A Tale of Two Palms: An Assessment of *Trachycarpus fortunei* and *T. wagnerianus* (Arecaceae)

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Abstract

The taxonomic status of *Trachycarpus fortunei* and *T. wagnerianus* varies considerably. These small to moderate, solitary, highly esteemed, cold-tolerant fan palms are likely from China and perhaps Japan but are unknown in a truly wild, natural, original state. Their taxonomic status varies: they have been considered separate species, the latter has been placed in synonymy with the former, or the latter has been listed as an infraspecific taxon of the former. Here, we amply illustrate, discuss, and review their histories, nomenclature and typification, distribution and ecology, conservation, ethnobotanical uses, and cultivation. We also provide detailed descriptions and a morphometric character comparison to develop reliable character tools for distinguishing both taxa. The results indicate that these taxa are highly variable because of long histories spanning thousands of years of selection, breeding, and hybridization, intentional or not, mostly for enhancement of the numerous products derived from them. In many respects, they are artificial, domesticated species. While these results suggest but do not confirm their separate taxonomic status, they provide reliable character tools for distinguishing both taxa. A rigorous and robust molecular phylogenetic analysis is needed to sort out these two taxa and the entire genus.

Introduction

Trachycarpus (from the Greek *trachus*, meaning rough, and *karpos*, meaning fruit, and alluding to the irregularly shaped fruit), includes about 10 species of moderate, mostly solitary, dioecious or polygamous, variable fan palms ranging from mountainous regions of northern India to northern Thailand, Vietnam, and China (Dransfield et al. 2008).

Trachycarpus fortunei (windmill palm, Chinese windmill palm, Chusan palm, Fortune's windmill palm, hemp palm) is one of the most distinctive, exotic, landscape palms for California and around the world where it is cultivated in suitable subtropical and warm-temperate locales (**Fig.**

1). Indigenous to China and perhaps neighboring areas and a solitary, slender-stemmed, palmate-leaved palm, its most defining characters are the windmill-like leaves and the vertically elongated mass of fine, long, dark brown to black, hair-like fibers emanating from the margins of the persistent leaf bases and typically densely clothing the trunk in its entirety. For thousands of years these fibers have been harvested locally and much prized to make ropes, mats, mattresses, brooms, and brushes, and other everyday household products while the fruits are the source of wax, food, and medicine (Essig and Dong 1987).

Another feature that sets *Trachycarpus fortunei* apart and is especially esteemed by palm growers, collectors and the landscape industry in more temperate regions, where cold hardiness is critical, is its remarkable tolerance of extended periods of damp to wet and cool to cold, even severe sub-zero (C) temperatures. These features make it one of the most cold-tolerant palms, enabling its cultivation in the Pacific Northwest of the United State and adjacent Vancouver, Canada, Ireland and the British Isles, southern Switzerland and northern Italy, and central Japan, to name a few challenging places to cultivate palms year-round outdoors.

Trachycarpus wagnerianus (dwarf or miniature windmill palm, waggie palm, miniature Chusan palm, Wagner's windmill palm), a closely related taxon with a similar, hairy trunk and cold hardiness, is much less common in the landscape (**Fig. 2**). However, it is exceedingly handsome, especially when young, because of its smaller habit and smaller, nearly dwarf leaves with stiff, rigid segments, immediately setting it apart from the more common and larger *T. fortunei*.

In recent, major, on-line botanical databases, *Trachycarpus wagnerianus* is listed as a synonym of *T. fortunei* (POWO 2025, TROPICOS 2025, WFO 2025); these databases are probably mostly based on Govaerts and Dransfield (2005), Henderson (2009), Iwatsuki et al. (2016), Pei et al. (2010), and Wu et al. (2010). Another major on-line database, IPNI (2025) offers no opinion about the synonymy of *T. wagnerianus* with *T. fortunei* but refers one to the WFO. The WFO (2025) does list *T. wagnerianus* as a synonym but, strangely, also bases its synonymy opinion on the IPNI (International Plan Names Index). On the other hand, in popular, mostly horticultural accounts, *T. wagnerianus* is typically maintained as a separate taxon, either as a species (Jones 1995, Kimnach 1977, MBG 2025, McCurrach 1960 [incorrectly as *T. takil*], Osborne et al. 2005, RHS 2025, Stevens 2010, TPC 2025), variety, or even a cultivar of *T. fortunei* (Gibbons and Spanner 2013 [informally], Jacquemin 1999, Riffle et al. 2012) although Palmpedia (2025) treats it as a synonym.

The basis of this conundrum of the taxonomic status of *Trachycarpus fortunei* and *T. wagnerianus* is likely that the former is unusually variable and is probably now unknown in a truly wild, natural, original state. Garry Tsen of China Gardening Nursery (Coldplant.com), who has explored exten-

1. *Trachycarpus fortunei* is one of the most distinctive, exotic, cold-hardy, landscape palms for California and subtropical and warm-temperate locales. Note the bent leaf blade segment tips. In 2011, Santa Barbara, California.

2. *Trachycarpus wagnerianus*, a closely related taxon to *T. fortunei*, has a similar, hairy trunk and cold hardiness but is much less common in the landscape. Note the stiff, unbent leaf blade segment tips. In 2021, Seal Beach, California.

sively throughout China for *Trachycarpus* and other plants, responded to the question of the wild status of *T. fortunei* (pers. comm., 30 January 2026), "As for whether there are wild types of *T. fortunei*, this is a difficult question to answer. It depends on the definition of *T. fortunei*. Based on my explorations in many regions, I have indeed found *Trachycarpus* growing in the wild, but it's hard to determine whether they are truly wild *T. fortunei*."

Also, *Trachycarpus fortunei* has been extensively cultivated for thousands of years in China (Gibbons and Spanner 2013), where various forms have been selected for their quality and/or quantity of ethnobotanical products (Essig and Dong (1987), ornamental qualities, cold tolerance, and fast growth rate, and perhaps where hybridization of the two taxa and their forms, intentionally or not, has occurred. Indeed, Stevens (2010) listed 10 cultivars of *T. fortunei*, nearly all from cultivation.

In contrast, *Trachycarpus wagnerianus* can be traced to plants cultivated in Japan and introduced first to European horticulture, is much less variable than *T. fortunei*, but is also unknown in a truly natural, wild state. Although *T. wagnerianus* might hybridize with *T. fortunei* in gardens and landscape where both taxa are together, we have noticed only several instances of apparent hybridization of these two taxa despite surveying literally hundreds of individuals of each taxon, often growing together. Nonetheless, hybrids would further muddle the situation.

Stührk (2006) performed the only molecular study of which we are aware but was unable to find resolution of *Trachycarpus fortunei* and *T. wagnerianus*. A present-day, robust molecular phylogenetic study is sorely needed to sort out these two taxa, as well as the remaining taxa in the genus. Until that is achieved, we address the conundrum of their taxonomic status with a preliminary study, including their histories, nomenclature and typification, distribution and ecology, conservation, ethnobotanical uses, and cultivation. We also provide detailed descriptions and a morphometric character comparison to identify reliable character tools for distinguishing both taxa. The descriptions are mostly based on fresh, living, non-dried material used in our morphometric character comparison while that of *T. fortunei* is carefully supplemented from Beccari (1905), Hooker (1860), Pei et al. (2010), and Wu (2010) and that of *T. wagnerianus* is supplemented from Beccari (1921). Also, because *T. wagnerianus* has long been synonymized with *T. fortunei*, nearly all information, including descriptions, typically refers to *T. fortunei*; little if any refers to *T. wagnerianus* unless information for the latter taxon has been simply included in that of *T. fortunei* without making a distinction.

History

The first introduction of *Trachycarpus fortunei* to western horticulture is unclear. Many considered it first introduced to Europe at the beginning of the 19th century (Gay 1861, Jacobi 1998, Siebold 1856). Gibbons and Spanner (2013) and TSO (2026) suggested that Phillip Franz Balthasar von Siebold (17 February 1796 — 18 October 1866), a German physician, botanist, and traveler best known for his studies and collections of Japanese plants, first introduced seeds of *T. fortunei* to Leiden, Netherlands from Japan about 1830 where it was likely cultivated (**Fig. 3**). From this batch of seeds, one plant subsequently was sent to Kew in 1836 and grown in the tropical palm house where it attained about nine m in height by 1860 but it eventually died (TSO 2026), perhaps an early indication of its poor suitability to ever-warm, moist, tropical conditions. However, CABI (2026) reported it was in Belgium by 1828.

Nonetheless, Robert Fortune, who saw *Trachycarpus fortunei* as early as 1843 on Chusan Island and again in 1848 in Chekiang, both places in China, made the most famous and successful introduction of this species from Japan to western horticulture in the late 1840s. He sent a container of live plants to Kew in 1849 where, at Fortune's recommendation, one was planted outdoors and has survived ever since (TSO 2026). Fortune also grew plants in his nursery and started distributing them in 1860 (Gardener 1971, Gay 1861, TSO 2026). Glendinning's Nursery auctioned off plants grown from seeds that Fortune had collected and sent from the Ningpo region of Chekiang (TSO 2026). Dutch, English, and French introductions continued through the latter half of the 19th century.

Robert Fortune (16 September 1812[3?]), Edrom, Kelloe, Berwickshire, Scotland—13 April 1880, London) (Boulger 1889, Chilsom 1911, EB 2025, Godfrey 2017) was a well known and distinguished, 19th-century botanist, plant hunter, traveler, and nurseryperson credited with introducing about 250 new types of mostly ornamental plants, and mostly from China, into gardens in Britain, Australia, and North America. His name is commemorated in many of the plants he introduced, including one genus, *Fortunearia sinensis*, and numerous species, including *Berberis fortunei*, *Crytomium fortunei*, *Hosta fortunei*, *Rhododendron fortunei*, *Rosa fortuniana*, and, of course, *Trachycarpus fortunei*, to name just a few (Wikipedia 2025).

Born into a humble family, Fortune was an apprentice at a local nursery and then graduated to work at the Royal Botanic Garden, Edinburgh. In 1840, he moved to London where he became superintendent of the Hothouse Department of the Horticultural Society of London (later the Royal Horticultural Society) garden at Chiswick (Boulger 1889, Godfrey 2017). In 1843, the Society commissioned him to undertake a three-year plant exploring and collecting expedition to southern China (Wikipedia 2025). He made three other trips to China and one to Japan over the next 18 years. He brought back seeds and perhaps seedlings or small plants of *Trachycarpus fortunei* during his first trip to China, 1843–1846, to his nursery, which would have been sufficiently large to distribute three years later in 1849 when Kew obtained their plants.

3. *Trachycarpus fortunei* was first introduced to western horticulture from Japan about 1830. Note the bent leaf blade segment tips. In 2013, Hamarikyu Gardens, Tokyo, Japan.

Fortune is also famous (or infamous) for surreptitiously traveling farther into China where foreigners were not allowed and obtaining and smuggling out tea (*Camellia sinensis*) plants and knowledge of their cultivation, which China prohibited or tightly controlled at the time, to India and Sri Lanka for the British East India Company, forming the basis of the successful tea industries in those countries (Boulger 1889, EB 2025, Godfrey 2017). He is infamous for introducing Japanese chestnuts into the United States, which later led to the introduction of chestnut blight disease after his death (Tredici 2017).

Hooker (1860) reported that the plant of *Trachycarpus fortunei* (then known as *Chamaerops fortunei*) at the Royal Botanic Gardens, Kew, near London and upon which he based this species, was from a batch introduced to horticulture by Fortune in 1849. By 1860, these plants had attained about 2.5 m in height at Kew and the finest specimens were moved inside the conservatory for the winter but the other remained outdoors with little or no protection from the elements. Other early, notable introductions include Turkey in 1849 and Australia in 1888 (CABI 2026).

Trachycarpus wagnerianus was introduced from Japan to western horticulture in the third quarter of the 19th century (**Fig. 4)**. Albert Wagner, for whom this species is named, was a successful nurseryperson in Leipzig, Germany who propagated, grew, and sold palms out of his steam-heated stove houses and made several plant exploring and collecting trips to Japan and China in the third quarter of the 19th-century. In Japan he encountered *T. wagnerianus* and introduced it about 1873. He sold nearly his entire stock of this species to L. Winter who had a nursery in Italy (Gibbons and Spanner 2013).

Today, *Trachycarpus fortunei* and to a lesser extent *T. wagnerianus* are widely cultivated in subtropical and warm temperate regions of the world where they are much prized for their ornamental qualities and tolerance of adverse conditions, especially severe cold.

Typification

Trachycarpus fortunei

We thought that the typification of *Trachycarpus fortunei* would be mostly straight forward; however, that turned out not to be the case. Sir William Jackson Hooker (1860) first named and described this species as *Chamaerops fortunei* in the *Botanical Magazine*, of which at the time, he was the editor and sole author. Hooker (6 July 1785, Norwich, Norfolk, England—12 August 1865, Kew, Surrey) was an English botanist, botanical illustrator, and first full-time director of the Royal Botanic Gardens, Kew, where he founded the herbarium and enlarged the gardens and arboretum (Fitzgerald 2020, Turril 1959). Just a year later, Wendland (1861) transferred the name to

4. *Trachycarpus wagnerianus* was also introduced to western horticulture from Japan but in the third quarter of the 19th century. Note the stiff, unbent leaf blade segment tips. In 2013, City Hall, Kyoto, Japan.

Trachycarpus. Wendland (11 October 1825, Herrenhausen—12 January 1903, Hannover) was a distinguished German botanist, horticulturist, gardener, and noted authority of the palms (Arecaceae), aroids (Araceae), cyclanths (Cyclanthaceae), and cycads. He traveled in Central America studying and collection these groups of plants and returned to Germany with plants to enhance the living collections at Herrenhausen (JSTOR 2025).

Checking in JSTOR, a digital library of academic journals, books, and primary sources, did reveal two historical specimens of *Trachycarpus fortunei* at K (Royal Botanic Gardens, Kew), where Hooker's specimens should be, and they are associated with one another (by their accession numbers, K000736112 and K000736113), bear the handwritten name "*Chamaerops fortunei*," the date "1860" (the same year that *Chamaerops fortunei* was published), and have the phrase "from which the drawing was made." We inquired about type material of *T. fortunei* at Kew without tipping our hand about these two specimens, and Kew sent high resolution images of the two specimens in question.

At first we thought for sure that these specimens must constitute original material of *Trachycar-pus fortunei* but we have since convinced ourselves otherwise. In the first place, we are not told which drawing was made from these specimens (and a rough drawing, different from that in the protologue, is affixed to one of the sheets of K000736112). Second, this same sheet with the rough drawing bears the inscription "Hort. Bot. Jamaica May 6/82," at the top of the sheet and adjacent to this inscription are some leaf base fibers, a rachilla, and a folded leaf blade segment, which appear to be extraneous material added later. The Jamaica origin of the later material and the date, 1882, would quickly exclude this later, extraneous material as original. Third, the writing on the two sheets is not in Hooker's hand. Finally, these two sheets at Kew do not include any of the reproductive parts handsomely illustrated (and briefly described) in Hooker's protologue (other than the single rachilla that should likely be associated with the later, extraneous addition from 1882); indeed, the rough drawing that is affixed to one of the sheets shows a sterile plant. Thus, no explicit indication that Hooker actually saw these specimens and used them in his 1860 Botanical Magazine original account is on the specimens, such as annotations referring to Hooker's original account and signed by Hooker.

Therefore, despite the date and their deposition at Kew, no incontrovertible evidence exists that these specimens qualify as original material; indeed, good evidence exists to the contrary! Be-cause these specimens are not original, types generally cannot be associated with them. Moreo-ver, it would appear that, during the past 150+ years, no one has annotated these sheets as types.

Nonetheless, Hooker's plate (1860, pl. 5221) is part of the protologue and, therefore, is incontrovertibly original material with which type status can be associated. Thus, we here designate Hooker's plate as the lectotype (**Fig. 5**).

Trachycarpus wagnerianus

The typification of *Trachycarpus wagnerianus* is a bit more complicated. It was long thought that Beccari (1921) named and described this species. But Beccari actually cited Roster's prior usage of the name (Roster 1914). However, Roster had cited Berger's earlier name (Berger 1912) and liberally paraphrased Berger's text (albeit in Italian).Thus, Berger (1912) must be the original, legitimate, and accepted authority of *T. wagnerianus*, and the names of Roster (1914) and Beccari (1921) are later homonyms and illegitimate.

In the course of searching for Berger's original or type material of *Trachycarpus wagnerianus* to establish proper typification of the species, we found two sheets at FI (Università degli Studi di Firenze, Sistema museale di Ateneo, Museo di Storia naturale, University of Florence, University Museum System, Museum of Natural History, Italy) that caught our attention. These two sheets actually contain three different elements or specimens. One sheet has two different labels and (significantly) two different barcodes: FI050504 (at the bottom) and FI050505 (at the top). Clearly, this sheet includes material from two separate gatherings, a practice that was not particularly unusual 100 years ago. These gatherings must be dissociated for the purpose of typification.

A holotype is defined in the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018) as "the one specimen or illustration...used by the author, or designated by the author as the nomenclatural type." We feel it would be difficult, if not impossible, to identify a holotype in the present case. In the first place, Berger did not himself designate a type or did he publish any illustrations. A prospective holotype—or, indeed, any original material—would have to bear evidence of having been studied by Berger during or before his preparation of the protologue, which was published sometime from January through May, 1912. TL-2 (2025) indicates that Berger was at La Mortola from 1897–1914, so it makes sense that he would have seen any collections made there during that period. The protologue states that *T. wagnerianus* "was introduced by Mr. Wagner, a horticulturist at Leipzig, and has flowered and fruited in Mr. Winter's establishment in 1911," which suggests that Berger might have seen fertile material obtained in 1911 from "Mr. Winter's establishment," and we know that Berger must also have had plants growing at La Mortola because the *T. wagnerianus* entry is included in a book that enumerates all the plants cultivated at La Mortola. Armed with this information, we considered the three elements portrayed on the two sheets:

5. We selected Hooker's plate in Botanical Magazine (1860, pl. 5221) as the lectotype.

FI050503 first sheet (the leaf): this leaf evidently originated from a plant grown at La Mortola and bears the inscription “Dal Sig. B. Berger Giugno [i.e., June] 1911.” It is the only one of the three elements that actually bears Berger’s name and also was collected in plenty of time to have been considered for the protologue. Therefore, this element is probably the best candidate of the three to be considered as original material, perhaps even the holotype. Nonetheless, some uncertainties remain. For example, we are unsure what is implied here by Berger’s name; did he actually collect the specimen himself? Why is his first initial (if that is what it is) given as “B.,” rather than “A.”? Is it because someone else (not Berger) wrote this? We are presuming that “Sig.” is an abbreviation for “Signóre,” and that “Dal” is the definite article (“The”). A letter envelope (perhaps empty) addressed from Albert Wagner of Leipzig, Germany to Dr. Odoardo Beccari of Florence, Italy and postmarked 27 June 1911 is attached to the upper left portion of the sheet. How did the contents of this letter figure into these events, if at all?

FI050504 second sheet (lower portion of sheet with inflorescences): this inflorescence is perhaps the second-best element, in terms of qualifying as original material. The tag attached to the inflorescence is printed with “from the Gardens of La Mortola” and bears handwriting identifying it as *Trachycarpus wagnerianus* followed by partially undecipherable handwriting that appears to state, “*Infiorescenze pres à Don Preva dal Signor L. Winters il* 19 VI 1911,” which, if correct, translates to “Inflorescence given to Don Preva by Mr. L. Winters 19 June 1911.” The inflorescence presumably vouchers the very flowering/fruiting event mentioned by Berger in the protologue. It might be assumed that Berger saw this material before publishing his protologue, but that is not necessarily the case; dates on labels can be deceiving, because specimens sometimes sit in boxes for years before being mounted. Just because a specimen was collected in 1911 does not mean that it was available to Berger at that time, or even a year later.

FI050505 second sheet (upper portion of sheet with inflorescences): this element, in our opinion, is the least eligible of the three depicted elements for consideration as original material. Although (like FI050504) it has a tag bearing the imprint of La Mortola and did originate from L. Winter’s establishment, it bears the date “Aprile 1912”; in the protologue, Berger indicated no awareness that *Trachycarpus wagnerianus* had flowered for Winter in 1912, only in 1911. Indeed, the protologue might very well have been published before April 1912. Again, much of the remaining handwriting is undecipherable.

In conclusion, we eliminate FI050505 from consideration and limit our choice to FI050503 and FI050504. A problem here is that there is no clear dividing line, on the sheet with the inflorescences, between FI050504 and FI050505; for that reason, we would conclude that FI050504 (the lower portion, most eligible for typification) must be limited to only that inflorescence to which the label is attached.

We do not feel that a holotype for *Trachycarpus wagnerianus* is present in the two elements on the two sheets considered as original material because holotype is defined as "The one specimen...," whereas, in the present case, two specimens, each of a different gathering, are more or less equally in contention. Because we feel strongly that one or both of the contending specimens must qualify as original material, lectotypification is the appropriate choice; after all, Berger likely saw these specimens because they bear the printed labels of La Mortola where he was employed from 1897–1914 (TL-2 2025), a period covering the dates on the specimens we consider original material.

Berger, in the effective protologue, makes no mention of fertile structures. In comparing and contrasting *Trachycarpus wagnerianus* with *T. excelsa*, he employed only vegetative features ("It is closely related..., especially in the way the leaves are cut, in the stem and the petioles, but it is much smaller, the petioles and leaves are stiffer and more erect"). Berger does state that the species "flowered and fruited in Mr. Winter's establishment in 1911," but (as noted previously) evidence is lacking that Berger himself actually saw any of this fertile material by the time the protologue was published; thus, we feel that lectotypification of the leaf (50503) is appropriate (**Fig. 6**)

Morphometric Character Comparison

The objective of the morphometric analysis was to identify or confirm reliable characters for distinguishing *Trachycarpus fortunei* and *T. wagnerianus*. We do not consider this analysis a phylogenetic study; for such a study we would have to include data for all taxa in *Trachycarpus* and include more characters.

Materials and Methods

An unpublished, preliminary study in 2016 that co-authors Hodel and Komen performed on three individuals each of *Trachycarpus fortunei* and *T. wagnerianus* but using only the vegetative characters we have used in the present study plus several additional ones showed that some significant differences existed between these two taxa. We realized and appreciated the limitations of this study, though, and decided to undertake a more comprehensive study using vegetative and reproductive characters and more individuals of each taxon.

In 2025, we identified or confirmed, collected, and vouchered 20 individuals each of what are commonly identified, known, or referred to as *Trachycarpus fortunei* and *T. wagnerianus* from multiple sources around southern California and representing a mix of public and private botanical gardens, institutions, and landscaped areas (**Table 1**). All collections were deposited at

6. We selected a leaf of *Trachycarpus wagnerianus* (50503) at FI as the lectotype. ©2025 and courtesy of Museo di Storia naturale di Firenze, University of Florence, Italy.

Table 1. Species, Hodel collection No., and location of material of *Trachycarpus fortunei* and *T. wagnerianus* in California collected and used in the morphometric analysis, 2025.

Palm No.	Species	Hodel No.	Location
1	T. fortunei	3753	Leisure World, Seal Beach
2	T. fortunei	3754	Leisure World, Seal Beach
3	T. fortunei	3755	Leisure World, Seal Beach
4	T. fortunei	4042	LASCA[Z]
5	T. fortunei	4043	LASCA
6	T. fortunei	4044	San Diego Zoo, San Diego
7	T. fortunei	4045	San Diego Zoo, San Diego
8	T. fortunei	4046	San Diego Zoo, San Diego
9	T. fortunei	4047	San Diego Zoo, San Diego
10	T. fortunei	4048	San Diego Zoo, San Diego
11	T. fortunei	4049	San Diego Zoo, San Diego
12	T. fortunei	4050	San Diego Zoo, San Diego
13	T. fortunei	4051	San Diego Zoo, San Diego
14	T. fortunei	4052	LASCA
15	T. fortunei	4058	LASCA
16	T. fortunei	4059	LASCA
17	T. fortunei	4061	LASCA
18	T. fortunei	4062	LASCA
19	T. fortunei	4064	LASCA
20	T. fortunei	4069	Duval garden, Vista
21	T. wagnerianus	3750	Leisure World, Seal Beach
22	T. wagnerianus	3751	Leisure World, Seal Beach
23	T. wagnerianus	3752	Leisure World, Seal Beach
24	T. wagnerianus	4038	Hodel garden, Lakewood
25	T. wagnerianus	4041	LASCA
26	T. wagnerianus	4053	LASCA
27	T. wagnerianus	4054	LASCA
28	T. wagnerianus	4055	LASCA
29	T. wagnerianus	4056	LASCA
30	T. wagnerianus	4057	LASCA
31	T. wagnerianus	4060	LASCA
32	T. wagnerianus	4063	LASCA
33	T. wagnerianus	4065	LASCA
34	T. wagnerianus	4066	Leisure World, Seal Beach
35	T. wagnerianus	4067	Leisure World, Seal Beach
36	T. wagnerianus	4068	Leisure World, Seal Beach
37	T. wagnerianus	4075	Lai garden, Topanga
38	T. wagnerianus	4076	Lai garden, Topanga
39	T. wagnerianus	4077	Lai garden, Topanga
40	T. wagnerianus	4078	Lai garden, Topanga

[Z]LASCA = Los Angeles County Arboretum and Botanic Garden, Arcadia.

the herbarium of the Los Angeles County Arboretum and Botanic Garden, Arcadia, California (LASCA).

For each collection, we selected one mid-canopy leaf most exposed to sunlight and one current-year inflorescence. From these we measured and/or determined various quantitative and qualitative characters, including:

Vegetative

Petiole: length; width and thickness at base; width and thickness at apex.
Blade: length; width; roundness (degrees).
Segments: quantity; center tip bifurcation; bending); fold angle; midrib thickness and shape; length center, lateral left and right, basal left and right; width center, lateral left and right, basal left and right.
Palman length: center; lateral left and right; basal left and right.

Reproductive

Inflorescence: length; width.
Peduncle: length.
Quantity 1^{st}-order branches.
Quantity peduncular bracts (including prophyll).
Quantity rachis bracts.
Most proximal rachis bract length.

We acknowledge that character selection could affect the overall results of this analysis. In selecting characters, we tried to be as unbiased as possible. Although we added some reproductive characters for the present study, we tended to base character selection on the unpublished preliminary study, which itself was based on only vegetative characters, because we wanted information that would prove useful to identify taxa even if the plants were without reproductive organs. Also, we predominantly selected vegetative characters because these seem to be used more often to distinguish between both taxa. We sampled from mature individuals growing in full sun or mostly so and, although we were unable to control for cultivation (water, nutrition, mulch) at the various sites, we were able to compile sample populations that appeared to be normal, healthy, uniform, and pest- and disease-free.

Also, palm height and accessibility to the palm canopy played a role in the characters we selected. For example, in the preliminary study the palms were shorter but still mature and we were easily able to access the canopy by standing on the ground to measure or assess characters like leaf whorls and distance between whorls and individual leaves and the ochrea formed from joining of leaf base fibers of the newer leaves. To perform these types of measurements and assessments, considerable time must be spent in the palm canopy, and we lacked the necessary equipment to elevate ourselves into the canopy for this study; thus, we had to cut leaves and inflorescences and remove them from the palm and make measurements and assessments while on the ground, neglecting other characters in the canopy like some of those in the preliminary study that looked promising. Thus, in the current study, we predominantly selected easy-to-see and measure or assess rather gross leaf and inflorescence characters.

A few other caveats accompany our data collection and measurements. We neglected leaf and inflorescence bases, which precluded short, proximal portions of the petiole and peduncle being included in our data, because it is exceedingly difficult and time-consuming to remove these intact from the palm, even when standing on the ground. Our lack of access into the canopy made it impossible to collect these parts of the petioles and peduncles; thus, our measurements and assessments of these organs include only what we were able to cut close to the palm trunk and they exclude their bases although this information was gathered for a few specimens so we could include their measurements in the descriptions.

When determining whether leaf segments bend or not, older, lower leaves in the canopy must be viewed. It appears that segment bending, if it is to occur, is partly a product of age. New and newer leaves in the upper and middle part of the canopy of both taxa are rigid and non-bending, and if bending occurs, it happens on older leaves in the lower part of the canopy. Thus, intensely maintained landscape palms where older leaves and inflorescences are regularly removed, are mostly useless to assess whether leaf segments bend or not.

Also, we measured the degree of leaf segment folding immediately after retrieval from the palm because we found that once removed, leaves seem to lose water and turgor quickly and segments begin to fold up, resulting in artificially small folding angles.

We made all measurements from fresh, non-dried material. Two analyses were performed. The first calculated means and standard deviations, and these data were then analyzed using one-way Analysis of Variance (ANOVA) to determine significant differences between the two presumed different taxa. The second analysis combined traits to attain a full measure of the differences from the presumed different taxa. This approach, called Principal Component Analysis (PCA), is a statistical technique that reduces the dimensionality of complex datasets while retaining as much variation as possible. PCA works by creating new, independent variables called principal components (PCs), which are unknown combinations of the original variables. The first principal component (PC1) captures the largest share of variation, the second (PC2) captures the next largest share, and so forth. By plotting data using two of these components at a time, PCA reveals clustering patterns and group separations in the data that may not be obvious when examining each individual trait separately.

Results and Discussion

Of the 36 characters we measured or assessed and analyzed using the ANOVA (29 vegetative, 7 reproductive), 25 were significantly different (20 vegetative, 5 reproductive) between the two taxa, leaving 11 that were not significantly different (9 vegetative, 2 reproductive) (**Table 2**).

Generally, *Trachycarpus fortunei* has significantly larger leaves including petioles, blades, and segments (**Fig. 7**). Although we were unable to measure canopy dimensions, these are rather easy to estimate accurately. Because canopies are mostly symmetrical, doubling the sum of petiole and leaf blade center segment length (does not include the trunk diameter, which seemed to be similar in both taxa) is a mostly accurate estimate of canopy dimensions, and our data show that *T. fortunei* has larger leaf canopies than *T. wagnerianus* (**Figs. 8–9**)

The two taxa are also significantly different in leaf center segment tip bifurcation, segment fold angles, and whether segments bend or not. *Trachycarpus wagnerianus* has significantly shorter segment tip bifurcation and more strongly folded segments and has segments that do not bend (**Figs. 10–15**) In our study, this latter character appears especially consistent and diagnostic in distinguishing the two taxa, and the shallower tip bifurcation and more strongly folded segments might contribute to segment rigidity and lack of bending. Palm Society of Southern California member Chris Stevens (pers. comm. August 2025) told of the "touch test," where pressing on the leaf segments tips of *T. wagnerianus* typically will cause the blade to move downward without bending the segments but in *T. fortunei* the same technique will cause the segments to bend.

We were so intrigued why *Trachycarpus wagnerianus* had leaf segments that did not bend while *T. fortunei* had segments that did bend, that, in addition to measuring segment tip bifurcation and degree of segment folding, which we feel affect segment rigidity and bending, we also tried to determine segment midrib diameter and shape. Our thinking was that thicker and vertically oriented oblong rather than round midribs would be stronger and contribute to segment rigidity. Unfortunately, these latter two characters proved to be not significantly different, which might reflect our lack of equipment and/or technique to measure and assess such minute characters more accurately. Thus, we feel that revisiting midrib diameter and shape, as well as segment thickness from an anatomical approach might prove especially revealing.

While leaf blades of *Trachycarpus fortunei* are significantly larger than those of *T. wagnerianus*, no significant difference was found in palman size between the two taxa. These findings show that the palman-to-leaf-blade ratio is larger for *T. wagnerianus* (0.53) than for *T. fortunei* (0.29),

Table 2. Results of a morphometric analysis of *Trachycarpus fortunei* and *T. wagnerianus*, 2025.

Character	T. fortunei (mean)	SD[Z]	T. wagnerianus (mean)	SD	Significance, P <
Petiole (cm)					
length	93.8	24.9	63.6	15.3	.001
width base	2.2	0.4	1.9	0.3	.05
thickness base	1.4	0.2	1.2	0.2	.05
width apex	1.8	0.3	1.8	0.2	NS[Y]
thickness apex	0.9	0.2	0.9	0.2	.05
Blade					
length (cm)	99.4	19.3	52.1	19.3	.001
width (cm)	121.0	18.1	63.0	12.7	.001
roundness (degrees)	254.2	48.9	160.1	35.4	.001
Segments					
quantity	46.4	3.7	47.2	2.4	NS
tip bifurcation length (cm)	2.3	2.1	0.4	0.2	.001
bending (1 = yes, no = 0)	1	0.0	0.0	0.0	.0000
fold angle (degrees)	100.4	25.8	54.4	16.4	.001
midrib thickness (mm)	1.2	0.3	1.1	0.3	NS
midrib shape (1 = round, 2 = oblong)	1.4	0.5	1.7	0.5	NS
Segment Length (cm)					
center	71.1	10.4	51.8	9.7	.001
lateral left	64.0	10.3	43.6	9.8	.001
lateral right	62.1	10.7	43.2	10.1	.001
basal left	43.9	10.5	23.5	7.2	.001
basal right	40.2	10.0	23.6	8.0	.001
Segment Width (cm)					
center	3.4	0.5	2.7	0.4	.001
lateral left	3.0	0.7	2.6	0.6	.05
lateral right	3.0	0.6	2.4	0.5	.05
basal left	1.0	0.3	0.8	0.2	.05
basal right	1.0	0.4	0.8	0.2	.05
Palman length (cm)					
center	29.2	6.1	27.8	5.5	NS
lateral left	17.7	5.6	17.1	3.8	NS
lateral right	17.6	3.5	18.9	4.0	NS
basal left	7.5	2.8	8.8	3.2	NS
basal right	7.7	3.9	9.1	3.9	NS
Inflorescence					
length	79.9	18.7	64.9	11.1	.01
width	77.8	20.4	58.7	19.2	.01
Peduncle					
length (cm)	31.7	15.2	13.7	8.4	.001
Quantity 1st-order branches	19.9	3.8	17.0	3.6	.05
Quantity visible peduncular bracts (including prophyll)	2.8	0.6	2.5	0.7	NS
Quantity rachis bracts	3.0	1.1	5.7	2.8	.001
Most proximal rachis bract length (cm)	20.3	7.7	20.0	4.3	NS

[Z]SD = standard deviation. [Y]NS= not significant.

7. Generally, *Trachycarpus fortunei* (top) has significantly larger leaves, including petioles, blades, and leaf blade segments, than *T. wagnerianus* (bottom). Ruler is ca. 30 cm.

8. Marianne A. Hodel stands next to several *Trachycarpus wagnerianus*, which have smaller leaf canopies than *T. fortunei*. In 2022, Seal Beach, California.

9. Marianne A. Hodel stands next to several *Trachycarpus fortunei*, which have larger leaf canopies than *T. wagnerianus*. In 2022, Seal Beach, California.

10. *Trachycarpus wagnerianus* has shorter, leaf blade segment tip bifurcation than *T. fortunei* (see Fig. 11).

11. *Trachycarpus fortunei* has longer leaf blade segment tip bifurcation than *T. wagnerianus* (see Fig. 10).

12. *Trachycarpus wagnerianus* has narrower leaf blade segment fold angles than *T. fortunei* (see Fig. 13).

13. *Trachycarpus fortunei* has wider leaf blade segment fold angles than *T. wagnerianus* (see Fig. 12).

14. *Trachycarpus wagnerianus* has stiff, unbent leaf blade segment tips. Compare with bent leaf blade segment tips of *T. fortunei* (see Fig. 15).

15. *Trachycarpus fortunei* has bent leaf blade segment tips. Compare with unbent segment tips of *T. wagnerianus* (see Fig. 14).

indicating that *T. wagnerianus* has shorter, free, distal portions of segments, which might contribute to their rigidity and lack of bending.

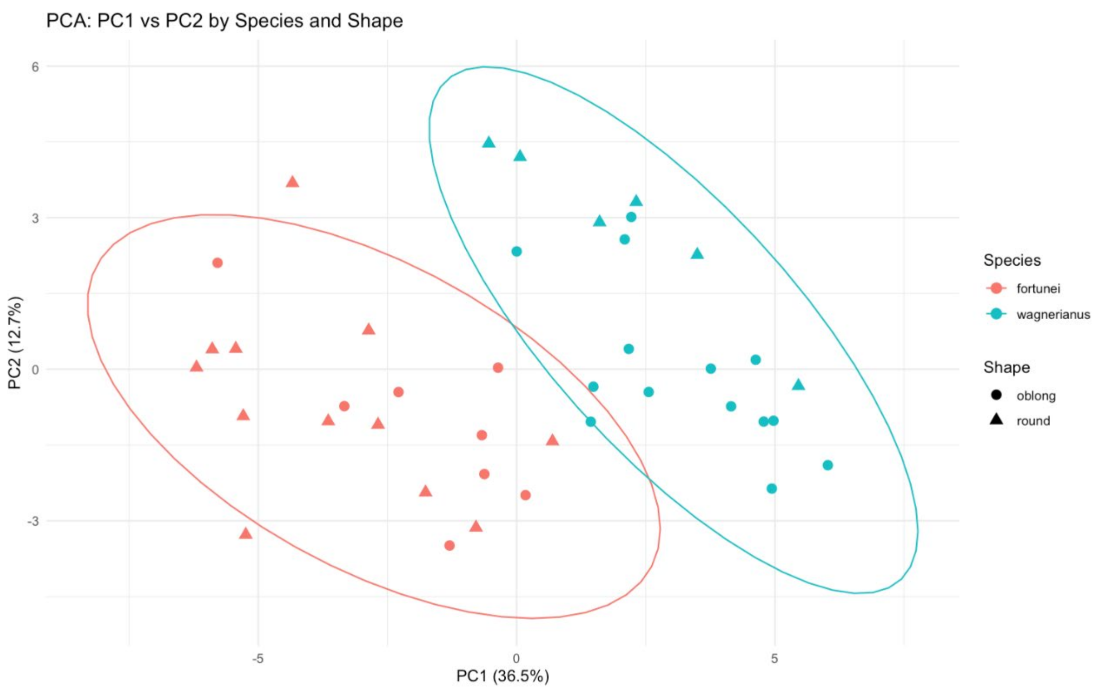
The morphometric data show that *Trachycarpus fortunei* can typically be readily distinguished from *T. wagnerianus* by its larger canopies (ca. 3.45 vs. 2.45 m wide), leaves (ca. 165 vs. 116 cm long), and inflorescences (ca. 90 × 78 cm vs. 65 × 59 cm); leaf segment tips that bend (vs. no bending); larger leaf segment fold angles (ca. 100 vs. 54°); and longer center leaf segment tip bifurcation (ca. 2.3 vs. 0.4 cm), among other differences.

Also, in the preliminary study, which was performed about three years after planting and composed of three plants of each of the two taxa, all six plants the same age and just attained maturity, planted at the same time in proximity, and subjected to the same cultivation parameters, *Trachycarpus fortunei* tended to be taller than *T. wagnerianus* (2.3 vs. 1.9 m). However, the preliminary study also showed that *T. wagnerianus* had significantly greater six-month leaf production (17 vs. 13, $P < 0.05$) but shorter distance between each whorl of leaves (6.9 vs. 9.4 cm, $P < 0.01$). So, even though *T. wagnerianus* produced more leaves than *T. fortunei*, it did not grow as quickly in height because the distance between whorls of leaves was significantly shorter than those of *T. fortunei*. Now, 12 years after planting, *T. fortunei* is still the taller, larger plant. In the preliminary study, *T. fortunei* had significantly longer but narrower ochrea than *T. wagnerianus* (30.2 vs. 22.6 cm, $P < 0.01$; 1.6 vs. 2.1 cm, $P < 0.01$) but, as explained earlier, we did not measure these characters in the current study.

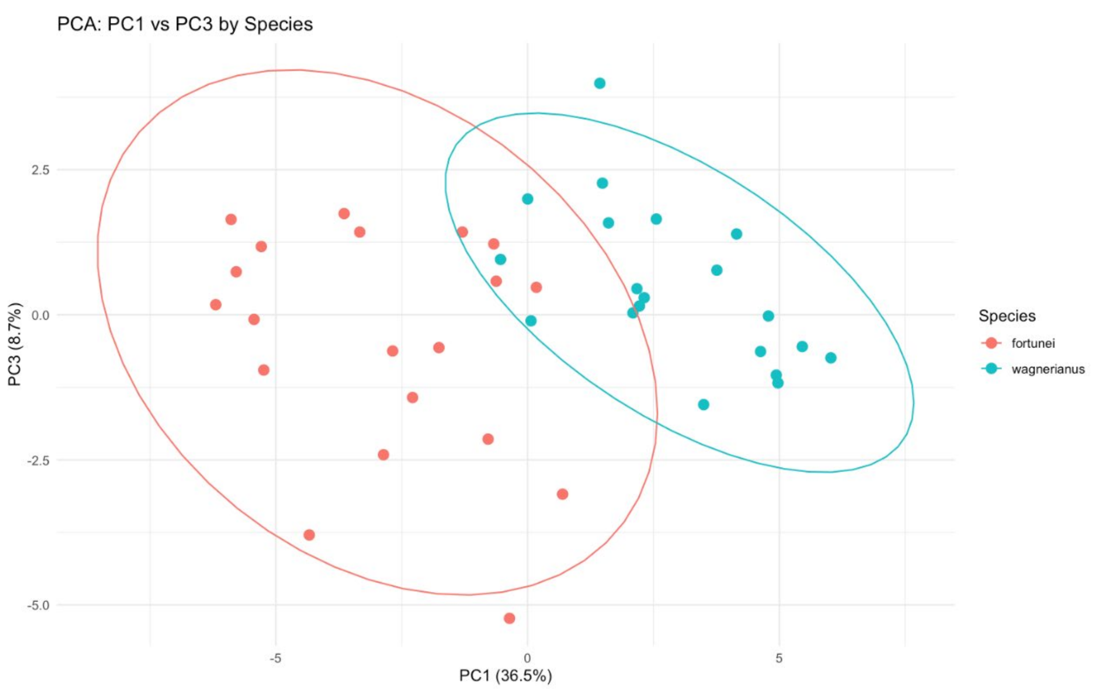
In this taxa character comparison, the PCA analysis separates *Trachycarpus fortunei* and *T. wagnerianus* characters strongly along PC1–PC2 (**Fig. 16**), which explains 36.5% of the variation. PC2–PC3 captures additional but smaller sources of character variation (**Fig. 17**). The PC1–PC2 and PC1–PC3 plots show clear taxa separation of characters, while the PC2–PC3 plot reveals greater overlap (**Fig. 18**), suggesting these latter two components alone are less effective at distinguishing these taxa. The ellipses shown in the graphs represent the 95% confidence intervals, indicating the typical range of variation for each taxa and helping visualize how clearly the taxa are separated in multivariate space.

Summary of Morphometric Character Comparison

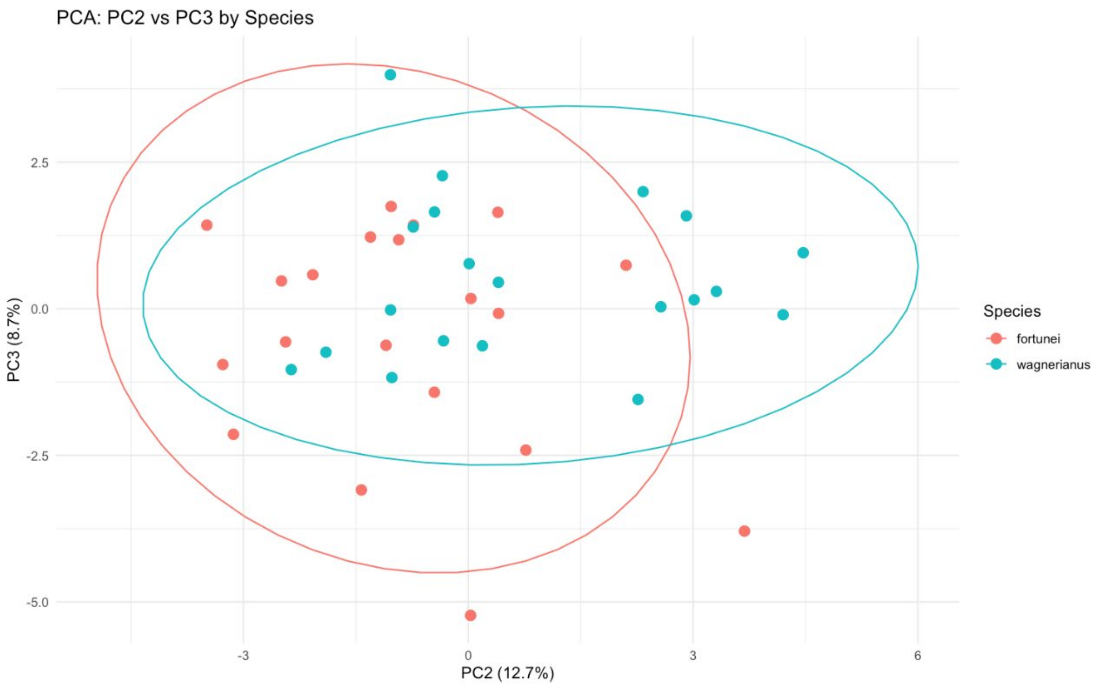
We conclude that these morphometric data clearly identify and/or confirm that some characters are reliable for distinguishing *Trachycarpus fortunei* and *T. wagnerianus*. We emphasize that the data are insufficient to prove that *T. fortunei* and *T. wagnerianus* are different and separate species or merely genetically distinct groups of the same species, which was not the focus of this analysis. Despite including 20 individuals of each taxon in our morphometric analysis, we are still



16. PC1–PC2 analysis strongly separates *Trachycarpus fortunei* (orange) and *T. wagnerianus* (blue), capturing 36.5% of character variation between them.



17. PC2–PC3 analysis also separates *Trachycarpus fortunei* (orange) and *T. wagnerianus* (blue), capturing additional but smaller sources of character variation between them.



18. PC2–PC3 analysis reveals greater overlap and little separation between *Trachycarpus fortunei* (orange) and *T. wagnerianus* (blue), suggesting these two components alone are less effective at distinguishing these two taxa.

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likely attaining only a rather narrow slice of genetic variation of each taxon because both taxa are unknown in a truly wild state and are likely the result of artificial selection over millennia of time. The potential for intermediate forms and/or the presence of hybrids of the two taxa is another concern. It is important to remember that PCA is sensitive to data outliers, meaning that if we include only these two data sets of *Trachycarpus* characters, they tend to cluster separately, but if we add a third data set of a characters from a distinct taxon, the clustering could change. Perhaps more characters and individuals would provide a more confident resolution. Otherwise, our best hope is a molecular study.

Taxonomy

Trachycarpus fortunei (Hook.) H. Wendl. in J. Gay, Bull. Soc. Bot. France 8: 429. 1861. 'Fortunei'.

= *Chamaerops fortunei* Hook., Bot. Mag. 86: pl. 5221. 1860. (1 Dec.) '*Fortunei*'. Type. Cultivated at Kew from a plant introduced in 1849 from Chusan Island, China, (Lectotype: pl. 5221 in Hooker [1860], designated here). (**Fig. 5**).

Etymology: named for Robert Fortune, 19th-century Scottish botanist, plant hunter, traveler, and nurseryperson who was instrumental in introducing this species to Western Cultivation (see earlier discussion under History).

Common Names: windmill palm, Chinese windmill palm, Chusan palm, Chusan fan palm, hemp palm, Fortune's windmill palm; 棕榈 *Zong lü* (China); *palmier á chanvre*, *palmier de Chine* (France); *Hanf-Palme*, *Chinesisch* (Germany); *palma de Giappone* (Italy).

Habit: solitary, slender, unarmed, mostly dioecious fan palm to 15 m tall (**Figs. 19–21**).

Trunk: with persistent leaf bases 15–25 cm DSH, conspicuously covered with fine, long, dark brown, hair-like fibers of leaf base margins (**Fig. 22**); 10–15 cm DSH when clean of persistent leaf bases, then closely ringed (**Fig. 23**).

Leaves: up to 20 per plant, stiffly dropping to ascending (**Figs. 19–21**) ; **base** with prominent and conspicuous fibrous margins (**Fig. 24**), ca. 35 cm long from point of attachment to trunk distally

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19. *Trachycarpus fortunei* is a solitary, slender, unarmed fan palm to 15 m tall. Note the bent leaf blade segment tips. In 2015, Whittier, California.

20. A group planting of *Trachycarpus fortunei* shows its solitary, slender, habit. Note the bent leaf blade segment tips. In 2012, Norwalk, California.

21. This planting of *Trachycarpus fortunei* shows its solitary, slender, habit. Note the bent leaf blade segment tips. In 2009, Los Alamitos, California.

22. The trunk of *Trachycarpus fortunei* is conspicuously clothed with fine, long, dark brown, hair-like fibers of persistent leaf bases.

23. If cleaned of persistent leaf bases, the trunk of *Trachycarpus fortunei* is closely marked with leaf attachment scars.

24. Leaf bases of *Trachycarpus fortunei* have fine, long, dark brown, hair-like fibers on their margins.

25. Ochrea of *Trachycarpus fortunei* are formed from united, hair-like fibers of distal leaf base margins.

to end of fibrous margins attachment, at attachment to trunk ca. 35 cm wide including fibrous margins when unrolled and flattened, non-fibrous part ca. 15 cm wide at attachment to trunk, gradually transitioning and tapering into petiole and there ca. 55 cm wide including fibrous margins when unrolled and flattened, fibrous margins extending ca. 35 cm from base at attachment to trunk on to petiole at which point the petiole/base ca. 2 cm wide, ca. 1 cm thick, flat adaxially, rounded abaxially with a prominent, rounded costa when dried, fibers to 40 cm long, 0.1–0.35 mm diam., hair-like, brown aging to tan, in 3 layers, proximally the 3 layers sandwiched between smooth, glossy, reddish brown, paint-like, flaky tissue; **ochrea** 17–40 × 0.5–3 cm (**Fig. 25**) ; **petiole** 60–145 cm long, 1.2–2.8 cm mm wide and 0.8–1.7 cm thick proximally, 1.2–2.3 cm wide and 0.7–1.4 cm thick at apex wing-like extensions that extend for 1–1.5 cm from blade along petiole, flat to barely rounded adaxially, rounded abaxially with faint light green to yellowish green band extending to base, margins with faint, minute protuberances or teeth especially proximally (**Fig. 26**), brownish woolly tomentum proximally along abaxial margins and adaxially (**Fig. 27**); **blade** 61–130 × 95–150 cm, 190–345° circular, flat (**Fig. 28**); **hastula** ca.1.5 cm long or high from apex to base, 1.5 cm wide, parabolic-shaped with center mucronate apex, entire hastula reclined at ca. 45° angle toward blade apex (**Fig. 29**); **segments** 41–52, center ones longest, 59–89 × 2.5–4.3 cm, lateral left segments 51–80 × 2.1–3.8 cm, lateral right segments 47–80 × 2–4.3 cm, most proximal left segments 26–62 × 0.6–1.8 cm, most proximal right segments 16–65 × 0.5–2.3 cm, all initially stiff, rigid but tending to bend with age in lower canopy (**Fig. 15**), leathery, conspicuously folded to form a v-shaped trough adaxially 34–146° (**Fig. 13**), apically bifid 0.9–9 cm (**Fig. 11**), adaxially green, abaxially green but with a slight, white-waxy, glaucous bloom (**Fig. 30**), adaxially midrib conspicuous and slightly elevated, 3–4 primary veins on either side of midrib, these faint, obscure, veins of lesser orders very faint and obscure, abaxially midrib prominently elevated and angled, light or yellow-green proximally, primary veins and veins of lesser orders obscure, transverse veinlets numerous, slender, and conspicuous when tissue backlit (**Fig. 31**); **palman** 18–41 cm long at center segments, decreasing to 8–33 cm lateral left, 10–24 cm long lateral right, 3–13 cm basal left, and 4–20 cm basal right segments, distal margins irregular uneven due to individual segments and clusters of 2–4 segments being unevenly and variably connate basally within themselves and to adjacent clusters of segments or individual segments, and the cleft between adjacent clusters being much more profound than that between segments within a cluster (**Fig. 28**).

Inflorescences: 6–8 per plant not including old, dried persistent ones from previous years, interfoliar, 70–145 × 42–115 cm, branched to 4 orders, somewhat sexually dimorphic; **staminate** sometimes initially drooping (**Figs. 32–34)** but mostly stiffly ascending-spreading, yellowish to cream-colored at anthesis (**Figs. 33–34**), aging yellowish, rachis, branches, and rachillae light greenish to greenish yellow in flower, aging to yellowish, when panicle bare of flowers it appears more slender, finer textured, and “lighter” than pistillate; **pistillate** stiffly ascending-spreading

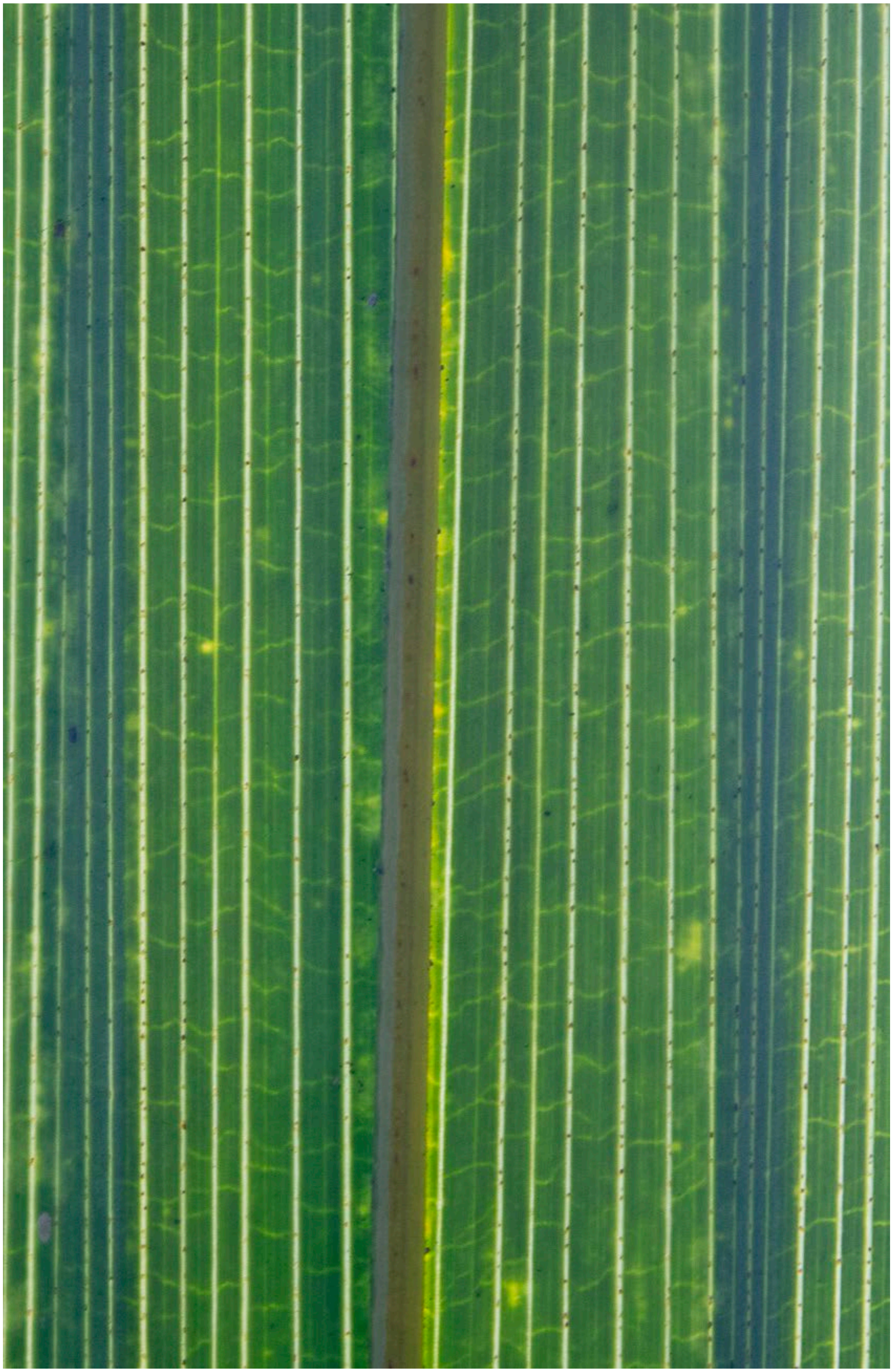
26. Petioles of *Trachycarpus fortunei* are rounded abaxially with faint light green band and have margins with faint, minute protuberances or teeth, especially proximally.

27. Petioles of *Trachycarpus fortunei* have brownish woolly tomentum proximally and adaxially.

28. Mychael McNeeley of the San Diego Zoo holds a nearly circular leaf blade of *Trachycarpus fortunei*. Note the uneven palman distal margins.

29. The hastula of *Trachycarpus fortunei* at the petiole/leaf blade junction is typically reclined at about a 45° angle towards the blade apex.

30. Leaf blades of *Trachycarpus fortunei* typically have a white-waxy, glaucous bloom abaxially. Note the spreading, bright yellow inflorescences.



31. Transverse veinlets of leaf blade segments of *Trachycarpus fortunei* are numerous, slender, squiggly, and faint but conspicuous when tissue is backlit.

32. Staminate inflorescences of *Trachycarpus fortunei* are drooping and yellowish to cream-colored when initially emerging.

33. Staminate inflorescences of *Trachycarpus fortunei* are drooping and yellowish to cream-colored when initially emerging but eventually begin to spread.

34. Eventually staminate inflorescences of *Trachycarpus fortunei* are typically stiffly ascending-spreading and yellowish to cream-colored.

35. Pistillate inflorescences of *Trachycarpus fortunei* are stiffly ascending-spreading.

in flower (**Fig. 35**), becoming drooping to pendulous when heavily laden with fruits (**Fig 36**), initially greenish yellow in flower becoming yellowish to grayish green in young fruit and then purplish when heavily laden with mature fruit, rachis, branches, and rachillae greenish yellow at anthesis and yellowish in fruit, aging dark brown to black in old fruit, when panicle bare of flowers it appears more robust, coarser textured, and "heavier" than staminate; staminate inflorescences with mostly staminate flowers but also with bisexual or perhaps some pistillate flowers (**Figs. 37–38**) can be distinguished by their pistillate and/or bisexual flowers; **peduncle** 43–95 long, 3–5.5 × 1–1.5 cm near prophyll attachment, oval-shaped in transverse section, typically completely concealed by prophyll and peduncular bracts, 3.5–5 cm wide and ca. 2.5 cm thick with peduncular bracts; **prophyll** attached ca. 8 cm distal of trunk attachment, ca. 24 cm long and ca. 6.5 cm wide at attachment and there with cordate base, ca. 1.5 cm thick, expanding to ca. 8 cm wide slightly distal of half-way point, thin-leathery, reddish brown, bicarinate, the "wing" with reddish brown fuzzy tomentum, apex shallowly rounded-lobed or bifid (**Fig. 39**); **peduncular bracts** 4–6, emerging green (**Fig. 40**) with scattered to occasionally dense, tan, mostly caducous indument abaxially, then quickly aging to brown and rich coppery brown in flower and fruit (**Fig. 41**), 1st peduncular bract attached ca. 10 cm distal of prophyll attachment, ca. 29 cm long, ca. 5.5 cm wide, thin-leathery, bicarinate, reddish brown, apex shallowly bifid or lobed, 2nd peduncular bract attached 22 cm distal of prophyll attachment, ca. 22 cm long, 3rd peduncular bract flared and split apically into 2 tips 6 and 13 cm long, these bifid again for 0.5 cm, acute, 4th peduncular bract flared and split apically into 2 tips 10 and 14 cm long, these bifid again for 0.5 cm, other bracts progressively reducing in size, thin-leathery, stiff, coppery brown, longitudinal veins visible, most distal enveloping base of and extending on to 1st branch; **rachis** 27–52 cm long, mostly glabrous but with scattered, light, short, whitish indument, 9–28 1st-order branches and 9–10 simple rachillae, most proximal branch typically largest, most complex, and with greatest orders of branching, branches progressively reduced in size, complexity, and orders of branching distally until replaced by simple rachillae; most proximal 1st-order branch 27–33 cm long, 1st-order peduncle 2.5–5 cm long, 1.5–2.5 cm wide, 1 cm thick, flat adaxially, rounded abaxially, with 2 1st-order peduncular bracts to 1 cm long and 0.4 cm wide, 1st-order rachis 20 cm long, 2nd-order branches 17 and 15 simple rachilla, most proximal 2nd-order branch the largest and most complex, 2nd-order peduncle 2 cm long, 0.8 cm wide and thick, 2nd-order rachis 12–16 cm long, 3rd-order branches 6 and simple rachillae 14, 3rd-order peduncle 1.5 cm long, 0.5 cm wide; 3rd -order rachis 6 cm long; **rachis bracts** similar to peduncular bracts in color and indument, 1–6, subtending 1st-order branches and much reduced ones subtending branches of lesser orders and rachillae most proximal bract the largest, these 11–37 cm long, bifid apically, extending on to base of most distal branch, rachis bracts becoming progressively shorter at each more distal branch or rachilla and eventually becoming inconspicuous, most distal conspicuous bract ca. 0.9 cm wide, bifid for 0.25 cm**; staminate rachillae** 1.5–6 cm long, 0.8–2 mm diam., greenish yellow to yellow, nearly glabrous but with few, scattered, very short, erect, whitish hairs (**Fig. 43**); **pistillate rachillae** 1.5–

36. Pistillate inflorescences of *Trachycarpus fortunei* become drooping to pendulous when heavily laden with fruits.

37. This *Trachycarpus fortunei* has a staminate inflorescence nearly at anthesis (front) and a post-anthesis, mostly staminate inflorescence with some bisexual flowers (behind).

38. This *Trachycarpus fortunei* has a post-anthesis, mostly staminate inflorescence with some young, developing fruits.

39. The prophyll of *Trachycarpus fortunei* has a cordate base and is thin-leathery, red-dish brown, and bicarinate.

40. Peduncular and rachis bracts of *Trachycarpus fortunei* are conspicuous, numerous, and emerge green but quickly turn brown.

41. Peduncular and rachis bracts of *Trachycarpus fortunei* are conspicuous and quickly age to brown and rich coppery brown in flower and fruit.

42. Rachis bracts of *Trachycarpus fortunei* become progressively shorter distally at each branch or rachilla.

43. Staminate rachillae of *Trachycarpus fortunei* are greenish yellow to yellow and nearly glabrous but with few, scattered, noticeably short, erect, whitish hairs.

6 cm long, 1.5–2.5 mm diam. (**Fig. 44**), stiffly spreading, yellowish green to green in flower, yellow in fruit, typically with scattered, short, erect, whitish hairs but sometimes nearly glabrous.

Flowers: staminate solitary or in 1–3-flowered, tight clusters (**Fig. 45**), these 3–7 mm distant but typically crowded and contiguous (**Fig. 46**), individual flowers or clusters on stalks 0.3–2.5 × 0.5–0.8 mm, subtended by small, long-triangular, clear-colored to white bracts 0.9–1 mm high; individual **flowers** 3.5–4 × 3–5 mm, very broadly ovoid to bowl-shaped, yellowish to cream-colored (**Fig. 47**); **calyx** 1.5 × 2–2.5 mm, crownlike, **sepals** 1.25–1.5 × 2–2.5 mm, broadly ovate-triangular, imbricate in proximal 1/3–1/2, free and rounded-triangular in distal 2/3–4/5, yellow with white sometimes explanate margins; **petals** 2–3.5 × 2–3.5 mm, broadly oblong-rounded to ovate, imbricate in proximal 1/2, free and spreading and rounded-triangular often with a short, acute, triangular tip in distal 1/2, yellow; **stamens** 6, ca. 3.5 mm tall, outwardly leaning or curved, exceeding petals, between petals exserted ca. 2 mm above them, opposite petal exserted ca. 1.25 mm above them, **filaments** ca. 3.25 mm long, robust, thick, ca. 0.8–1.2 mm diam. at base, narrowing distally to 0.4–0.5 mm diam. at apex, clear-colored to whitish, **anthers** 0.8–1 × 0.4–0.6 mm, oblong-elliptic, bi-lobed, medifixed, white aging to light brown; **pistillode** somewhat variable, shorter than petals, 3-lobed nearly to base, lobes spreading outwardly (**Fig. 47**), typically +/- equal in size and shape but sometimes one conspicuously larger than the other two, 1–1.2 mm tall, 0.25–0.4 mm diam. at base, narrowing to 0.12–0.15 mm diam. at apex and there rounded to truncate but undifferentiated, columnar, yellowish to clear-colored or whitish, if one lobe taller than the other two, the two smaller ones ca. 0.3 mm tall, bulbous, cream-colored; **pistillate** (in pistillate inflorescences) solitary or in 2–3-flowered clusters (**Figs. 44, 48**), these 3–6 mm distant, typically not contiguous; individual flowers or clusters sessile or on stalks ca. 0.5–2.5 × 1–1.25 mm, subtended by an erect, slender, rusty brown, hair-like bract 0.3–1 mm high; individual flowers, 3–3.25 × 2.5–3.25 mm, goblet-shaped, yellow to yellowish green in flower (**Figs. 44, 48**), grayish green post-anthesis; **calyx** 1–2 × 2–2.5 mm, crown-like, **sepals** 1–2.25 × 1.5–2.5 mm, slightly shorter than to nearly equaling petals, rounded to broadly ovate, bowl-like, imbricate and/or connate in proximal 1/2, free and rounded to triangular in distal 1/2, yellowish green with margins transparent to whitish; **petals** 2 × 2.25–2.5 mm, broadly ovate, imbricate in proximal 1/2–2/3, free and obtuse to triangular in distal 1/3–1/2, yellow; **gynoecium** with **ovary** 2.5–3.25 × 2.25–3.25 mm, clear-colored, prominently 3-lobed, stigma lobes ca. 0.4 mm high, equaling or barely exceeding petals, erect, narrowly conic, truncate, with moderate to dense, white-wax and some silvery white hairs; **hermaphroditic or bisexual** flowers similar to staminate flowers but the gynoecium appears like a well developed pistillode with bulbous lobes and a differentiated, short style with a truncate stigma.

44. Pistillate rachillae of *Trachycarpus fortunei* are stiffly spreading and yellowish green to green in flower. Note the goblet-shaped, yellow to yellowish green pistillate flowers with the gynoecium covered with silky, white hairs.

45. Staminate flowers of *Trachycarpus fortunei* are solitary or in 1–3-flowered, tight clusters.

46. Staminate flower clusters of *Trachycarpus fortunei* can be unusually crowded and contiguous.

47. Staminate flowers of *Trachycarpus fortunei* are very broadly ovoid to bowl-shaped and yellowish to cream-colored. Note the 3-lobed pistillode at the base of the stamens.

48. Pistillate flowers of *Trachycarpus fortunei* are goblet-shaped and yellow to yellowish green. Note the silky white hairs covering the gynoecium.

49. Fruits of *Trachycarpus fortunei* are kidney-bean-shaped and purplish black to black with a white-waxy, glaucous bloom.

Fruits: ca. 0.9 × 1.4 cm, kidney-bean-shaped, purplish black to black with a white-waxy, glaucous bloom (**Fig. 49**); **seed** ca. 0.7–0.8 × 0.6 cm, embryo lateral, endosperm homogeneous with shallow to deep lateral intrusions of seed coat; germination remote-tubular, eophyll simple.

Cytology: 2n = 36 (Dransfield et al. 2008).

Trachycarpus wagnerianus A. Berger, Hort. Mortol. 1912: 322, 435. (Jan.–May). '*Wagneriana*'. Type: Cultivated. ITALY. Ventimiglia: La Mortola, June 1911, *Berger s.n.* (Lectotype FI050503, designated here) (**Fig. 6**)

= *Trachycarpus wagnerianus* Roster, Bull. Reale Soc. Tosc. Ortic. ser. 3, 19(11): 240–241. 1914. (1 Nov 1914). '*Wagneriana*'. Nom. illeg. (later homonym).

= *Trachycarpus wagnerianus* Becc., Webbia 5: 70. 1921. '*Wagneriana*'. Nom. illeg. (later homonym).

Etymology: named for Albert Wagner, 19th-century German plantsperson and nurseryperson who introduced this species to Western cultivation (see earlier discussion under History).

Common Names: windmill palm, Chinese windmill palm, Chusan palm, hemp palm, Wagner's dwarf windmill palm; 棕榈 zong lü (China).

Habit: Solitary, slender, unarmed, mostly dioecious fan palms to 15 m tall (**Figs. 50–52**).

Trunk: with persistent leaf bases trunk 15–25 cm DSH, conspicuously covered with fine, long, dark brown, hair-like fibers of leaf base margins (**Fig. 53**); 10 cm DSH when clean of persistent leaf bases, then closely ringed (**Fig. 54**).

Leaves: up to 20 per plant, stiffly dropping to ascending (**Figs. 50–52**); **base** with prominent and conspicuous fibrous margins, at attachment to trunk ca. 33 cm wide including fibrous margins when unrolled and flattened, non-fibrous part ca. 20 cm wide at attachment to trunk, gradually transitioning and tapering into petiole and there ca. 35 cm wide including fibrous margins when unrolled and flattened, fibrous margins extending ca. 33 cm from base at attachment to trunk on to petiole at which point the petiole/base ca. 2 cm wide, ca. 1.1 cm thick, flat adaxially, rounded abaxially with a prominent, rounded costa when dried, fibers to 40 cm long, 0.1–0.35 mm diam., hair-like, brown aging to tan (**Fig. 55)**, in 3 layers, proximally the 3 layers sandwiched between smooth, glossy, reddish brown, paint-like, flaky tissue; **ochrea** 10–30 × 0.7–3.8 cm (**Fig 56**); **petiole** 40–91 cm long, 1.4–2.5 cm wide and 0.7–1.5 cm thick proximally, 2–2.2 cm wide and 0.7–1.2

50. *Trachycarpus wagnerianus* is one of the most distinctive, exotic, cold-hardy, landscape palms for California and subtropical and warm-temperate locales. Note the stiff, unbent leaf blade segment tips. In 2020, Seal Beach, California.

51. *Trachycarpus wagnerianus* is a slender, cold-hardy palm. In 2025, Los Angeles County Arboretum and Botanic Garden, Arcadia, California.

52. *Trachycarpus wagnerianus* is a solitary fan palm with a compact canopy of rigid leaves. Note the stiff, unbent leaf blade segment tips. In 2013, Kyoto Botanical Gardens, Kyoto, Japan.

53. The trunk of *Trachycarpus fwagnerianus* is conspicuously clothed with fine, long, dark brown, hair-like fibers of persistent leaf bases.

54. If cleaned of persistent leaf bases, the trunk of *Trachycarpus wagnerianus* is closely marked with leaf attachment scars.

55. Leaf bases of *Trachycarpus wagnerianus* have fine, long, dark brown, hair-like fibers on their margins.

56. Ochrea of *Trachycarpus wagnerianus* are formed from united, hair-like fibers of distal leaf base margins.

cm thick at apex with wing-like extensions that extend for 1–1.5 cm from blade along petiole, flat to barely rounded adaxially, rounded abaxially with faint light green to yellowish green band extending to base, margins with faint, minute protuberances or teeth especially proximally and there with brow to grayish woolly tomentum along abaxial margins (**Fig. 57**); **blade** 35–70 × 47–95 cm, 110–220° circular, flat (**Fig. 58**); **hastula** 1.5 cm long or high from apex to base, 1.5 cm wide, parabolic-shaped with center mucronate apex, entire hastula reclined at a ca. 45° angle toward blade apex (**Fig. 59**); **segments** 44–51, center ones longest, 40–70 × 2–3.5 cm, lateral left segments 29–61 × 1.8–3.5 cm, lateral right segments 27–61 × 1.5–3.7 cm, most proximal left segments 13–37 × 0.3–1.3 cm, most proximal right segments 11–40 × 0.4–1 cm, all stiff and unbent (**Figs. 50–52, 58**), rigid, leathery, conspicuously folded to form a v-shaped trough adaxially 17–80° (**Fig. 12**), center segment apically bifid 0.2–1 cm (**Fig. 10**), adaxially green, abaxially green but with a slight, white-waxy, glaucous bloom, sometimes when young segment margins and tip lined with white, ribbon-like, caducous indument (*haute*), adaxially midrib conspicuous and slightly elevated, 3–4 primary veins on either side of midrib, these faint, obscure, veins of lesser orders very faint and obscure, abaxially midrib prominently elevated and angled, light or yellow-green proximally, primary veins and veins of lesser orders obscure, transverse veinlets numerous, slender, and conspicuous when tissue backlit (**Fig. 60**); **palman** 19–39 cm long at center segments, decreasing to 12–25 cm lateral left, 13–27 cm long lateral right, 3–18 cm basal left, and 4–17 cm basal right segments, distal margins uneven due to individual segments and clusters of 2–7 segments being unevenly and variably connate to adjacent clusters of segments or individual segments, and the cleft between adjacent clusters being much more profound than that between segments within a cluster (**Fig. 58**).

Inflorescences: 6–8 per plant not including old, dried persistent ones from previous years, interfoliar, 75–125 × 21–85 cm, branched to 4 orders, somewhat sexually dimorphic; **staminate** sometimes initially drooping but mostly stiffly ascending-spreading (**Figs. 61–62**), yellowish to cream-colored at anthesis, aging yellowish, rachis, branches, and rachillae light greenish to greenish yellow in flower, aging to yellowish, when panicle bare of flowers it appears more slender, finer textured, and “lighter” than pistillate; **pistillate** stiffly ascending-spreading in flower (**Figs. 63–64**) becoming drooping to pendulous when heavily laden with fruits, initially greenish yellow in flower becoming yellowish to grayish green in young fruit and then purplish when heavily laden with mature fruit, rachis, branches, and rachillae greenish yellow at anthesis and yellowish in fruit, aging dark brown to black in old fruit, when panicle bare of flowers it appears more robust, coarser textured, and “heavier” than staminate; staminate inflorescences with mostly staminate flowers but also with bisexual or perhaps some pistillate flowers (**Figs. 65–66**) can be distinguished by their pistillate and/or bisexual flowers; **peduncle** 47–74 cm long, ca. 4 × 0.75 cm near prophyll attachment, 2.5–3 cm wide, 1–2 cm thick, oval shaped in transverse section, typically completely concealed by prophyll and peduncular bracts, ca. 5 cm wide and 1–2.5 cm thick with

57. Petioles of *Trachycarpus wagnerianus* have margins with faint, minute protuberances and brownish woolly tomentum proximally. Note the few leaf base hairs.

58. Leaf blades of *Trachycarpus wagnerianus* are typically not completely circular. Note the uneven palman distal margins and the stiff, unbent leaf blade segments.

59. The hastula of *Trachycarpus wagnerianus* at the petiole/leaf blade junction is typically reclined at about a 45° angle towards the blade apex.

60. Transverse veinlets of leaf blade segments of *Trachycarpus wagnerianus* are numerous, slender, squiggly, and faint but conspicuous when tissue is backlit.

61. Although sometimes initially drooping, staminate inflorescences of *Trachycarpus wagnerianus* are mostly stiffly ascending-spreading.

62. Staminate inflorescences of *Trachycarpus wagnerianus* are mostly stiffly ascending-spreading.

63. Pistillate inflorescences of *Trachycarpus wagnerianus* are stiffly ascending-spreading.

64. Pistillate inflorescences of *Trachycarpus wagnerianus* are stiffly ascending-spreading.

65. This *Trachycarpus wagnerianus* has a post-anthesis staminate inflorescence with some young developing fruits.

66. This slightly post-anthesis, staminate inflorescence of *Trachycarpus wagnerianus* has some young developing fruits.

prophyll and bracts; **prophyll** attached ca. 6 cm distal of trunk attachment, ca. 23 cm long and ca. 5 cm wide at attachment (**Fig. 67**) and there with cordate base, ca. 1 cm thick, widening to ca. 6 cm wide ca. 3 cm proximal of apex, thin-leathery, reddish brown, bicarinate, the "wing" with reddish brown fuzzy tomentum, apex shallowly rounded-lobed or bifid; **peduncular bracts** 5–7, emerging green (**Fig. 68–69**) with dense, tan to brown but mostly caducous indument abaxially, then quickly aging to brown and rich coppery brown in flower (**Fig. 70**) and fruit, 1st peduncular bract attached ca. 8 cm distal of prophyll attachment, ca. 25 cm long, ca. 5 cm wide at base, tapering to ca. 4 cm wide at apex, 2nd peduncular bract attached ca. 16 cm distally of prophyll attachment, ca. 22 cm long, 3rd peduncular bract attached ca. 24 cm distally of prophyll attachment, ca. 26 cm long, apices shallowly lobed, 4th peduncular bract flared and split apically into 2 tips 6 and 13 cm long, these bifid again for 0.5 cm, acute, 5th peduncular bract flared and split apically into 2 tips 10 and 14 cm long, these bifid again for 0.5 cm, other peduncular bracts progressively reducing in size, thin-leathery, stiff, longitudinal veins visible, most distal enveloping base of and extending on to 1st branch; **rachis** 33–51 cm long, with dense, whitish, mostly caducous indument, 8–23 1st-order branches and 9–10 simple rachillae, most proximal branch typically largest, most complex, and with greatest orders of branching, branches progressively reduced in size, complexity, and orders of branching distally until replaced by simple rachillae; most proximal 1st-order branch 27–33 cm long, 1st-order peduncle 2.5–5 cm long, 1.5–2.5 cm wide, 1 cm thick, flat adaxially, rounded abaxially, with 2 1st-order peduncular bracts to 1 cm long and 0.4 cm wide, 1st-order rachis 20 cm long, 2nd-order branches 17 and 15 simple rachilla, most proximal 2nd-order branch the largest and most complex, 2nd-order peduncle 2 cm long, 0.8 cm wide and thick, 2nd-order rachis 12–16 cm long, 3rd-order branches 6 and simple rachillae 14, 3rd-order peduncle 1.5 cm long, 0.5 cm wide; 3rd -order rachis 6 cm long; **rachis bracts** similar to peduncular bracts in color and indument, 2–13, subtending 1st-order branches and much reduced ones subtending branches of lesser orders and rachillae, most proximal bract the largest, these 11–28 cm long, bifid apically, extending on to base of most distal branch, rachis bracts becoming progressively shorter at each more distal branch or rachilla (**Fig. 71**) and eventually becoming inconspicuous, most distal conspicuous bract ca. 9 mm wide, bifid for 2.5 mm; **staminate rachillae** 1.5–6 cm long, 1–2.2 mm diam., stiffly spreading, yellowish to light green, glabrous or nearly so, sometimes with very sparse, scattered, short, white hairs **(Fig. 72**); **pistillate rachillae** 1.5–6 cm long, 2.2 mm diam. proximally, tapering to 1 mm diam. distally, spreading, straight to slightly zig-zag proximally and distally, yellowish green, moderately to densely covered with short, white hairs (**Fig. 73**).

Flowers: staminate in 2–3-flowered, tight clusters (**Fig. 74**), or less frequently solitary, these 1.3–3.5 mm distant, often severely crowded and contiguous or nearly so (**Fig 75**), individual flowers or clusters sessile or nearly so to on stalks 0.5–1.2 × 0.5–1 mm, these green to yellow, subtended by small, long-triangular, white aging to brown bracts to 0.5 mm high; individual **flowers** ca. 2.8

67. The prophyll of *Trachycarpus wagnerianus* has a cordate base and is thin-leathery, reddish brown, and bicarinate.

68. Peduncular and rachis bracts of *Trachycarpus wagnerianus* are conspicuous, numerous, and emerge green but quickly begin to turn brown.

69. Peduncular and rachis bracts of *Trachycarpus wagnerianus* are conspicuous, numerous, and emerge green but quickly begin to turn brown.

70. Peduncular and rachis bracts of *Trachycarpus wagnerianus* are conspicuous and quickly age to brown and rich coppery brown in flower and fruit.

71. Rachis bracts of *Trachycarpus wagnerianus* become progressively shorter distally at each branch or rachilla.

72. Staminate rachillae of *Trachycarpus wagnerianus* are stiffly spreading, greenish yellow to yellow, and nearly glabrous.

73. Pistillate rachillae of *Trachycarpus wagnerianus* are stiffly spreading, yellowish green, and moderately to densely covered with short, white hairs. Note the goblet-shaped, yellowish pistillate flowers with silky, white hairs on the gynoecium.

74. Staminate flowers of *Trachycarpus wagnerianus* are solitary or in 1–3-flowered, tight clusters.

75. Staminate flower clusters of *Trachycarpus wagnerianus* can be unusually crowded and contiguous at anthesis.

76. Staminate flowers of *Trachycarpus wagnerianus* are very broadly ovoid to bowl-shaped and yellowish. Note the 3-lobed pistillode at the base of the stamens.

× 3.7 mm, very broadly ovoid to bowl-shaped, yellowish (**Fig. 76**); **calyx** ca. 1 × 2.2 mm, crownlike, **sepals** ca. 1 × 2.2 mm, broadly ovate-triangular, bowl-like, nearly 1/3 height of petals, imbricate in proximal 1/4–1/2, free and rounded-triangular in distal 1/2–3/4, yellowish with white margins; **petals** ca. 2.75 × 2.5 mm, broadly ovate to oblong-rounded, boat-shaped, imbricate in proximal 1/3–3/4, free and spreading and rounded-triangular often with a short, acute, triangular tip in distal 1/2, cream-colored to yellow, margins transparent; **stamens** 6, ca. 3 mm tall, mostly outwardly leaning but some erect, exceeding petals, between petals exserted ca. 1.25 mm above them, opposite petal exserted ca. 1 mm above them, **filaments** ca. 2.75 mm long, robust, thick, ca. 1 mm diam. at base, narrowing distally to ca. 0.5 mm diam. at apex, clear-colored to whitish, **anthers** ca. 0.7 × 0.65 mm, oblong-elliptic, bi-lobed, medifixed, yellow aging to white and then tan; **pistillode** somewhat variable, shorter than petals, 3-lobed nearly to base, lobes spreading outwardly, typically +/- equal in size and shape but sometimes one conspicuously larger than the other two, 1–1.2 mm tall, 0.25–0.4 mm diam. at base, narrowing to 0.12–0.15 mm diam. at apex and there rounded to truncate but undifferentiated, columnar, yellowish to clear-colored or whitish, if one lobe taller than the other two, the two smaller ones ca. 0.3 mm tall, bulbous, cream-colored; **pistillate** (in pistillate inflorescences) solitary or in 2–3-flowered clusters, sessile or nearly so, pedicels or stalks 0.5 × 1 mm, spaced 1–2 mm distant (flower perimeter to flower perimeter), sometimes flowers contiguous or near so especially those in cluster, pedicels or stalks subtended by erect, long-triangular bract ca. 0.25–0.5 mm high, this whitish aging to brown; individual flowers at anthesis ca. 2.5 × 2.5 mm, goblet-shaped, greenish yellow (**Figs. 77–78**), grayish green post-anthesis (**Fig. 79**); **calyx** ca. 1.5 × 2.5 mm, crown-like, **sepals** ca. 1.5 × 2.5 mm, slightly shorter than to nearly equaling petals, broadly ovate, bowl-like, imbricate in proximal ca. 1.2 mm (ca. 4/5), free and broadly rounded apically, greenish yellow with white margins; **corolla** ca. 2 × 2.5 mm, crown-like, **petals** ca. 2 × 2.5 mm, broadly ovate, imbricate in proximal ca. 1.5 mm, free and obtuse to obtuse-triangular distally, yellow; **gynoecium** with **ovary** ca. 2.25 × 2.25 mm, clear-colored, prominently 3-lobed, stigma lobes ca. 0.4 mm high, equaling or barely exceeding petals, erect, narrowly conic, truncate, with moderate to dense, white-wax and silvery white hairs; **hermaphroditic or bisexual** flowers similar to staminate flowers but the gynoecium appears like a well developed pistillode with bulbous lobes and a differentiated, short style with a truncate stigma.

Fruit: 0.7–0.9 × 1–1.4 cm, kidney-bean-shaped, purplish black to black with a white-waxy, glaucous bloom (**Figs. 80–81**); **seed** ca. 0.7–0.8 × 0.6 cm, embryo lateral, endosperm homogeneous with shallow to deep lateral intrusions of seed coat; germination remote-tubular, eophyll simple.

Cytology: 2n = 36 (Dransfield et al. 2008).

77. Pistillate flowers of *Trachycarpus wagnerianus* are goblet-shaped and greenish yellow. Note the silky white hairs covering the gynoecium.

78. Pistillate flowers of *Trachycarpus wagnerianus* are goblet-shaped and greenish yellow at anthesis. Note the silky, white hairs starting to cover the gynoecium on the rachilla.

79. Pistillate flowers of *Trachycarpus wagnerianus* are grayish green post-anthesis. The grayish color is from the silky, white hairs covering the gynoecium.

80. Fruits of *Trachycarpus wagnerianus* are kidney-bean-shaped and purplish black to black with a white-waxy, glaucous bloom.

81. Fruits of *Trachycarpus wagnerianus* are kidney-bean-shaped and purplish black to black with a white-waxy, glaucous bloom.

Distribution and Ecology

Pei et al. (2010) noted that *Trachycarpus fortunei* occurred in China, Bhutan, Myanmar, Nepal, and Vietnam, from 100 to 2400 m elevation, where it was commonly cultivated and rarely found in forests. Those few instances where it did occur in forests can likely be attributed to plants escaping from cultivation because Gibbons and Spanner (2013) noted that *T. fortunei* is unknown in a truly natural, wild, original state, suggesting it is extinct in the wild. Nothing is known of its original origin and distribution although where it is widely cultivated and utilized in south-central China provides a hint of its natural distribution and perhaps habitat.

Jousson et al. (2022) suggested that Guizhou province in China might be within its natural range, basing this supposition on Mao et al. (2020) who were investigating genetic diversity to identify and enhance performance characters of this species that finds wide use among local people. Another similar study, Peng at al. (2020), whose objective was to identify specific groups or individuals of *T. fortunei* for breeding to produce fast-growing plants with good genetic qualities, noted that *T. fortunei* was a widely cultivated economic species in southern China where it was prized for ornamental use and fiber. These reports suggest that the *T. fortunei* in southern China are likely cultivated plants, not truly natural, wild plants.

Nonetheless, we can look at the climate and remaining habitat of these areas and to places it has naturalized for guidance on what its natural habitat might be. Guizhou has a humid, subtropical climate (WWC 2025). It is an unusually mountainous place, and the mountains greatly affect and make for extremely variable weather conditions within short distances. Annual average temperatures range from 10 to 20 C, 1 to 10 C in January and 17–28 C in July. While frost can occur regularly at the appropriate elevations, severe freezes do not occur. Average annual rainfall ranges from 1000 to 1400 mm. Relative humidity is above 70 percent. Although mostly stable and uniform, unstable periods of occasional drought, winds, cold, heat can occur. Most of the forests are broad-leaved evergreen at lower elevations with deciduous elements at higher elevations.

In the Insubric region of southern Switzerland and northern Italy where *Trachycarpus fortunei* is strongly invasive, winters are mild and sunny while summers are warm and sunny (Fehre and Burga 2016, Klötzli 1988, Walther 2001). Average annual precipitation is 1,300 to 2,300 mm (MS 2022). Lugano in Ticino, Switzerland averages 1620 mm of rainfall annually (WWO 2025). Many similarities in the climate and vegetation exist with southern China where *T. fortunei* is presumable indigenous (Walther 2001). The mean temperature during the coldest month of 2.2 C is the minimum tolerated for successful reproduction and spread of *T. fortunei* in the Insubric region (Jousson et al. 2022).

Trachycarpus wagnerianus, like *T. fortunei*, is unknown in a truly natural, wild, original state, suggesting it is also extinct in the wild. Also, but unlike *T. fortunei*, it is not even widely cultivated in southern China, a likely place for its natural origin. It is only known from cultivation in southern and central Japan, where it might have been cultivated as an ornamental subject but perhaps also for fiber. Its natural origin is even more of a mystery than that of *T. fortunei* and more, likely molecular work, is needed to determine both species' natural origins. Nonetheless, considering the climate and vegetation of southern and central Japan and the similar cultivation parameters of both species, the natural habitat of *T. wagnerianus* is likely similar to that of *T. fortunei*.

Another possibility is that both species are not natural species but simply the product of hundreds if not thousands of years of selection and breeding and are truly artificial, domesticated species or hybrids, differing significantly from their wild counterparts, if such even exist new. A robust molecular study might sort out this conundrum.

Sexual Systems

The sexual expression of palms has many implications, including in their reproduction, morphology, identification, use, landscape management, and invasiveness, among others. Nadot et al. (2016) noted that 30% of palm species are dioecious while Jousson et al. (2023) noted 53% are monoecious and 17% are hermaphroditic. Polygamy, the presence of staminate and/or pistillate and bisexual (hermaphroditic) flowers in the same individual (Nadot et al. 2016, Renner 2014), is uncommon in palms, appearing in a few genera and then mostly in the tribe Trachycarpeae (Dransfield et al. 2008, Morrow 1965, Nadot et al. 2016).

These different forms of sexual expression or flowering strategies separate staminate, pistillate, and bisexual flowers to promote and effect evolutionarily advantageous outcrossing (Nadot et al. 2016, Renner and Ricklefs 1995). *Trachycarpus* has long been thought to be dioecious and/or polygamous (Dransfield et al. 2008). Although Morrow (1965) provided a detailed survey of floral morphology and anatomy of numerous genera of Coryphoideae, including *Trachycarpus*, the reproductive biology of *Trachycarpus* has been little studied (Jousson et al. 2023), and recent information shows sexual expression in *Trachycarpus* is much more nuanced and variable (Sys 2008), and our observations confirm that strict dioecy is typically not the case in *T. fortunei* and *T. wagnerianus*.

Sexual expression in *Trachycarpus fortunei* has been described as monoecious with both staminate and pistillate inflorescences on the same individual (Friedel 1907) and polygamous with bisexual flowers (Beccari 1905, Bosch 1947). On *T. fortunei*, Beccari (1905) noted bisexual flowers on a “staminate” individual. A few of the “staminate” inflorescences had all bisexual flowers, which produced mature, viable fruits.

Beccari (1905) described three types of flowers in *Trachycarpus fortunei*:

1. staminate with a pistillode of three rudimentary carpels;
2. pistillate with three carpels and silvery white, silky hairs encircling and covering their apex;
3. bisexual with a similar indument as pistillate and always on staminate inflorescences.

We were unable to observe bisexual flowers on a staminate inflorescence of either taxon of *Trachycarpus*. However, on *T. wagnerianus*, we observed staminate flowers and young fruit, that latter of which still had stamens protruding from the perianth, which confirms that bisexual flow-ers occur on staminate inflorescences(**Fig. 82**). We might have observed a fourth type of flower-ing scheme where pistillate flowers were on a staminate inflorescence. More work is needed to sort out this complex, seemingly unusually variable flowering scheme.

82. Staminate flowers and young fruit on the same inflorescence of *Trachycarpus wagnerianus*, that latter of which still had stamens protruding from the perianth, confirms that bisexual flowers occur on staminate inflorescences.

Plasticity, where an individual transitions from one sexual system to another (Ming et al. 2011, Nadot et al. 2016, Renner 2014), can also promote outcrossing among individuals and is known in some palms, including *Trachycarpus*. Unstable sexual expression leading to an XY genetic evolutionary system can also increase dispersibility (Jousson et al. 2023). For example, Kholia (2009) found that *T. takil* from northern India was not strictly dioecious and that its sexual expression was unstable, with younger plants tending to be staminate but as the plants aged they transitioned to bisexual and pistillate. Furthermore, Kholia discovered that if plants failed to cross-pollinate with other *T. takil*, they have the ability to develop fertile pollen grains in their staminodes.

Plasticity has also been observed on *Trachycarpus fortunei*. André (1874) and Nardy (1877) noticed yearly changes in sexual expression. Jousson et al. (2023) provide another, vivid example of plasticity in *T. fortunei*. They observed a cultivated plant at the Conservatoire e Jardin Botaniques de Genève with a history of producing only staminate inflorescences but suddenly and unexpectedly put out green and yellow, intermediate inflorescences that carried viable but smaller fruits than typically found on pistillate inflorescences.

Jousson et al. (2023) and our observations show that sexual dimorphism is somewhat if not subtly evident in inflorescences of *Trachycarpus fortunei* and *T. wagnerianus*. Staminate inflorescences are sometimes initially drooping but mostly stiffly ascending-spreading, yellowish to cream-colored at anthesis, and aging yellowish. Rachis, branches, and rachillae are light greenish to greenish yellow in flower, aging to yellowish. When the panicle is bare of flowers it appears more slender, finer textured, and "lighter" than the pistillate. Pistillate inflorescences are stiffly ascending-spreading in flower becoming drooping to pendulous when heavily laden with fruits. They are initially greenish yellow in flower becoming yellowish to grayish green in young fruit and then purplish when heavily laden with mature fruit. The gray color in young fruit or aging unpollinated pistillate flowers is primarily from the whitish silky hairs densely covering the apices of the ovary. Rachis, branches, and rachillae are greenish yellow at anthesis and yellowish in fruit and aging dark brown to black in old fruit. When the panicle is bare of flowers it appears more robust, coarser textured, and "heavier" than the staminate.

Flowers of *Trachycarpus fortunei* and *T. wagnerianus* are similar. Staminate are mostly in clusters of two to four flowers or an occasionally solitary flower and either sessile or on short stalks. They are densely placed and contiguous or nearly so. In contrast, pistillate flowers are mostly in clusters of two to three flowers or an occasionally solitary flower and either sessile or on longer stalks. They are much less densely placed although they can be contiguous or nearly so, especially in the multi-flowered clusters. Hermaphroditic or bisexual flowers appear to be similar to staminate flowers but have a gynoecium about one-third as high as the stamens. They are restricted to staminate inflorescences where they are easy to overlook.

Pistillate flowers in pistillate inflorescences of *Trachycarpus fortunei* and *T. wagnerianus* transition remarkably from anthesis to post-anthesis. At anthesis the sepals and petals are greenish yellow while the gynoecium is clear colored with white wax and some silky white hairs distally. Post-anthesis if unpollinated, the sepals, petals, and rachillae become green while the gynoecium of three carpels (stigma lobes) swells or "plumps up" outward and upward well beyond the petals. The carpels are clearly separated and densely covered with white wax and long, sometimes matted, silky white hairs. If pollinated, one carpel (stigma lobe) swells or "plumps up" outward and upward well beyond the petals and develops into the fruit while the other two carpels abort. The sepals and petals become brownish.

Invasiveness

Invasive plants are non-native species that reproduce rapidly and aggressively outcompete native vegetation for such resources as light, water, and nutrients (USDA 2026). They can cause significant ecological and/or economic harm, often transforming diverse, multi-species habitats into dense, non-diverse, often single-species habitats. Human activity introduces them to new areas (USDA 2026). Interest in the invasiveness of *Trachycarpus fortunei* has increased because of the harm it can inflict on natural, indigenous ecosystems (Jousson et al. 2022). It can be invasive, sometimes aggressively so, in moist, warm-temperate areas, and is considered one of the most invasive palms worldwide (Fehr et al. 2020). It is invasive in central Japan (**Fig. 83**) and especially the Insubric region of southern Switzerland and northern Italy, where it is currently dispersing to higher altitudes due to several well documented factors (Jousson et al. 2022):

1. rising winter temperatures (Walther et al. 2007);
2. ecosystem disturbance (Grund et al. 2005);
3. changes in landscape uses (Conedera et al. 2018);
4. and other human-induced causes (Fehr and Burga 2016, Genazzi et al. 2022, Tonellotto et al. 2022).

Trachycarpus fortunei was introduced in the latter quarter of the 19th century to Insubric, especially the renowned Isola Madre in the Lake Maggiore region of Italy (Pfister 1977, Schröter 1936, Walther 2000) and southern Switzerland in 1882 (Kny 1882).

By the 1950s, *Trachycarpus fortunei* had escaped from cultivation into natural areas of Insubric (Schmid 1956, Walter et al. 2007). By 2000, it was strongly invasive (Fehre et al. 2020) in forested areas of southern Switzerland (Info Flora 2014) and northern Italy (Banfi and Galasso 2010, Galasso et al. 2020). It is now a signature and iconic plant of the evergreen, broad-leaved forests and landscapes of the Insubric region (Fehr and Burga 2016, Fehr et al. 2020, Jousson et al. 2022, Walther et al. 2007).

Trachycarpus wagnerianus does not appear to be recorded as invasive unless it has been simply lumped into the invasive research and reports of *T. fortunei*.

Ethnobotany

Trachycarpus fortunei is one of the most useful and widely grown palms in China and, along with *T. wagnerianus*, has been cultivated for thousands of years for a wide variety of products and applications, which we feel has greatly modified its genotypic and phenotypic composition. In many respects, they are artificial, domesticated species.

83. *Trachycarpus fortunei* is naturalized and invasive in the moist woods of central Japan. In 2014, trail up Mt. Inari, Kyoto, Japan.

Nearly every part of the palm has been used for one purpose or another, including material and industrial uses, food and fodder, and medicinal use (Essig and Dong 1987, Yunfa 2005). Multiple use is the key to successful exploitation of *T. fortunei* in China. It is only an economically viable crop if it is exploited for all its products (Essig and Dong 1987). In modern times, *T. fortunei* has gained wide popularity for use as an outdoor landscape subject to impart an exotic, tropical motif in warm-temperate regions where tropical-looking, cold-tolerant plant material choices are limited.

Material and Industrial

The hard, durable, water-resistant trunks are employed as posts, pillars, rafters and other construction needs (Essig and Dong 1987, GLTMS 2026). Leaves are used as thatch for roofs (Essig and Dong 1987).

The strong, moisture-resistant leaf base fibers typically clothing the trunk are woven into mats, coarse cloth, brushes, broom, ropes, bags, and sacks. They have also been fashioned into coarse, water-proof raincoats or ponchos and hats (Beccari 1905, Essig and Dong 1987, GLTMS 2026, Grisard and Vanden-Berghe 1889, HB 2026, MH 2026, SG 2026, Wilson 1913). Production and use of these fibers, which have a quality and use comparable to that of coconut coir, form a major and important local industry. Wilson (1913) noted that large quantities of baled fibers were frequently seen being shipped from Sichuan Province down the mighty Yangtze River for export.

Leaf blade segments are woven into hats, fans, baskets, fishing nets, chairs and sofas (Essig and Dong 1987, MH 2026).

Fruit exteriors or coats provide high-grade wax used for waxes and polishes (shoes, floors), stencils, and wax and carbon paper. Seen on mature fruits as a white-waxy bloom, the wax is comparable in quality to the more famous *carnauba* wax from *Copernicia* palms in South America only it is produced in much smaller quantities (Essig and Dong 1987).

Production of wax and the medicine *bsuen an* (see later for an explanation on this medicine) from fruits of cultivated *Trachycarpus fortunei* is a substantial industry in China. Essig and Dong (1987) reported that about 18,000 metric tons of palm fruits are produced annually in Hubei, Hunan, Sichuan, and Guizhou provinces and that one palm can produce about 25 to 50 kg of fruit annually.

Food and Fodder

Humans consume cooked flower buds, which are said to be similar to bamboo shoots (Essig and Dong 1987, Facciola 1990, HB 2026, Stuart 1911, Sturtevant 1919, Tanaka 1976). They also consume raw or cooked fruits and seeds (Sturtevant 1919) and the apical meristem (hearts of palm) (Facciola 1990). The latter is said to be tasty but somewhat bitter and is used mostly to flavor soups and stews.

Fruits and seeds are used as livestock fodder (Essig and Dong 1987) while local birds and insects consume fruits.

Medicinal

Traditional folk medicine and remedies have led to many modern medicines, and China has a long history of plant-based traditional medicine. This long history has renewed interest in the immense store of Chinese medicinal folklore; thus, it is no surprise that *Trachycarpus fortunei*, sometimes called *Zonglu* or *Zong*, figures prominently in traditional Chinese medicine. A number of pharmaceutical uses are listed for it in the Chinese Pharmacopeia (Chung yao ta tz'u tien 1977) but strangely under the name *T. wagnerianus* (Essig and Dong 1987). Yunfa (2005) noted that nearly all parts of the palm, including roots, trunk, leaves, flowers, and seeds contain chemical compounds with potential medicinal value.

Extracts from flowers, seeds, and ash from burned lead base fibers have astringent and hemostatic properties and are used to treat nosebleeds, bloody stools, coughing up blood, and related conditions, and gonorrhea and other venereal diseases (Duke and Ayensu 1985, HB 2026, Hu-nan Zhong 1974, MH 2026, SG 2026).

Dong et al. (1981) reported that a seed extract called *bsuen an* is used to treat bleeding of the uterus, bowl, and respiratory tract through capillary constriction. They also reported that this extract is used to cause uterine contractions during birth and to treat hypertension and diarrhea.

Essig and Dong et al. (1987) reported that an extract from roots, leaves, and flowers contains a compound similar to those of the seeds and can be used as a female birth control by causing uterine contractions. They also noted that the petiole contains a compound used to treat hypertension and that the carbonized petiole is said to have hemostatic properties through capillary constriction. This compound, sometimes called *Zonglu*, is an essential oil extract from the dried, proximal part of the petiole, which in addition to treating hypertension is also used for stroke prevention (GLTMS 2026). Decoctions of roots and fruits are used as a contraceptive (MH 2026). Various extracts are used to treat gonorrhea and other venereal diseases (MH 2026).

Extracts of outer seed coats of *Trachycarpus fortunei* have been investigated for their antibacterial activity (Ahmed et al. 2017, Li et al. 2025) while another study looked at similar properties of the flower buds (Ni et al. 2025). Fruit extracts have been investigated for their anti-tumor properties (Chen et al. 2012).

Other Uses

Trachycarpus fortunei and *T. wagnerianus* have long been employed as effective and handsome, cold-hardy palms, imparting a warming, exotic, tropical motif to gardens and landscapes in their typically cool- to cold-winter range, which few or no other plants can provide.

Because of their relatively large leaves, abundant leaf base fiber, and prodigious flowers and fruits, they offer unparalleled harborage, food, and nesting material for birds, mammals, and other animals.

Because of its sensitivity to temperatures, *Trachycarpus fortunei* can serve as a bioindicator for tracking climate change (GISD 2026).

Breeding for Improvement

Numerous, recent studies continue to document *Trachycarpus fortunei* genetic resources, especially in Guizhou, China, where high genetic diversity, geographic isolation, and extensive differentiation among populations create a significant potential for selection and breeding to increase and refine exploitation and utilization of this species or to understand its sexual expression for phylogenetic studies and invasiveness assessments. These studies utilize molecular markers such as SRAP and transcriptome analyses and chloroplast genome composition to identify genetic traits governing sexual expression, environmental stress resilience (drought, cold tolerance), pest and disease resistance, and desirable growth features (Jousson et al. 2022, 2023; Mao et al. 2020; Xiao et al. 2020a, 2020b, 2021, 2023). Jiawei et al. (2019) investigated the anatomical properties of leaf-base and trunk fibers.

Cultivars of Trachycarpus fortunei

Numerous cultivars of *Trachycarpus fortunei* are recognized but not all are likely distinct. These cultivars might be simply natural variation, infra-specific taxa of *T. fortunei*, hybrids, or other named or unnamed species. In many cases, names based on people, a particular feature, or geographic location were assigned to these cultivars and little or no diagnostic information was provided.

'Baihutan'
Stevens (2010) reported that Garry Tsen of China Gardening Nursery (coldplant.com) found this plant in the wild on limestone mountains in China and is a ". . . stout palm with a short, fat trunk that has lots of shaggy, coarse hair." Because it only has half the quantity of leaf-blade segments of *Trachycarpus fortunei*, Stevens (2010) suspected that it might actually be *T. geminisectus*.

'Bulgaria' ('Plovdiv', *T*. 'Bulgaria')
Stevens (2010) reported this cultivar originated from 50-year-old plants in a museum garden in Plovdiv, Bulgaria. It is more compact and has small, stiff, deeply split leaf blades.

'Darjeeling'
Stevens (2010) reported that this cultivar, from 2,450 m elevation in the town of Darjeeling, West Bengal, India, is one of the most cold-tolerant *Trachycarpus fortunei* and has a compact crown of leaves. It is different from *T.* 'Darjeeling', which is likely *T. latisectus*.

'Hasan'
Palmeraie (2017) reported that this cultivar is similar to 'Tesan' but has smaller leaves and the leaf-base fibers on the trunk are easy to remove.

'Hayes Stiffie'
JLBG (2025) reported that this cultivar was characterized by unusually stiff leaves, which Alabama plantsperson Hayes Jackson selected and introduced it to the trade.

'Kiril'
Palmeraie (2017) reported that this cultivar from Bulgaria is unusually cold tolerant.

'Misan'
Garry Tsen of China Gardening Nursery (coldplant.com) found this plant in the wild on isolated mountains in China (Tsen 2026a). He described it as even smaller than *T. wagnerianus* with a slender trunk and compact canopy of leaves, making it ideal for small areas and gardens and containers.

'Naini Tal' ('Chaubattia')
Stevens (2010) reported that this cultivar, from Nainital, India, was long but erroneously thought to be *Trachycarpus takil*. Indeed, most of what is cultivated as *T. takil* is likely *T.* 'Naini Tal'. This robust cultivar has the conspicuous ochrea surrounding the emerging leaves and formed from

the leaf-base fibers while *T. takil* does not have these ochrea; otherwise, they are somewhat similar. Stevens (2010) described this cultivar as “bolder, more distinguished . . . faster, larger, nicer, and more cold-hardy than the average *T. fortunei*.” Stevns (2010) also noted that the leaf-blade segment tips do not droop, which might indicate it is a hybrid of *T. fortunei* and *T. takil*.

‘Nova’

This taxon is mired in confusion about its source and identity. Originally thought to be from India or the Tiger Leaping Gorge area of Yunnan, China, Garry Tsen of China Gardening Nursery (coldplant.com) has now documented it from the wild in the famous Stone Gate region in Yunnan (Tsen 2026b). It is unusually variable, grows exceedingly fast, and at least two forms are in the trade (narrow and wide) (Tsen 2026b). The narrow form, which occurs in the wild and might be a new taxon, has evenly divided leaf blades with narrow segments, segment tips that bend, a heavy white-waxy bloom on leaf blades abaxially, elongated petioles, and a slender trunk. In contrast, the wide form, which is only known from cultivation and might be a hybrid between *Trachycarpus fortunei* and *T. princeps*, has irregularly divided leaf blades with wide segments, green leaf blades abaxially, shorter petioles, enormous, long ochrea, and a stout trunk. Both forms grow exceedingly fast (Tsen 2026b).

‘Taylor’

Stevens (2010) reported that this cultivar with bent or droopy leaf-blade segment tips originated in Florida and a Mr. Taylor took it to his nursery in North Caolina.

‘Tesan’

Garry Tsen of China Gardening Nursery (coldplant.com) found this plant in China (Tsen 2026c). Erroneously thought to have originated near Beijing in northern China, it is famous for its extreme cold hardiness (tolerating temperatures to -20 C with little or no damage) and has a short, robust trunk, a relatively compact canopy of leaves, and large fruits (Tsen 2026c).

‘Winsan’

Garry Tsen of China Gardening Nursery (coldplant.com) found this plant in China (Tsen 2026d), where it is noted for its unusually round, deeply divided leaf blades, fast growth rate, eophyll and subsequent strap-like seedling leaves with three to six primary veins, and unique infructescences with second- to fourth-order branches pendulous and hanging like strings heavily loaded with fruits.

Cultivation

For comprehensive reviews of palm horticulture and landscape management, see Broschat et al. (2014) and Hodel (2012).

Trachycarpus fortunei and *T. wagnerianus* are typically tough, durable, and hardy palms admirably adapted to a variety of subtropical and mild temperate climates and regions around the world. They are tolerant of and grow unusually well in warm-summer/cool-winter, drier, and more arid subtropical conditions, like the Mediterranean-climate regions of southern California, southern Europe (**Figs. 84–85**), southern Africa, parts of Australia, and elsewhere, and also perform well in moist to wet, warm-temperate locations like the coastal Pacific Northwest of the United States and adjacent southwestern Canada, the British Isles, central Japan (**Fig. 86**), and other areas with similar climates. They are especially tolerant of wet cold and accumulation of snow on their leaves for short periods. They do not seem particularly well adapted to moist to wet, tropical and near tropical conditions, like those of southern Florida, northern Australia, Thailand, and elsewhere.

Their legendary cold hardiness is much talked about, celebrated, and championed. In laboratory tests, Larcher and Winter (1981) found that large portions of leaves of *Trachycarpus fortunei* were damaged at ¯12 C while Hodel (2012) estimated that the temperature at which serious damage can occur was ¯12 to ¯17 C. They are known to survive temperatures as low as ¯20 to ¯27 C (Palmpedia 2026).

Trachycarpus fortunei and *T. wagnerianus* generally have best growth and flowering and fruiting in sunny locations in the garden or landscape although protection from the afternoon sun is beneficial in regions with extremely hot, arid summers. Despite generally performing better in sunny locations, they are surprisingly tolerant of light shade. Also, consider wind protection, especially for *T. fortunei*, which tends to be degraded in windy situations while T. wagnerianus is much more wind tolerant.

They grow well in just about any type of soil, from sands to clays, as long as irrigation is adjusted for each type of soil: lighter but more frequent irrigations on sandy soils and heavier but less frequent irrigation on clay soils. A general horticultural rule-of-thumb is at each irrigation event, apply sufficient water to moisten the root zone to a depth of 30 cm and then do not irrigate again until the soil three to five centimeters below the surface (not counting mulch) dries out. Although they tolerate occasional, short periods with little or no water, they are not drought tolerant and perform best with regular irrigation as needed and described earlier. Hodel (2012) rated their relative water needs as high, meaning they need regular irrigation to grow well. Pittenger et al.

84. *Trachycarpus fortunei* is well adapted to Mediterranean-climate regions, like here in southern France on the Côte d'Azur in 2010.

85. *Trachycarpus fortunei* grows well in northwestern Italy on the Italian Riviera in 2010.

86. *Trachycarpus fortunei* also grows well in moist to wet, warm-temperate locales like in the Kyoto Botanical Gardens, Kyoto, Japan in 2013. Note T. *wagnerianus* at lower right.

(2009) determined that *Trachycarpus fortunei* produced significantly more and greener leaves with at least 25 to 50% of reference evapotranspiration in a coastal Mediterranean climate. Insufficient water can lead to leaf segment folding, premature senescence of older leaves, leaf scorch (**Figs. 87–90**), and perhaps increased susceptibility to pests like banana moth. Also, severe heat can sometimes cause leaf scorch (**Fig. 91**).

Propagation of *Trachycarpus fortunei* and *T. wagnerianus* is by seeds. However, depending on the age and sexual expression phase of the palm as earlier described, fruit production can be abundant or abysmal. Broschat et al. (2014) and Hodel (1998) provided reviews and recommendations for germinating palms from seeds and growing on seedlings, and we generally adhere to their recommendations here.

When fruits are purple, mature, and soft ripe, they can be collected from the palm, cleaned of their pulp, and the seeds planted in a clean, moist, porous, well aerated medium composed of about 25% organic matter like peatmoss or coir and 75% inorganic matter like perlite, pumice, or sand, which is a general recommendation for palms and one that we have followed with success for *T. fortunei* and *T. wagnerianus*. However, Sento (1971) found that a clay-loam medium provided the best germination for *T. fortunei*.

Plant the seeds, barely covering them with about 5 to 10 mm of medium. Place the clean, planted containers off the ground and keep them clean. Keep the medium moist but not soggy wet and maintain temperatures of from 24 to 30 C. Sento (1971) found that the optimal temperature for germination of seeds of *T. fortunei* was 30 C, that germination occurred within 30 days, and maximum germination was 90 percent while Chatty and Tissauoi (1999) found that the optimal temperatures for germination ranged from 15 to 25 C.

When the eophyll has appeared, pot up seedlings into appropriately sized, clean containers using the same or similar mix used for germination, only now incorporate dolomite lime and a palm-special fertilizer into the mix following recommended rates. Keep plants off the ground and in light shade, especially in the afternoon. As roots fill out their containers, move up young plants into larger containers and gradually decrease any shade until they are in full sun. Keep the potting medium evenly moist (Broschat et al. 2014) and Hodel (2012).

When the plants are of sufficient size, they can be planted out into the ground. Dig a hole as deep as the root ball is high and twice as wide. Place an appropriate amount of palm-special fertilizer in the bottom of the hole. Remove the container and place the palm in the hole. Backfill with the same soil that was dug out of the hole without amending it, tamp firmly, apply about five cm of good quality mulch from the palm's stem out to 60 cm, and irrigate thoroughly. If rain is insuf-

87. Insufficient water with *Trachycarpus fortunei* can lead to folding up of leaf blade segments, premature senescence of older leaves, and leaf scorch.

88. One of the first symptoms of insufficient water with *Trachycarpus fortunei* is folding up of leaf blade segments.

89. *Trachycarpus fortunei* needs regular irrigation to perform best. Insufficient water can lead to folding up of leaf blade segments and premature senescence of older leaves.

90. Insufficient water with *Trachycarpus fortunei* can lead to folding up of leaf blade segments, premature senescence of older leaves, and leaf scorch.

91. Severe heat (temperatures exceeding 40 C) can sometimes cause leaf scorch on *Trachycarpus fortunei*.

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ficient, irrigate when the palm needs it by checking the original root ball, backfill, and surrounding site soil. Whichever one of these zones first dries out at a depth of about three to five cm under the soil surface (not counting the mulch), then immediately apply sufficient water to moisten the upper 30 cm of the root zone as described earlier (Broschat et al. 2014, Hodel 2012).

Established *Trachycarpus fortunei* can be successfully transplanted in the landscape if they are dug with a root ball at least 30 cm out from the trunk in the spring and replanted immediately when root activity will be highest for the long period through summer and into fall to ensure quick and successful reestablishment (Hodel et al. 2005). Replant at grade, using the same unamended soil for backfill that came out of the hole (Hodel at al. 2013). Apply and maintain 5 to 7.5 cm of good quality mulch from the trunk out to one meter and irrigate as described earlier.

Major pests of *Trachycarpus fortunei* include the coffee root mealybug (*Geococcus coffeae*), American palm cixiid (*Haplaxinus crudus*) (CABI 2026), South American palm borer (*Paysandisia archon*) (Fehr et al. 2024), and banana moth (*Opogona sacchari*) (Hodel and Santos 2020) (**Figs. 92–96**). Minor pests include the palm-infesting whitefly (*Aleurotrachelus atratus*) (CABI 2026) and red palm weevil (*Rhynchophorus ferruguineus*) (Milek and Šimala 2013). Diseases include lethal yellowing (LY) (Candidatus Phytoplasma Palmae) (Ferguson and Singh 2018), black shank (*Phytophthora nicotianae*) and coconut budrot (*P. palmivora*) (Cacciola et al. 2011), reniform nematode (*Rotylenchus reniformis*) (CABI 2026), and pink rot (Hodel 2012) (**Figs. 94, 97–98**). The best management strategies are to provide optimal cultivation, to practice pest and disease exclusion and sanitation, and to use appropriate pesticides and fungicides as a last alternative.

Yellow and dark splotching or orange-yellow margins sometimes occur on older or lower leaves in the canopy of *Trachycarpus fortunei*, which could indicate potassium and/or magnesium deficiency (**Fig. 99**) Fertilize with a palm-special fertilizer, which typically has high nitrogen and potassium and a moderate amount of magnesium with all elements in a time-release form, following label recommendations for rates and frequency. Because hybrids might occur in *T. fortunei* and *T. wagnerianus*, yellow and dark splotching on older or lower leaves in the canopy might be the disorder lesion mimic mutant, a genetic disorder and not a nutrient disorder or a disease and will not respond to fertilizer or fungicide applications (Dhillon et al. 2024).

Dead leaves and spent inflorescences and infructescences tend to persist on the palm, which can detract from its beauty. Sometimes a neat shag or skirt of dead leaves can be attractive, but dead inflorescences never seem so. Thus, general maintenance includes neatly and cleaning removing dead, brown, persistent leaves and spent inflorescences and infructescences, if these are not desired. To do so, neatly cut as close to the trunk as possible without damaging the fibers or trunk itself. Avoid leaving short petioles or inflorescences bases protruding from the hair-covered

92. Banana moth is one of the most serious pests of *Trachycarpus fortunei* in California. First symptom of an infestation includes damaged emerging leaves.

93. Later symptoms of banana moth on *Trachycarpus fortunei* include dead new leaves.

94. Banana moth damaged or dead leaves on *Trachycarpus fortunei* typically will show lesions, browning, and frass. A secondary pink rot infection might also be present.

95. Sometimes banana moth damage on *Trachycarpus fortunei* shows up as deformed, accordion-type growth on leaf blade segments.

96. The accordion-type growth on leaf blade segments on *Trachycarpus fortunei* can be banana moth damage.

97. Pink rot, typically a secondary infection on wounded and/or stressed palms and often in the apical meristem area, can occur on *Trachycarpus fortunei*.

98. Pinkish spore masses, typical of a pink rot infection, cover apical meristem tissues on this *Trachycarpus fortunei*.

99. Magnesium deficiency typically appears as an orange-yellow band around the outside of older leaf blades on palms, as here on these *Trachycarpus fortunei* in Santa Barbara, California.

100. Some people prefer a neat, clean, hairless trunk on *Trachycarpus fortunei*, as here in Camarillo, California.

101. Removal of the hair-like fibers of persistent leaf bases from trunks of *Trachycarpus fortunei* can be tedious and laborious but results in a neat, clean look.

trunk; not only are they unsightly but the former, especially, could snag an unwary passerby. Some people prefer a neat, clean, hairless trunk, which can be achieved by laborious and tedious removal of the persistent leaf base fibers (**Figs. 100–101**).

Trachycarpus fortunei and *T. wagnerianus* are sufficiently handsome and imposing to make a statement in any landscape. Their highly ornamental windmill-like leaves, hairy trunks, bright yellow inflorescences, dense clusters of purplish fruits, moderate size or habit, and mostly tough, durable, and hardy nature make them superb, landscape choices in appropriate climates. For best effect, plant them in groups of odd-number plants (for example 3, 5, or 7) of staggered heights.

In addition to their striking leaves, the other highly ornamental feature is the densely hairy trunks, which always provoke admiration and adoring comments from new and old admirers. Nonetheless, if desired, these fibers can be carefully but somewhat tediously and laboriously removed to reveal a slender, handsomely ringed trunk.

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