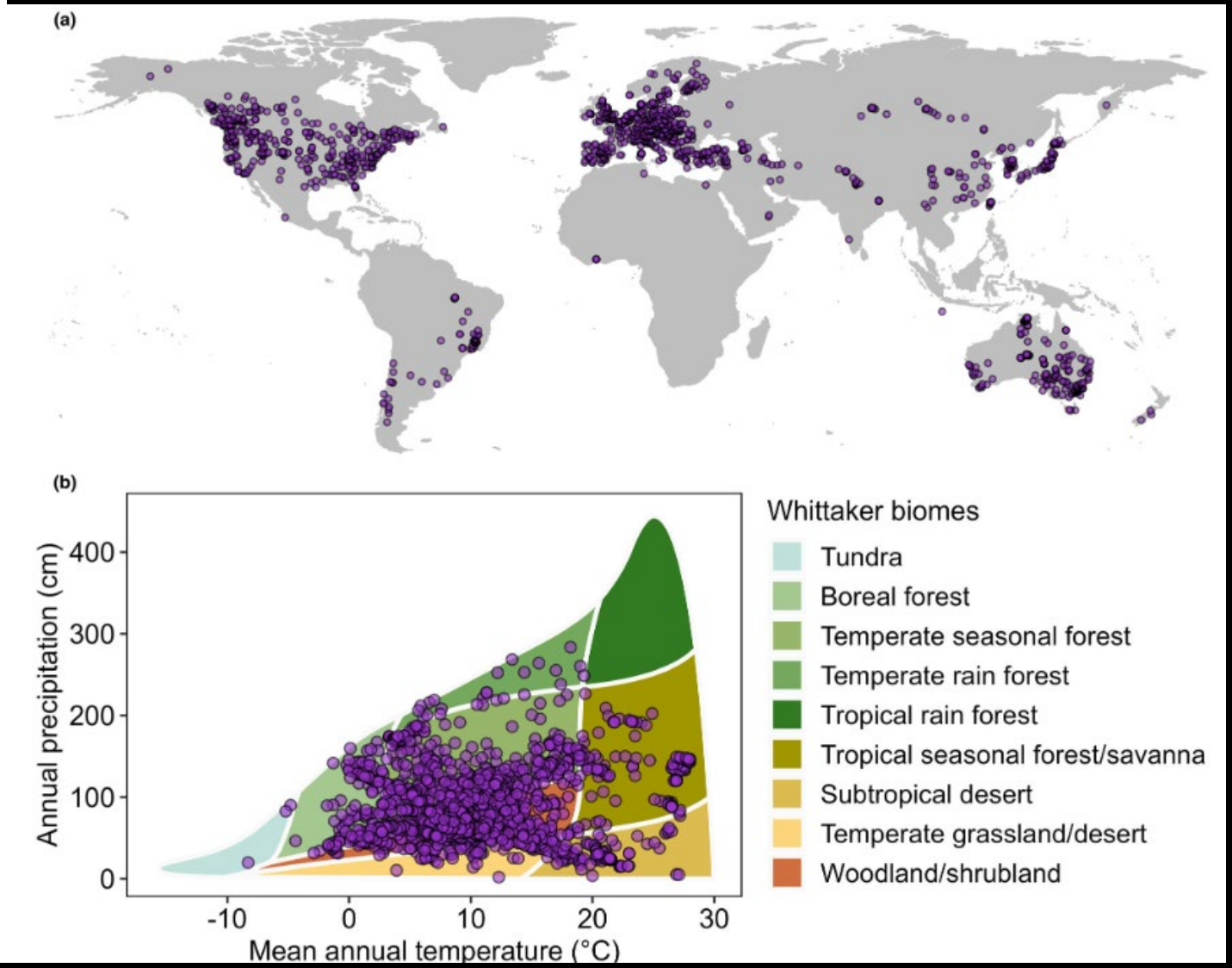
Psychotria (Rubiaceae) ~1,600 sp

Begonia (Begoniaceae) ~2,000 sp

Forum

Letters

SeedArc, a global archive of primary seed germination data



New Phytologist

Forum

Community resource

Tropical Seed Trait Database: advancing seed functional ecology in the world's most biodiverse region

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- 78 datasets, 33 countries, 137,583 trait records
- 44 seed traits (16 morphological, 13 biophysical, and 15 germination)
- 5115 species, 1453 genera, 195 families of Angiosperms

Appendix 1

The Tropical Seed Trait Database (TSTD) Consortium

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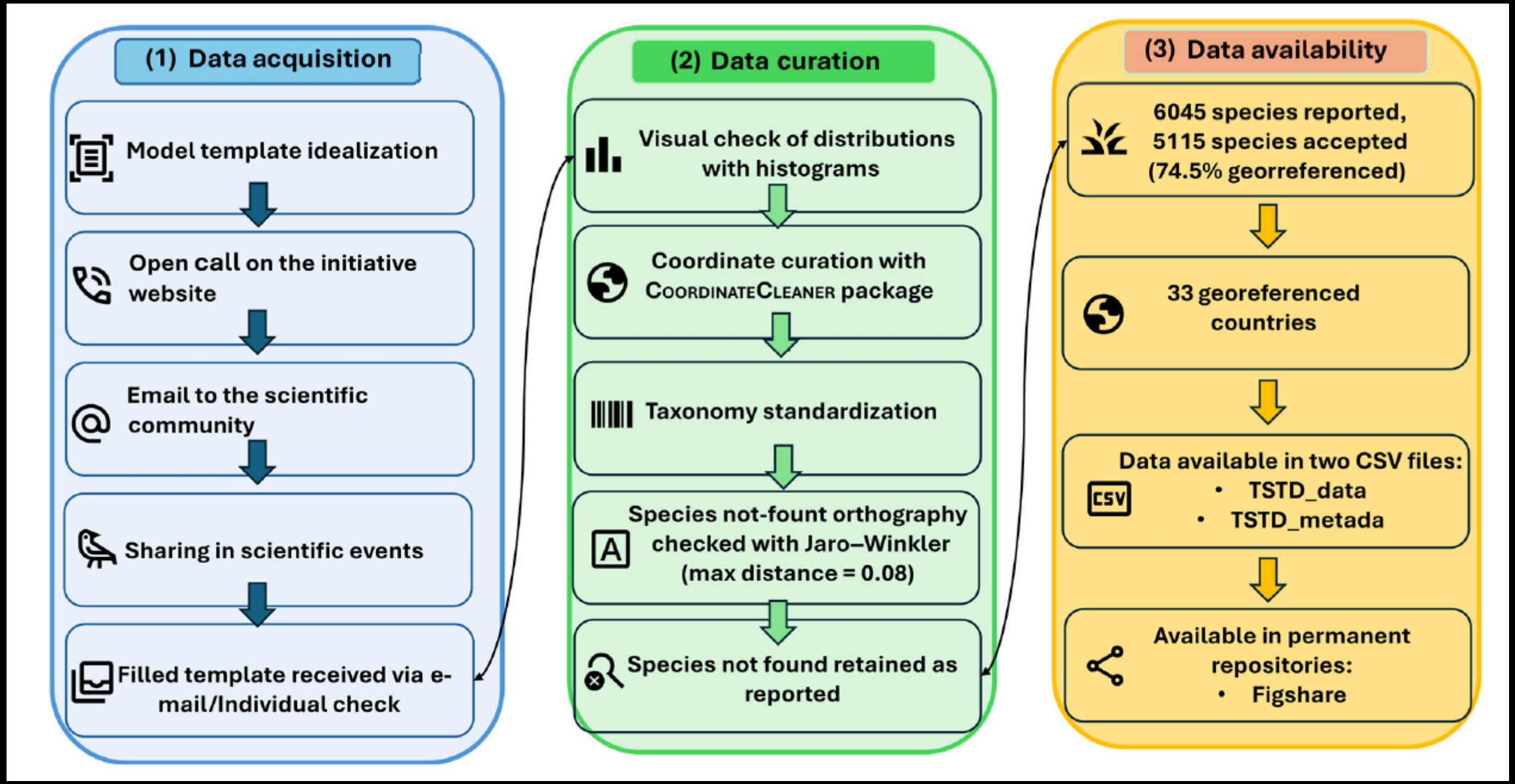
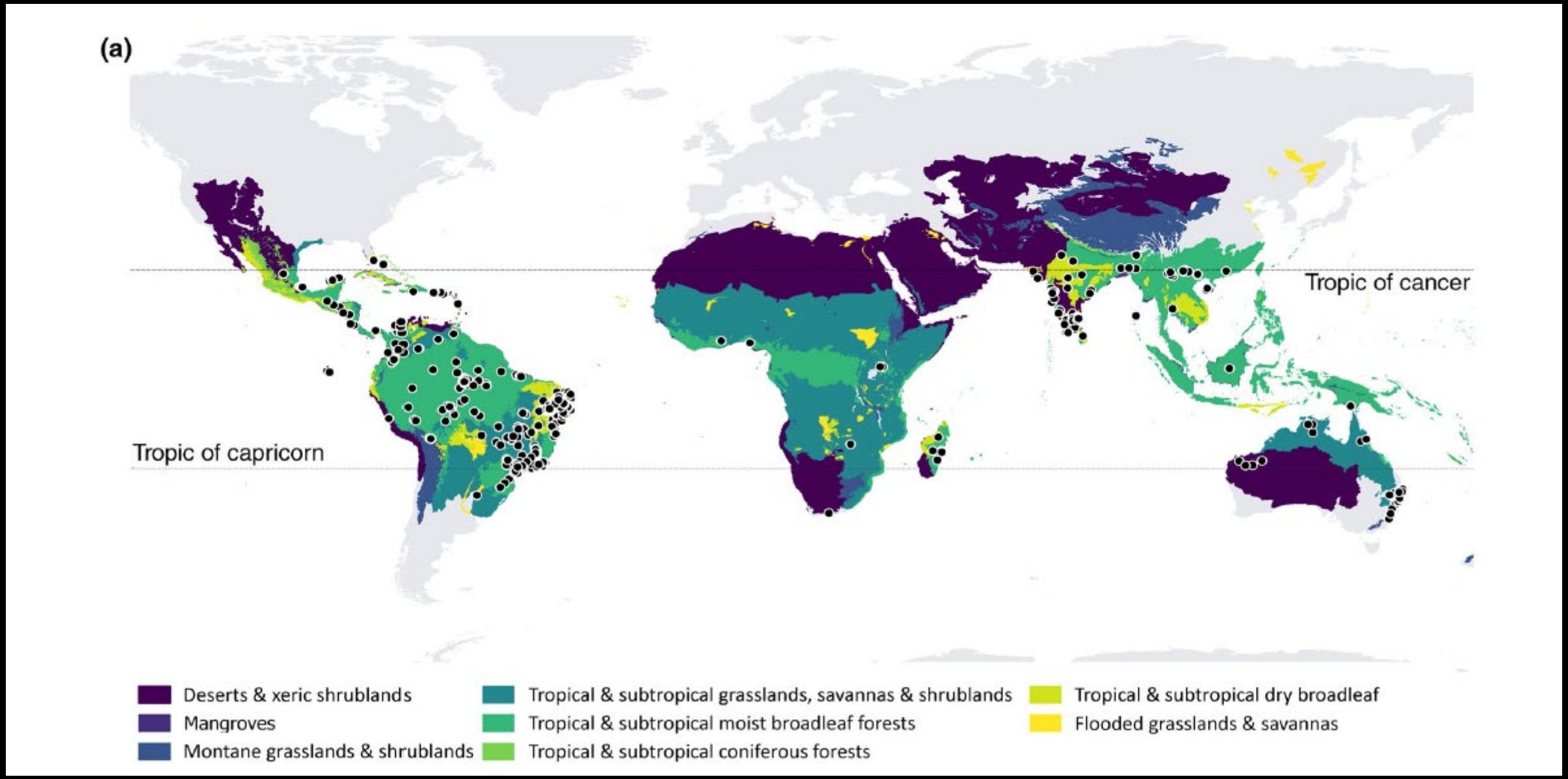
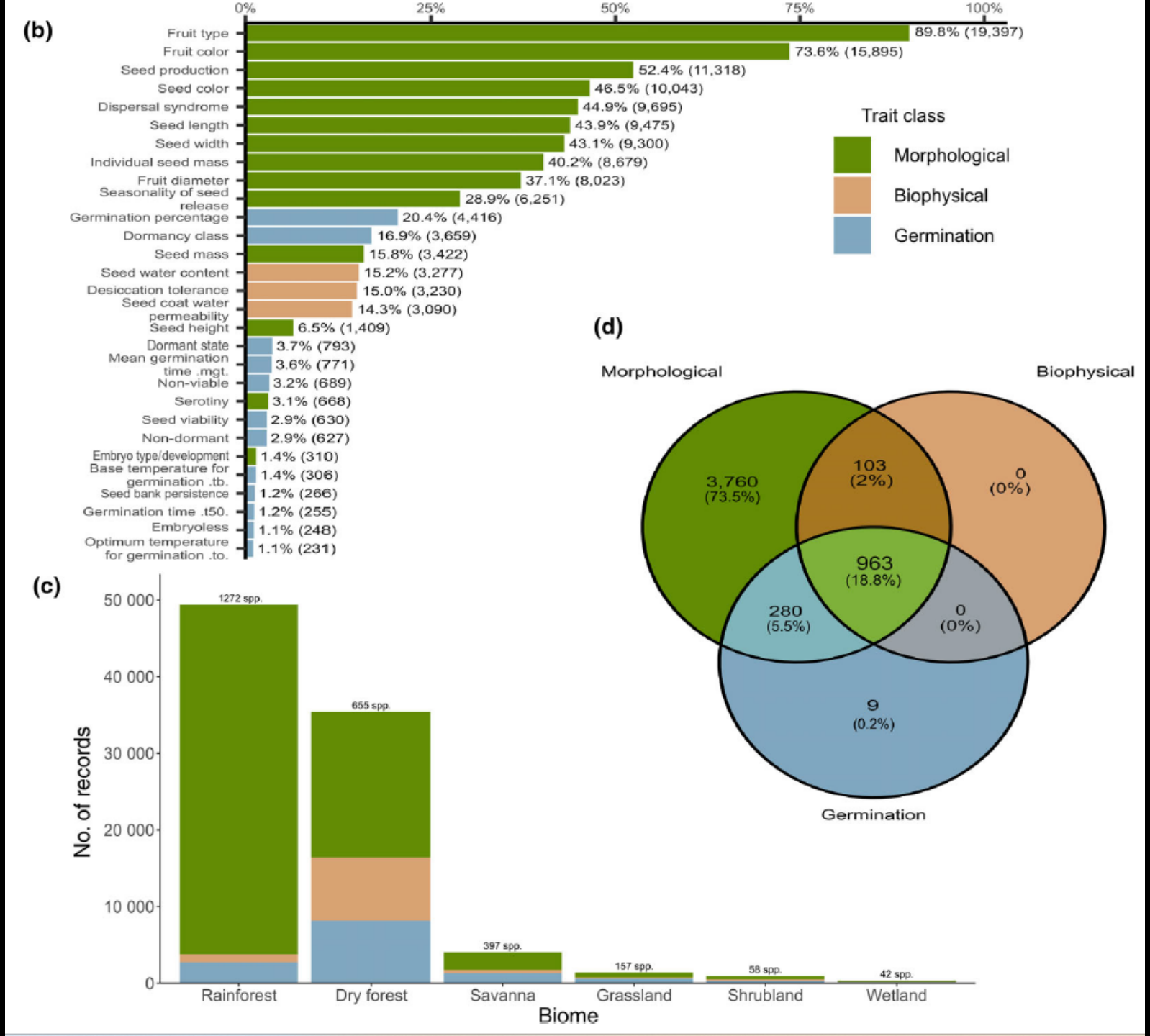
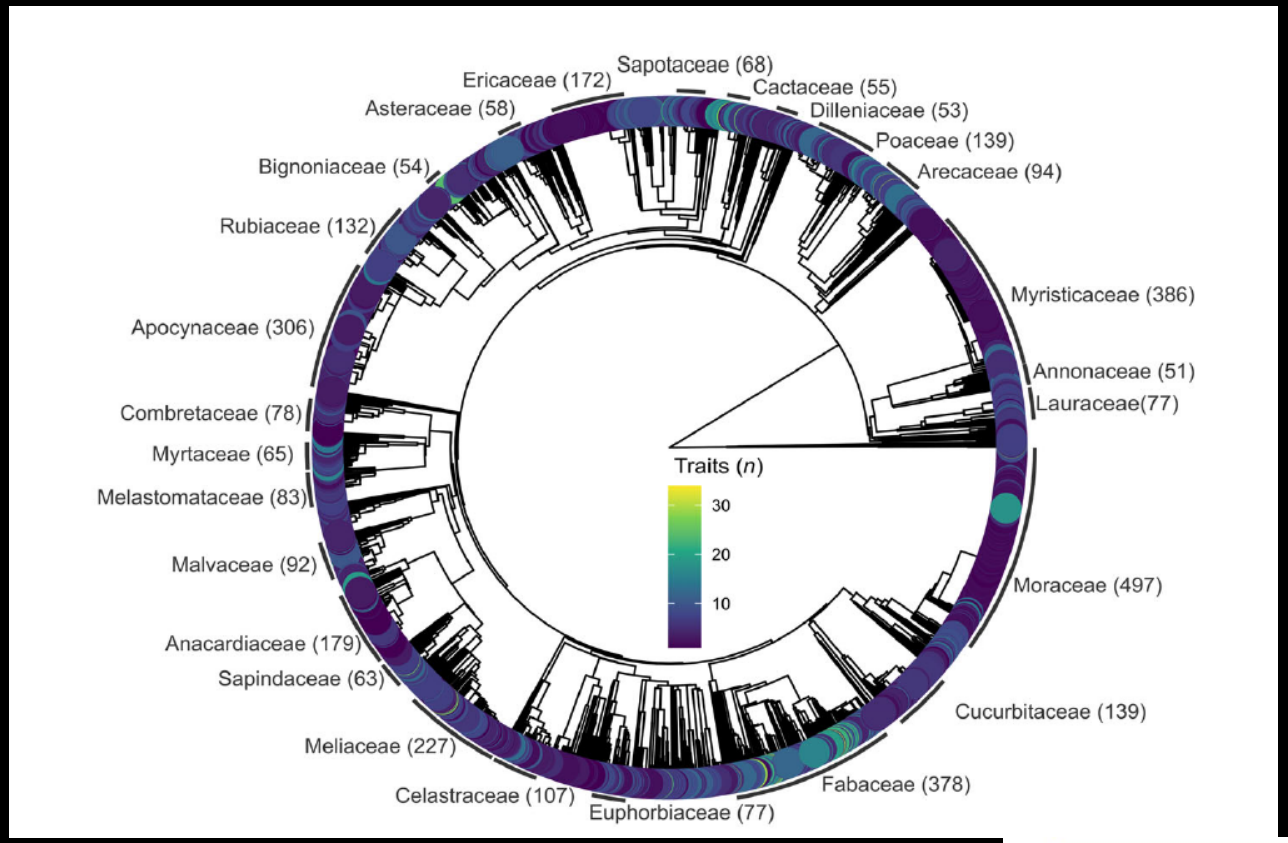
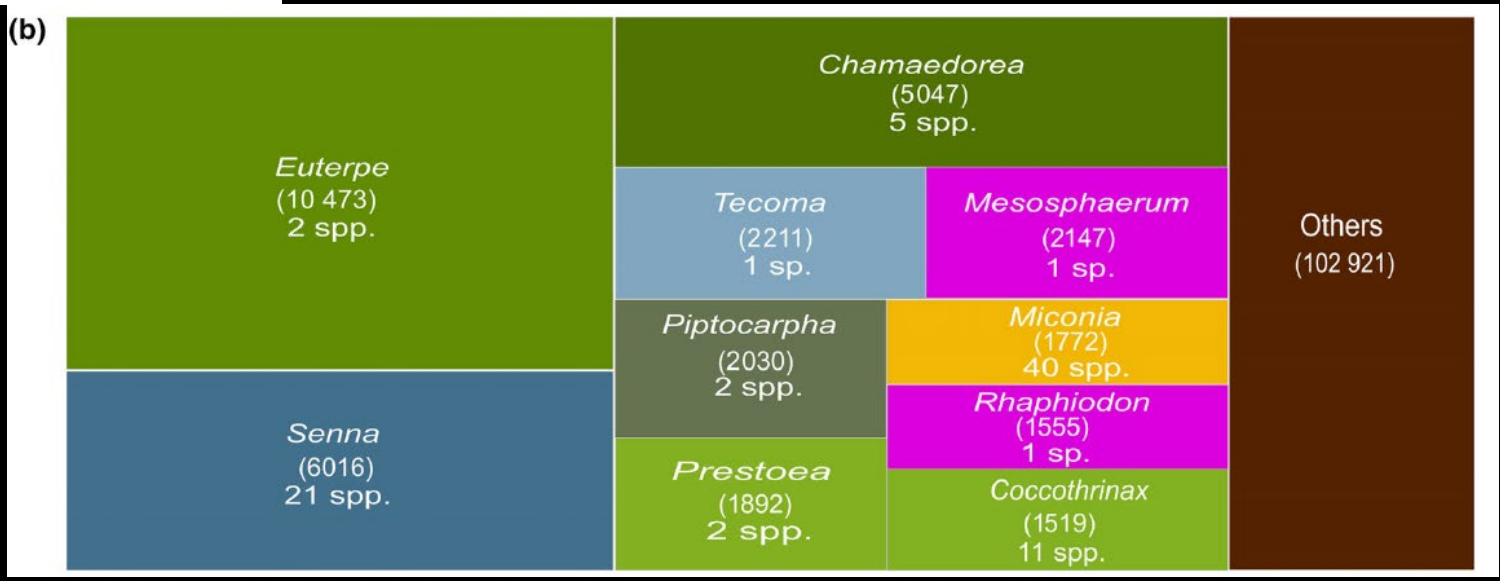
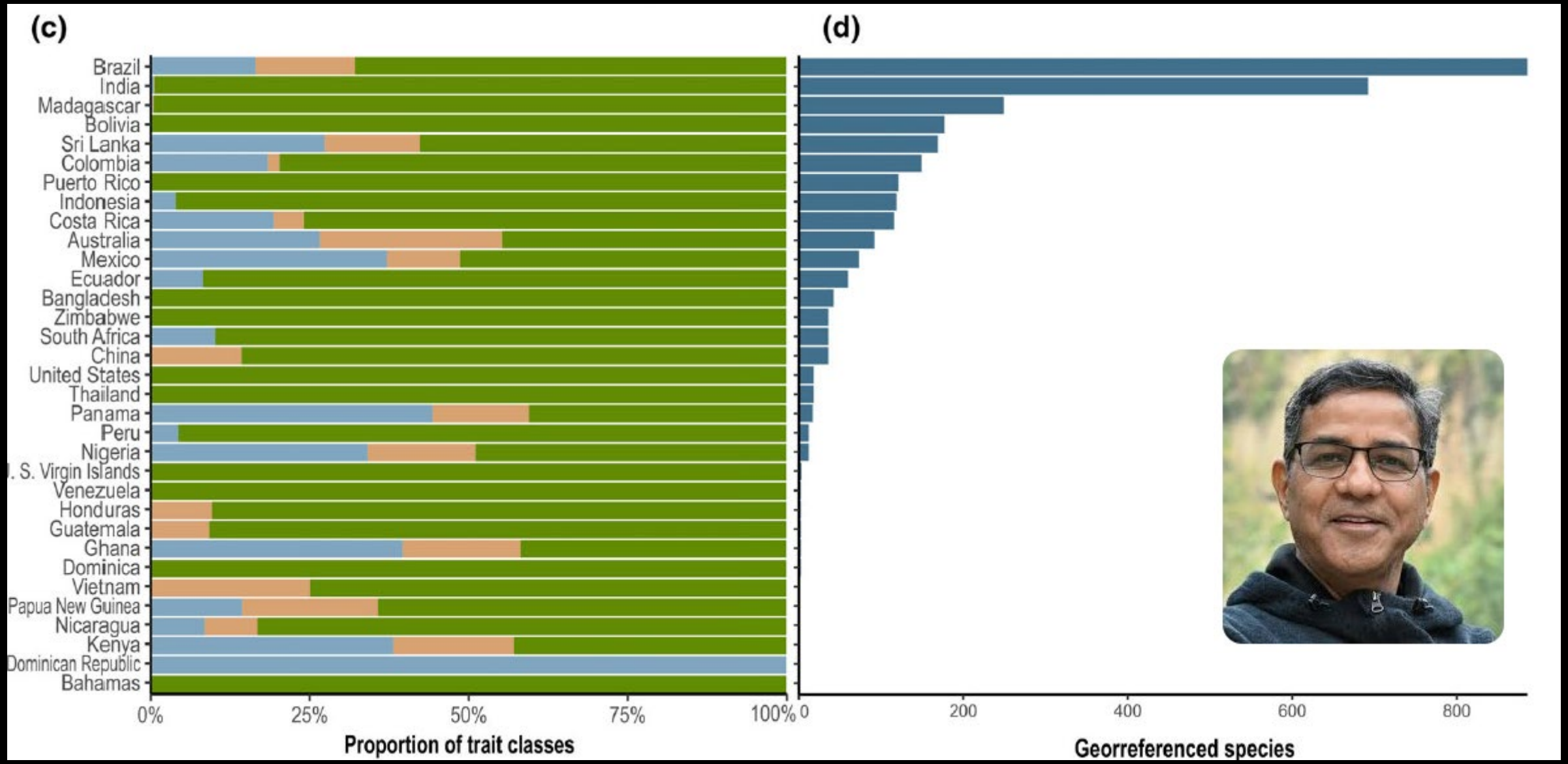

(1) Data acquisition
Model template idealization
Open call on the initiative website
Email to the scientific community
Sharing in scientific events
Filled template received via e-mail/Individual check
(2) Data curation
Visual check of distributions with histograms
Coordinate curation with CoordinateCleaner package
Taxonomy standardization
Species not-fount orthography checked with Jaro–Winkler (max distance = 0.08)
Species not found retained as reported
(3) Data availability
6045 species reported, 5115 species accepted (74.5% georreferenced)
33 georeferenced countries
Data available in two CSV files:
• TSTD_data
• TSTD_metada
Available in permanent repositories:
• Figshare


(a)
Tropic of cancer
Tropic of capricorn
Deserts & xeric shrublands
Mangroves
Montane grasslands & shrublands
Tropical & subtropical grasslands, savannas & shrublands
Tropical & subtropical moist broadleaf forests
Tropical & subtropical coniferous forests
Tropical & subtropical dry broadleaf
Flooded grasslands & savannas


(b)
0%
25%
50%
75%
100%
Fruit type 89.8% (19,397)
Fruit color 73.6% (15,895)
Seed production 52.4% (11,318)
Seed color 46.5% (10,043)
Dispersal syndrome 44.9% (9,695)
Seed length 43.9% (9,475)
Seed width 43.1% (9,300)
Individual seed mass 40.2% (8,679)
Fruit diameter 37.1% (8,023)
Seasonality of seed release 28.9% (6,251)
Germination percentage 20.4% (4,416)
Dormancy class 16.9% (3,659)
Seed mass 15.8% (3,422)
Seed water content 15.2% (3,277)
Desiccation tolerance 15.0% (3,230)
Seed coat water permeability 14.3% (3,090)
Seed height 6.5% (1,409)
Dormant state 3.7% (793)
Mean germination time .mgt. 3.6% (771)
Non-viable 3.2% (689)
Serotiny 3.1% (668)
Seed viability 2.9% (630)
Non-dormant 2.9% (627)
Embryo type/development 1.4% (310)
Base temperature for germination .tb. 1.4% (306)
Seed bank persistence 1.2% (266)
Germination time .t50. 1.2% (255)
Embryoless 1.1% (248)
Optimum temperature for germination .to. 1.1% (231)
Trait class
Morphological
Biophysical
Germination
(d)
Morphological
Biophysical
3,760 (73.5%)
103 (2%)
0 (0%)
963 (18.8%)
280 (5.5%)
0 (0%)
9 (0.2%)
Germination
(c)
No. of records
50 000
40 000
30 000
20 000
10 000
0
1272 spp.
655 spp.
397 spp.
157 spp.
58 spp.
42 spp.
Rainforest
Dry forest
Savanna
Grassland
Shrubland
Wetland
Biome


Sapotaceae (68)
Cactaceae (55)
Dilleniaceae (53)
Poaceae (139)
Arecaceae (94)
Myristicaceae (386)
Annonaceae (51)
Lauraceae(77)
Moraceae (497)
Cucurbitaceae (139)
Fabaceae (378)
Euphorbiaceae (77)
Celastraceae (107)
Meliaceae (227)
Sapindaceae (63)
Anacardiaceae (179)
Malvaceae (92)
Melastomataceae (83)
Myrtaceae (65)
Combretaceae (78)
Apocynaceae (306)
Rubiaceae (132)
Bignoniaceae (54)
Asteraceae (58)
Ericaceae (172)
Traits (n)
30
20
10


(b)
Euterpe
(10 473)
2 spp.
Senna
(6016)
21 spp.
Chamaedorea
(5047)
5 spp.
Tecoma
(2211)
1 sp.
Mesosphaerum
(2147)
1 sp.
Piptocarpha
(2030)
2 spp.
Miconia
(1772)
40 spp.
Rhaphiodon
(1555)
1 sp.
Prestoea
(1892)
2 spp.
Coccothrinax
(1519)
11 spp.
Others
(102 921)


(c)
(d)
Brazil
India
Madagascar
Bolivia
Sri Lanka
Colombia
Puerto Rico
Indonesia
Costa Rica
Australia
Mexico
Ecuador
Bangladesh
Zimbabwe
South Africa
China
United States
Thailand
Panama
Peru
Nigeria
. S. Virgin Islands
Venezuela
Honduras
Guatemala
Ghana
Dominica
Vietnam
Papua New Guinea
Nicaragua
Kenya
Dominican Republic
Bahamas
0%
25%
50%
75%
100%
Proportion of trait classes
0
200
400
600
800
Georreferenced species

METHOD PAPER
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Australian Journal of Botany

A handbook for standardised measurements of plant reproductive traits: from pollen grain to seedling

Peter Poschlod[A,*], Tereza Mašková[A,B,C,*], Si-Chong Chen[D,E], Shyam S. Phartyal[F], Sergey Rosbakh[A,G,H], Fernando A. O. Silveira[I], Arne Saatkamp[J], James W. Dalling[K,L], Emma Dalziell[M,N], John B. Dickie[E], Eduardo Fernández-Pascual[O], Lydia K. Guja[P,Q], Borja Jiménez-Alfaro[O], David J. Merritt[M,N], Mark K. J. Ooi[R] and Filip Vandelook[S,T]

58 standardized protocols for:

- flowers (10 traits),
- fruits (6 traits)
- seeds (36 traits)
- seedlings (6 traits)

Guidelines for flower, seed and fruit collection

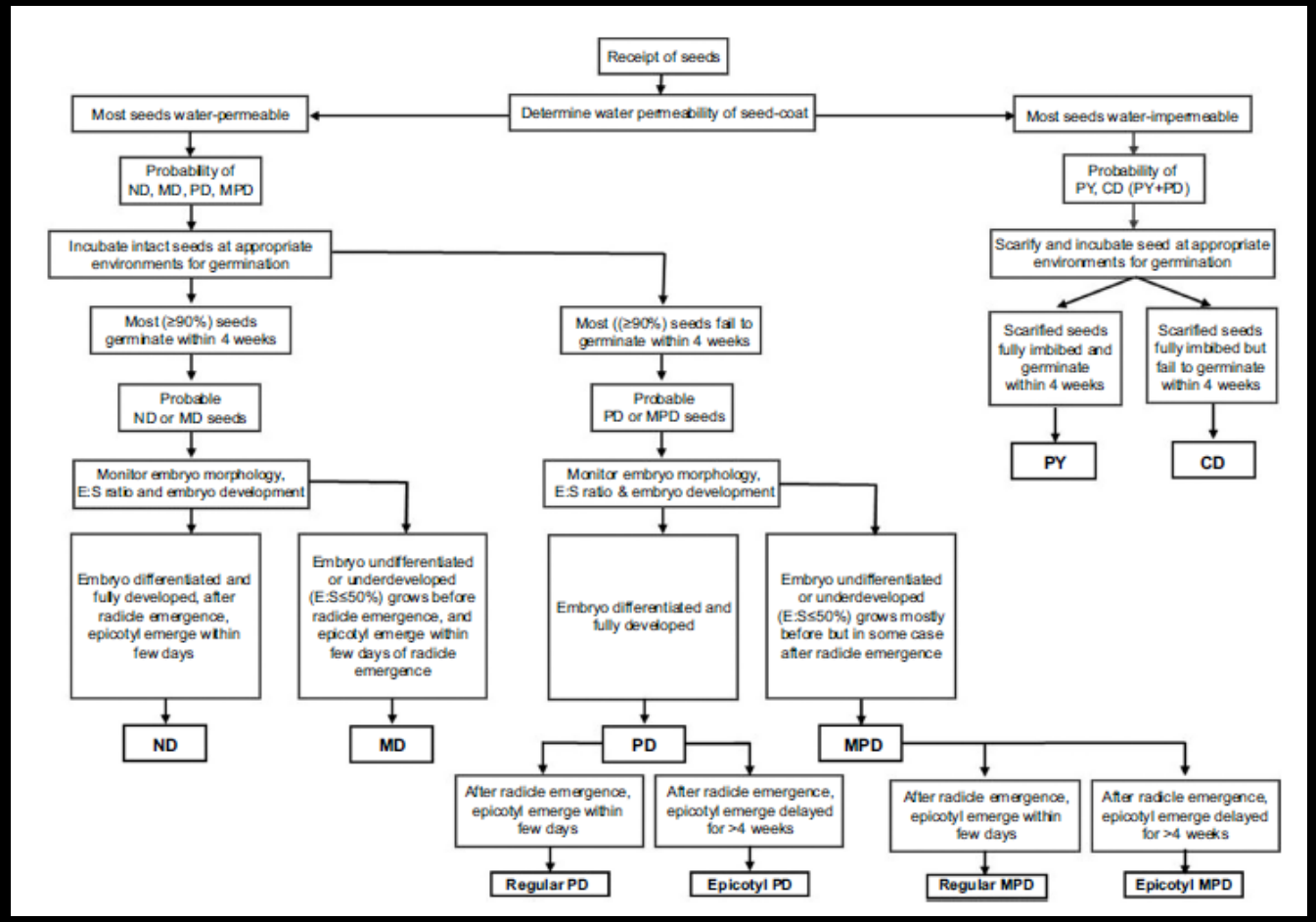
Guidelines for transport and cleaning

Guidelines for storage

Guidelines for experiments

Layout of the protocols

- definitions
- Functions and trade-offs
- Sources of variability
- Methodology



Next steps

- Expand TSTD using bioinformatic tools (tropicalseedtraits@gmail.com)
- Assess the effectiveness of the handbook protocols
- Better integrate seed testing rules with protocols

Thank you

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