

Farmers' knowledge of date palm (*Phoenix dactylifera* L.) agrobiodiversity in a Saharan oasis: folk nomenclature, fruit morphometrics and varietal turnover over four decades at Taghit, south-western Algeria

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Research Article

Keywords: *Phoenix dactylifera* L., oasis agroecosystem, small-scale farming, local knowledge, varietal diversity, fruit morphometrics, Bayoud disease, south-western Algeria

Posted Date: September 15th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11025038/v1>

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Additional Declarations: No competing interests reported.

Farmers' knowledge of date palm (*Phoenix dactylifera*
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22 Article in preparation for the *Journal of Ethnobiology and Ethnomedicine*, collection *Small-scale*
23 *farming and ethnobiology – Bridging local knowledge, biodiversity, and cultural landscapes*.

24

25 **Abstract (350 words)**

26 **Background:** Date palm (*Phoenix dactylifera* L.) sustains oasis livelihoods through farming systems in
27 which clonal propagation coexists with the retention of seed-derived palms. Documenting this diversity
28 requires attention to how farmers name, distinguish and manage their palms. In south-western Algeria,
29 long exposed to Bayoud disease, no inventory of local varietal repertoires has been published for Taghit
30 since 1985, to our knowledge. This study examined date palm diversity and farmers' knowledge and
31 practices in the Taghit oasis system, characterised fruit and seed variation among locally recognised
32 varieties, and assessed changes in the repertoire over four decades.

33 **Methods:** Semi-structured interviews with 70 farmers across 39 palm groves in six localities
34 documented varietal names, cultivation practices, knowledge transmission, uses and perceived
35 constraints, including resistance to Bayoud. We analysed varietal frequency, salience and spatial
36 distribution, and compared the repertoire with a 1985 inventory. Ten quantitative fruit and seed traits
37 were measured on 600 fruits from 75 palms representing 30 varieties to assess variation within and
38 among varieties.

39 **Results:** Farmers reported diverse uses of date palm products, regular grove management and continuing
40 intergenerational knowledge transmission. They listed 30 varieties, comprising a widely shared core and
41 numerous less frequent ones, twelve recorded in a single grove. Richness and composition differed
42 among localities. Varietal lists excluded males and collective seedling categories, while *ḥalt* served both
43 as a varietal name and as a collective designation for seed-derived palms. Fruit and seed traits

differentiated varieties clearly, variety accounting for 96.7% of the variance among palm means. After harmonisation, the 1985 and current inventories each comprised 30 varieties, but only fourteen were shared, historically common varieties being more often recovered. Perceived Bayoud resistance may have contributed to changes in the repertoire, as illustrated by the increased cultivation of tākarbūš, introduced for its reputed resistance but still uncommon in 1985.

Conclusions: Our study highlights smallholders' role in maintaining perennial crop diversity through clonal propagation, retention of seed-derived palms and local knowledge. Conservation should support the practices and knowledge transmission that sustain this diversity, household livelihoods and oasis landscapes.

Keywords (3-10): *Phoenix dactylifera* L.; oasis agroecosystem; small-scale farming; local knowledge; varietal diversity; fruit morphometrics; Bayoud disease; south-western Algeria.

1. Background

Agrobiodiversity encompasses crop and varietal diversity and associated knowledge and practices, supporting food security, ecological resilience and agricultural adaptation [1,2]. Agricultural intensification and the widespread adoption of a limited number of commercial cultivars threaten this diversity, although patterns of loss and maintenance vary among crops, regions and scales of observation [3]. Many small-scale farming systems nevertheless continue to harbour substantial varietal diversity, particularly in clonally propagated crops [4]. They are therefore key settings for understanding how farmers' knowledge and practices contribute to maintaining agrobiodiversity and for identifying conservation priorities [2,4].

In the arid regions of North Africa and West Asia, much of this small-scale agriculture is concentrated in oases. These anthropogenic ecosystems combine human settlements and networks of interdependent gardens managed by farmers, relying on collective organisation and the management of shared resources, particularly water [5]. The date palm (*Phoenix dactylifera* L.) forms their structural, cultural and economic backbone. Its canopy provides shade for fruit trees and annual crops grown beneath it in a multi-layered cropping system [6]. It supplies dates for household consumption and sale [7], as well as materials such as fibre, trunks and leaves used in construction, fencing and basketry [5,8].

Oasis gardens harbour substantial intraspecific diversity of date palms, with several thousand varieties reported worldwide [9]. To our knowledge, no comprehensive global inventory exists, and documentation remains based on surveys at national and local scales, including approximately 250 varieties reported in Tunisia [10] and approximately 100 named types in the oasis of al-‘Ulā, Saudi Arabia [11]. Only a small number of commercial varieties, such as majhūl [medjool] and daqlat nūr [deglet noor], are widely cultivated internationally. Each oasis holds its own local repertoire, which varies further among its constituent gardens and localities [12].

Date palm cultivation and oasis agroecosystems as a whole face mounting pressures from water scarcity, sand encroachment, soil salinisation, pests and diseases, alongside land abandonment and declining

knowledge transmission [6]. Bayoud, a vascular wilt caused by *Fusarium oxysporum* f. sp. *albedinis*, is a particularly destructive threat to date palms in the Maghreb. First reported in Morocco in the nineteenth century, it subsequently spread across the western and central Algerian Sahara, killing millions of palms and severely affecting highly valued cultivars [13,14]. In the absence of an effective curative treatment, management relies primarily on measures to prevent its spread and on the deployment of cultivars with lower susceptibility to Bayoud [14,15]. These pressures make documenting, characterising and conserving their diversity increasingly urgent.

Farmers' variety names provide an entry point for documenting crop diversity and its distribution within farming systems [4,16,17]. Together with farmers' descriptions, they reveal how this diversity is recognised, classified and valued according to morphology, growing requirements, origin and uses [18,19], and provide a basis for assessing changes in local varietal repertoires over time [11]. The relationship between named and biological diversity can, however, be complex in clonally propagated crops, where farmers may manage both vegetative propagation and recruitment from seed [20].

In date palm, female palms producing desirable fruits are propagated by offshoots, preserving selected genotypes and valued fruit characteristics across generations; a named type may thus correspond to a true-to-type cultivar [21]. Palm groves also contain genetically distinct seedlings, usually arising spontaneously from fallen fruits rather than deliberate sowing, that farmers have allowed to grow while removing most others. These palms, whose sex remains unknown until flowering, may be grouped under collective names, such as ḥalt and sā'ir in different regional contexts [16,22]. Once flowering reveals their sex, male palms may instead be referred to as ḍakar ("male" in Arabic), and retained as pollen donors for hand pollination. Female seedlings that produce desirable fruits may be selected for propagation by offshoots and given a new name. They may also be assigned to an existing named type on the basis of perceived similarities and subsequently propagated by offshoots, potentially bringing distinct clonal lines under a single name [16,23]. Further, within a locality, a single clone may bear several names, notably where different languages are used. Across localities, differences in nomenclature can likewise result in the same name designating distinct clonal lines, or the same clone

being known by different names [21]. Named diversity thus reflects both farmers' selection and propagation practices and naming conventions that vary across contexts.

In Algeria, approximately 1,000 date palm cultivars have been recorded [24], but their documentation remains uneven across regions and in the extent to which local nomenclature, farmers' knowledge and practices, and phenotypic variation are examined together. The country is a major date producer, with approximately 18 million palms grown over 169,000 ha and annual production exceeding 500,000 tonnes [24]. The south-eastern oases account for about three quarters of national output and have been studied through, for example, varietal inventories in the Ziban, Oued Righ, Souf and M'Zab [25,26] and phenotypic characterisation of cultivars in Biskra and Ghardaïa [27,28].

The south-western oases contribute approximately 15% of national date production [24] but remain less studied, despite their early and severe exposure to Bayoud [14]. Research includes resistance screening [29], a regional review of varietal diversity [30], and phenotypic characterisation of 26 varieties in Adrar Province [31]. In Béchar Province, a recent survey recorded 18 date varieties across the province and identified Taghit as its leading date-producing municipality [32]. In 1985, Brac de la Perrière and Ben Khalifa [33] had recorded 31 varieties in the oasis of Taghit alone. This local inventory has, to our knowledge, not been revisited since. Revisiting this repertoire four decades later offers an opportunity to assess changes in named diversity and document the knowledge and practices associated with its present maintenance, in an oasis increasingly affected by drought, Bayoud and grove abandonment [32,34,35]. Documenting this diversity also involves describing the characteristics of the cultivated palms, beyond their names and occurrence. Fruit and seed characterisation documents the range of phenotypes maintained in gardens, while farmers' assessments reveal the qualities they value and the susceptibility to Bayoud they attribute to different named types.

In this study, we investigated date palm agrobiodiversity in the Taghit oasis system, encompassing both cultivated diversity and the knowledge and practices through which farmers manage, use and maintain it. Our objectives were to: (1) document the current varietal repertoire and compare it with the 1985 inventory; (2) document farmers' recognition criteria, cultivation practices, knowledge transmission,

uses, and perceived constraints and management responses, particularly concerning Bayoud; and (3) characterise fruit and seed variation within and among varieties and assess their morphological differentiation. By combining ethnobotanical surveys, morphometric characterisation and historical comparison, we aim to provide a basis for monitoring and conserving date palm agrobiodiversity in Taghit.

2. Material and Methods

2.1 Study area and agroecosystem context

The Taghit (Tāġīt) oasis is located in southwestern Algeria (Béchar Province), along the eastern bank of Oued Zouzfana, approximately 100 km south-east of Béchar (Fig. 1). It lies at the interface between the *Grand Erg Occidental* dune fields to the east and rocky plateaus to the west [34]. The region has a hot, arid Saharan climate (Köppen BWh), with annual rainfall of 70–100 mm/year and summer temperatures of 33–35 °C, regularly exceeding 40 °C [36].

Within the Taghit commune, agricultural land includes the traditional oasis and newer agricultural perimeters outside it, together totalling approximately 2,360 ha of exploited land [37]. The traditional oasis forms an elongated green corridor extending over approximately 18–20 km (Elmehdi et al., 2020), and covers 960 ha, of which 750 ha are cultivated. It comprises five localities, all surveyed in this study: Zaouiya Foukaniya (Zāwiyah Fūqāniyyah), Taghit, Barbi (Barbī), Bakhti (Baḥtī) and Zaouiya Tahtaniya (Zāwiyah Taḥtāniyyah) (Fig. 1; Table 1). A sixth site, Laouina (la'wīnah), was also surveyed: this ha agricultural perimeter was established in the 80's under a governmental land development programme and lies approximately 19 km from central Taghit. Place names follow the official Algerian romanisation; transliterations of their Arabic forms are provided in brackets at first mention only.

Agriculture is largely subsistence-oriented and takes place in gardens close to the fortified villages (*ksour*), where farmers cultivate multiple crops in a traditional multi-layered intercropping system [37]. Date palms form the upper canopy, above an intermediate layer of fruit trees (*e.g.*, pomegranate, fig,

apricot) and an understorey of seasonal crops and/or fodder species (*e.g.*, wheat, barley, alfalfa). Palm-grove management is commonly integrated with small-scale livestock keeping (sheep and goats), which provides manure that contributes to maintaining soil fertility.

2.2 Study design and fieldwork

This study investigates date palm agrobiodiversity in the Taghit oasis system by combining ethnobotanical surveys with the morphometric characterization of selected date palm varieties based on fruit and seed traits. Fieldwork for both ethnobotanical survey and fruit sampling was conducted between October 2025 and January 2026. This period was chosen because it overlaps with the main date-harvest season and the immediate post-harvest period, when farmers are more likely to be present in their palm groves, date palm management activities are more readily observable, and ripe fruits are available for sampling.

2.3 Ethnobotanical survey design and data collection

A total of 39 palm groves distributed across the five localities of the traditional Taghit oasis and the Laouina perimeter were surveyed (Table 1). The surveyed groves covered 58.75 ha within the traditional oasis, representing approximately 7.8% of its 750 ha of cultivated land, and 11 ha in Laouina, representing approximately 3.2% of the perimeter's total area of 341 ha [37]. The number of surveyed groves per locality was uneven, ranging from 14 at Taghit to a single grove at Zaouiya Tahtaniya, which was therefore retained in descriptive summaries but excluded from statistical comparisons among localities.

A total of 70 semi-structured interviews were conducted, the number of respondents per palm grove ranging from one to five (21 groves with one respondent, 9 with two, 6 with three, 2 with four, and 1 with five), since several individuals may be involved in the same grove. Groves are commonly held in undivided ownership, farmers explaining that subdividing already small groves would compromise their viability and create practical constraints for irrigation and access, so co-owners manage the grove collectively and share the harvest according to agreed arrangements. Cultivation work, moreover, is not

necessarily carried out by the owners: sharecroppers and agricultural workers take part in the day-to-day management of some groves, and were interviewed alongside, or in place of, the owners.

Participants were recruited among date palm farmers, which we defined as a person who is actively involved in the cultivation and/or management of date palm within the Taghit oasis system, either as owner, sharecropper or worker. Recruitment was conducted primarily through field-based intercept sampling during visits to groves across the study area. Additional contacts were facilitated in some cases by previously interviewed farmers when knowledgeable individuals were absent during initial visits.

All participants provided free and informed oral consent before the interview, and all records were anonymised prior to analysis (see *Ethics approval and consent to participate*). RB conducted the interviews in Algerian Arabic, with a semi-structured questionnaire and the assistance of the Forest District of Taghit staff (Additional file 1: Text S1). Responses were recorded directly in writing on survey forms (no audio recordings were made) and entered into structured spreadsheets, during which they were translated into English. Local terms, particularly date palm named types and technical vocabulary related to irrigation, management practices, pests, and uses, were standardized using a predefined glossary, established before fieldwork and revised as data collection proceeded (Additional file 1: Text S2). Ambiguous terms or expressions were resolved by consulting the original field notes and applying consistent coding rules while preserving participants' intended meanings as closely as possible.

Vernacular names are given throughout in a modified DIN 31635 transliteration of Algerian Arabic, in which the letter jīm is rendered as j rather than ġ. Several named types are of Amazigh rather than Arabic origin; they are given in the same transliteration, applied to their Arabic-script rendering as recorded during data entry. The names used by Brac de la Perrière and Ben Khalifa [33] or other studies are given in their original spelling wherever the 1985 inventory is discussed.

2.4 Questionnaire variables and descriptive analyses

The semi-structured questionnaire documented five main components of the date palm agroecosystem (Additional file 1: Text S1): (i) respondent and palm grove characteristics, (ii) cultivation and management practices, (iii) date palm variety diversity and identification criteria, (iv) uses of date palm products and by-products, and (v) perceived environmental, economic, and biotic constraints together with farmers' management responses. Depending on the variable, information was collected using numerical, categorical, or open-ended questions. Open-ended responses were reviewed after fieldwork and grouped into standardized categories for analyses.

Two levels of observation are distinguished throughout. Respondent characteristics were recorded for each of the 70 farmers interviewed and are reported at the respondent level. All remaining variables were recorded at the palm grove level, a single value being retained for each of the 39 palm groves. Where several farmers were interviewed in the same palm grove, figures were checked among them in the field until an agreed value was reached, and categorical variables admitting several answers were aggregated into the set of modalities cited by any of them. Every palm grove therefore contributes equally to the analyses, regardless of the number of farmers interviewed there.

2.4.1. Respondent and palm grove characteristics

Respondent-level variables were collected to characterize the socio-professional profile of farmers and the transmission of agricultural knowledge, including gender, age, education level, status in the palm grove, years of experience in date palm cultivation, the main source of agricultural knowledge, and whether this knowledge was transmitted to younger generations.

Palm grove area and the numbers of female and male date palms were reported by the farmers during the interviews. Total palm number, male-to-female ratio, and palm density (palms/ha) were then calculated as derived descriptors of grove structure. These four descriptors were summarised by locality and compared among localities using Kruskal-Wallis rank tests (*kruskal.test* function, *stats* package in

R). The relationship between palm grove area and total palm number was assessed by linear regression (*lm* function, *stats* package).

2.4.2 Cultivation and management practices

Farmers' renewal and propagation practices were surveyed, including how females and males were propagated, the origin of offshoots used for vegetative propagation (own grove, neighbouring groves, or both), intentional seed planting and its motivations, and local terminology for seed-derived palms. Pollination practices were recorded, including the pollination method (manual or natural), the period, the origin of pollen, and the criteria used for selecting pollen donors.

The hydro-agricultural setting of surveyed groves was also documented, including the main irrigation water source (well, spring, and/or foggara), the irrigation method, and the irrigation interval during both summer and winter periods. Irrigation intervals were reported verbally by farmers and were converted into a number of days for analysis, with responses expressed as a rate converted accordingly (*e.g.*, two irrigations per week taken as one every 3.5 days) and months taken as 30 days. Farmers were also asked how frequently they carried out routine maintenance operations on their palms (removal of dry leaves, fertilisation and pest control, etc.).

2.4.3 Varietal diversity and farmers' identification criteria

As part of the semi-structured questionnaire, farmers were asked to free-list all date palm varieties cultivated in the palm grove they owned, managed, or worked in. The question was put in Algerian Arabic using the term *anwā'*, the plural of *naw'*, which farmers use for the named kinds of date palm they distinguish and cultivate. What the question elicits is therefore the farmers' own category rather than a botanical or agronomic one, and its boundaries are set by them: the names given are those of female palms propagated clonally from offshoots, each bearing a name of its own. Names that designate a class of palms rather than a kind fall outside it, and were not volunteered in the lists: *ḍakar/ḍakkār*, which covers male palms collectively and which farmers do not name individually, and the collective labels applied to palms grown from seed, whose identity is by definition unknown until they fruit.

Whether a given name belongs to one side or the other of this boundary is an empirical question, addressed in the Results rather than assumed here. They were recorded in Algerian Arabic (dialect) and subsequently standardized during data entry by harmonizing spelling variants and applying consistent transliteration. Analyses are detailed in section 2.5.

In addition, to document how farmers identify varieties in the field, respondents were asked how they know that a given palm bears its particular name. Answers were open-ended and were grouped after fieldwork according to the plant part spontaneously mentioned as the basis for recognition (fruit, leaflet, or both).

2.4.4 Uses of date palm products

Information on the uses of date palm products included date consumption (fresh, dried, or both), preparation of rob (a traditional concentrated date syrup), date storage methods, and medicinal, cosmetic, craft, construction, and animal-related uses of date palm products and by-products. For reported medicinal uses, additional information was collected on the plant part used (fruit or pollen), the preparation method (decoction, poultice, or powder), and the ailment treated.

2.4.5 Constraints, pests, diseases, and management responses

Information was collected on farmers' perceptions of the main climatic and economic constraints affecting date palm cultivation, as well as on the principal pests and diseases affecting date palms. Differences among localities in the distribution of the reported economic and climatic constraints were tested using Fisher's exact test with p-values obtained by Monte Carlo simulation (10,000 replicates).

The methods used by farmers to manage pests and diseases were then documented and grouped into two categories, traditional methods, exemplified in the questionnaire by plant-based preparations, ash, manual removal and other practices based on local knowledge, and modern methods, exemplified by synthetic pesticides, pheromone traps and biological control.

2.5 Analysis of varietal diversity and spatial structure

The varieties free-listed by farmers were used to quantify their diversity, prominence and spatial structure across the Taghit oasis system. Free lists were brought to the palm grove level by pooling the lists of the farmers interviewed there, so that a variety counts as present in a palm grove when cited by at least one of them.

2.5.1 Diversity and salience metrics

Variety citation frequency was summarized using frequency of citation (FC), the number of palm groves in which it was reported by at least one farmer, and relative frequency of citation ($RFC = FC/N$, $N = 39$). Both rest on presence alone.

Variety salience was assessed using Smith's salience index [38], which combines citation frequency and position in the list, with higher values indicating names both more frequently listed and mentioned earlier. Because free lists concerned the varieties cultivated in the respondent's own grove, salience scores reflect prevalence and order of mention within grove inventories rather than cultural prominence within the domain. Since lists from farmers of the same grove differed in the order of citation, and occasionally in content, the index was computed on each individual list and then averaged in two steps, first over the farmers interviewed in the same grove, then over the 39 groves, non-citations contributing a value of zero at both levels.

The relationship between the salience of a variety and the number of palm groves in which it was cited as resistant to Bayoud was examined using Spearman rank correlations (function *cor.test*), computed against both Smith's salience index and the relative frequency of citation.

2.5.2 Variation in variety richness and composition among localities

Localities were compared on two complementary descriptors of their palm groves: varietal richness, the number of distinct varieties recorded in a palm grove, and varietal composition, the set of varieties it holds, represented by a palm grove by variety presence-absence matrix. Composition was summarised

302 by Jaccard dissimilarities, which compare two palm groves on the varieties they share and disregard the
303 ones absent from both (*vegdist* function, *vegan* package).

304 Variety richness is a count, so differences among localities were assessed using a Poisson generalized
305 linear model with a log link and locality as the predictor (*glm* function, *stats* package), the effect of
306 locality being tested by analysis of deviance. Mean richness per locality was estimated from the model
307 on the response scale, and localities were compared pairwise with a Šidák adjustment for multiple
308 comparisons (*emmeans* package), summarised as compact letter displays (*cld* function, *multcomp*
309 package). Two features of the data could produce an apparent difference among localities without any
310 difference in the repertoire itself, and both were checked. Larger palm groves might hold more varieties
311 for that reason alone, so two further models were fitted, one adding log-transformed palm grove area to
312 locality and one with area as the only predictor. Palm groves where more farmers were interviewed
313 might yield longer pooled lists, so richness was correlated with the number of respondents (Spearman
314 rank correlation) and that number was added to the model as a covariate.

315 Differences in composition were tested using PERMANOVA (*adonis2* function, *vegan* package, 9999
316 permutations) with locality as the predictor, and visualised by principal coordinates analysis (*cmdscale*
317 function, *stats* package), the ordination method matching the decomposition of distances underlying the
318 PERMANOVA. Here again two checks were carried out. Because PERMANOVA can detect one
319 locality being internally more variable than the others rather than a difference in composition,
320 homogeneity of multivariate dispersion was assessed using *betadisper*, with significance tested by
321 analysis of variance on distances to group centroids. Because palm groves holding very few varieties
322 are by construction distant from every other palm grove, the test was repeated after excluding those with
323 fewer than three varieties.

324 Varieties preferentially associated with a locality were identified by indicator value analysis (IndVal.g,
325 *multipatt* function, *indicspecies* package, 9999 permutations), computed on the same presence-absence
326 data. The indicator value of a variety for a given locality combines two quantities: how faithful it is to
327 that locality, that is the proportion of its occurrences that fall there, and how frequent it is within it, that

is the proportion of the palm groves of that locality where it occurs. It is therefore highest for a variety present in most palm groves of one locality and in few or none elsewhere, and its significance is assessed by permuting palm groves among localities. The analysis was run with candidate groups restricted to single localities (duleg = TRUE).

2.5.3 Comparison of the present varietal repertoire with the 1985 inventory

To place the current repertoire in a historical context, the varieties documented in the present study were compared with the inventory published by Brac de la Perrière and Ben Khalifa [33]. Varieties reported in both studies were matched by harmonising spelling variants and transliteration before comparison (Additional file 2: Table S1).

Whether a variety recorded in 1985 was recorded again in our survey was then related to four characteristics reported by the 1985 authors: whether the variety was described as resistant or tolerant to Bayoud, whether a fruit sample could be collected from it, whether it was among the four cultivars described as the most represented at Taghit, and whether it was among the four described as the most appreciated (Additional file 2: Table S1). Each association was tested with Fisher's exact test.

2.6 Date fruit morphological analyses

2.6.1 Date fruit sampling and morphological variables

To characterize fruit morphological variation and evaluate the morphometric distinctiveness of farmer-recognized varieties, dates were sampled from 30 varieties cultivated in the Taghit oasis, with the farmers' prior permission (Table 2). Sampling was conducted at the *tamr* stage (fully ripe). A total of 75 palms were included (2 to 3 palms per variety). Whenever possible, palms were selected from different palm groves and localities. Twenty fruits were collected per variety. This sampling effort was assessed by drawing random subsamples of 2 to 19 fruits within each variety, 100 times per subsample size, and comparing the resulting trait means with those obtained from the full set of 20 fruits (see Results).

Fruit morphology was characterized using ten quantitative descriptors selected for their relevance in capturing the key dimensions of fruit and seed and for their widespread use in phenotypic characterization studies [39–41] : fruit length, width, weight, and pulp thickness; seed length, width, thickness, and weight; pulp weight and the pulp-to-seed weight ratio. Fruit dimensions and weights were measured on intact fruits before seed extraction, after which seed dimensions and weight were recorded. All measurements were obtained using a digital calliper (± 0.01 mm) and a precision balance (± 0.01 g). Pulp weight was calculated as the difference between fruit weight and seed weight. The pulp-to-seed weight ratio was calculated as an integrative indicator reflecting relative pulp development and, at its highest values, the absence of a normally developed seed.

In addition, two qualitative descriptors were recorded, namely fruit colour (black, dark brown, brown, reddish-brown, light brown, light amber to orange-brown, beige, yellow-orange and yellow, further grouped into two categories, dark and light) and texture (soft, semi-soft, dry), assessed visually and by palpation, and scored once per variety rather than on individual fruits.

2.6.2 Morphometric analyses

Traits were first described across the whole dataset, which showed that two varieties, şba‘ sulţān and ‘azm būlah, produced fruits bearing only a thin vestigial seed (see Results). All subsequent morphometric analyses were therefore conducted on the remaining 28 varieties (71 sampled palms). Pairwise Pearson correlations were computed among all ten quantitative descriptors at the fruit level to identify the covariation structure (*cor.test* function).

Farmers name and manage date palms as varieties, and the analyses that follow treat each name as designating a morphologically coherent set of palms. Whether a name does in fact cover such a set is an empirical question. Since two to three palms were sampled under each name, it can be addressed by asking how much morphological variation separates palms bearing different names, and how much separates palms bearing the same one. The variance of each of the ten quantitative descriptors was partitioned into a variety component, a palm-within-variety component and a residual fruit component, using linear mixed models with variety and palm nested within variety as random effects (*lmer* function,

378 *lme4* package). Multivariate differentiation was then assessed on the eight non-redundant descriptors
379 (pulp weight and pulp-to-seed weight ratio being derived from the others were excluded), each
380 standardised to zero mean and unit variance, using Euclidean distances and PERMANOVA (*adonis2*
381 function, *vegan* package, 9999 permutations). Because fruits from the same palm are not independent,
382 each palm was reduced to the mean of its fruits, so that the test was conducted on 71 palm means rather
383 than on 560 fruits. For each variety, morphological dispersion was measured as the mean Euclidean
384 distance of its fruits to its centroid (*betadisper* function, *vegan* package), and the share of its internal
385 variance attributable to palm identity was obtained by a separate PERMANOVA fitted within that
386 variety (9999 permutations). P-values were corrected for multiple testing using the Benjamini-Hochberg
387 procedure.

388 The arrangement of varieties in morphological space was then explored by principal component analysis
389 on the same eight standardised descriptors, computed at the fruit level (*PCA* function, *FactoMineR*
390 package). Variety positions were summarised as the centroid of their fruits on each component.

391 Whether a single fruit can be traced back to its variety on morphology alone was assessed with a random
392 forest classifier fitted on the eight non-redundant descriptors (*randomForest* function, *randomForest*
393 package, 500 trees). Because fruits borne by the same palm are highly similar, a classifier trained and
394 tested on fruits from the same palm would report an artificially high success rate. Validation was
395 therefore carried out palm by palm: all fruits of one palm were set aside, the classifier was trained on
396 the remaining palms, and the held-out fruits were assigned, each of the 71 palms being held out in turn.

397 All statistical analyses were conducted in R 4.5.1 [42].

3. Results

3.1 Date palm cultivation in the Taghit oasis system

3.1.1 Informant and palm grove characteristics

Detailed results of the semi-structured interviews are provided in Additional file 2: Table S2. Among the 70 date palm farmers who participated in the study, most were men ($n = 68$) and they were primarily owners ($n = 64$) (Table 3). Respondents spanned a wide age range (15 to 94 years, median 49) and were highly experienced, with nearly half reporting more than 30 years of date palm cultivation ($n = 34$; mean = 37 years). Most respondents acquired their agricultural knowledge from their father ($n = 65$) and most also reported transmitting this knowledge to the next generation ($n = 61$).

The 39 surveyed palm groves cover 69.75 ha, ranging from 0.25 to 5.00 ha, with 20 to 410 palms in total (Fig. 2), and the total number of palms increased with palm grove area (linear model: $R^2 = 0.29$; $p < 0.001$) (Additional file 2: Table S3). Palm density ranged from 17.7 to 204.0 palms/ha, and male palms made up only a small fraction of the standing population, with a median male-to-female ratio of 3.2% (range 0 to 13.3%), four palm groves having no male palm at all.

Among these descriptors (Fig. 2), only palm grove area differed among localities (Kruskal-Wallis, $\chi^2 = 9.87$, $df = 4$, $p = 0.043$), a difference resting on Laouina, whose three palm groves all measure 3 ha or more, against only four of the 35 palm groves elsewhere.

3.1.2 Cultivation practices: irrigation, pollination and propagation

Routine maintenance operations (pruning, removal of dry leaves, fertilisation, pest control) were carried out twice a year in most groves ($n = 25/39$; 64.1%), once a year in 13 (33.3%), and three times a year in a single grove (Table 4). Palm groves were irrigated predominantly from wells, either alone ($n = 24$; 61.5%) or in combination with springs ($n = 10$) or foggara ($n = 1$), whereas spring-only irrigation ($n = 4$) was uncommon. Flood irrigation was the dominant irrigation method ($n = 28$; 71.8%), followed by drip irrigation ($n = 7$), while only four groves combined both methods. Irrigation was less frequent in

422 winter, with a mean interval of 11 days (range 1 to 60), than in summer, with a mean interval of 5 days
423 (range 1 to 15). The median interval was 7 days in both seasons, since most groves irrigated weekly all
424 year round, but a minority irrigated far less often in winter.

425 Manual pollination was the predominant practice, with only two palm groves relying on natural wind
426 pollination (Table 4). Among the 37 palm groves pollinating manually, it was performed mainly in
427 March, either alone ($n = 26$; 70.3%) or extending before or after. In most groves pollen came exclusively
428 from the growers' own male palms ($n = 32/39$; 82.1%). Male palms were selected primarily for abundant
429 pollen production ($n = 30$), whereas in six groves no specific selection criterion was reported and in one
430 the locally recognised *ḍakkār abyad* was preferentially used, a male type distinguished by its whitish
431 inflorescences and reputed locally for its pollination performance.

432 Regarding the mode of propagation, farmers in all palm groves relied on offshoots to propagate their
433 female named types, two of them also reporting the use of seeds (Table 4). Offshoots were mostly taken
434 from the farmer's own palm grove ($n = 34/39$; 87.2%). In contrast, male palms were propagated
435 predominantly from seed rather than from offshoots ($n = 25/39$; 64.1%), whereas offshoots were used
436 in 12 palm groves (30.8%) and both methods in two (5.1%).

437 Deliberate seed planting was uncommon, being reported in only two palm groves (5.1%), where the
438 stated motivation was to test new varieties (Fig. 3). Elsewhere ($n = 37$), the most frequent reason for not
439 planting was the uncertain fruit quality of seedlings ($n = 25$; 67.6%), followed by the risk of obtaining
440 male palms (*ḍakkār*) ($n = 6$), the long time required ($n = 4$), and the lack of prior experience ($n = 2$).
441 Seed-derived palms were nevertheless common, since spontaneous seedlings arising from fallen fruits
442 were present in most palm groves ($n = 28/39$; 71.8%). In the remaining groves ($n = 11$), farmers
443 explained during the interviews that such seedlings were removed as they appeared.

444 Asked what name is given locally to palms grown from seed, farmers most often reported that such
445 palms are designated by a collective label, applying to seed-derived palms as a whole rather than
446 distinguishing individual named types, most commonly 'alfah or 'azmah ($n = 31/39$; 79.5%) (Fig. 3D).
447 The other answers were scattered: in two palm groves the name was said to be that of the named type

from which the sown fruit originated, in two the term ḥalt was used, in one the palm was simply called ḍakkār, and in one the term barhūšah was reported, while farmers in two palm groves did not know of any name. Two points are worth noting. First, the collective labels ‘alfah and ‘aḏmah were reported in eight palm groves where no spontaneous seedling was present, which indicates that it belongs to the shared vocabulary of the oasis. Second, in the two palm groves where seeds were deliberately planted, farmers reported the terms ḥalt and barhūšah, respectively, rather than ‘alfah or ‘aḏmah.

3.1.3 Uses of date palm products and by-products

Dates were consumed both fresh and dried in most palm groves (n = 36), and only fresh in the remaining three. Rob, a traditional concentrated date syrup, was prepared in most palm groves (n = 34), and dates were most often stored by both freezing and jar storage (n = 34).

Beyond fruit consumption, date palm products were put to a wide range of uses across the surveyed palm groves, most commonly animal feed (n = 33), followed by medicinal (n = 29), construction (n = 24) and cosmetic uses (n = 11), while handicraft use was rare (n = 1) (Table 5). Among the 29 palm groves reporting medicinal use, the date fruit was by far the plant part most frequently used (n = 26), while pollen was used less often (n = 3). The most common preparation method was as a poultice (n = 16), followed by decoction (n = 9) and powder (n = 3), one palm grove combining decoction and poultice preparations. These remedies were mainly used to treat wounds (n = 16) and anaemia (n = 9), with low fertility treated in three palm groves and one reporting a combined treatment for anaemia and wounds. Each preparation method was consistently associated with a specific ailment: decoction was used exclusively to treat anaemia, poultice to treat wounds, and powder, prepared from pollen, to treat low fertility.

3.1.4 Biotic and abiotic challenges encountered by date palm farmers

Farmers reported a range of economic, climatic and biotic constraints affecting date palm cultivation (Table 6). Among economic constraints, labour was dominant (n = 24/39; 61.5%), followed by market access (n = 2) and lack of resources (n = 1), whereas no economic problem was reported for 12 palm

groves. Among climatic constraints, drought combined with sand winds was the most frequent ($n = 16$), followed by drought alone ($n = 12$). Among pests and diseases, Bayoud was the most widespread ($n = 25$), followed by the date palm mite ($n = 20$), and the white scale insect ($n = 14$). The distribution of these constraints did not differ significantly among localities (Fisher's exact test with simulated p -values: economic constraints, $p = 0.254$; climatic constraints, $p = 0.106$).

In response to biotic constraints, farmers relied on traditional control methods, such as plant-based preparations, ash or manual removal, alone in 20 palm groves, on modern methods, such as synthetic pesticides or pheromone traps, alone in 3 and on both in 7, while no control method was reported in 9 palm groves (23.1%). Farmers in most palm groves knew at least one date palm named type they considered resistant to Bayoud ($n = 35/39$) (Fig. 4A). The named types cited were strongly skewed towards a few widely known ones: four accounted for most of the mentions, ḥalt in 21 of these 35 palm groves, faqūs in 11, tākarbūš in 10 and ġars in 4, while the eight remaining named types were each cited once or twice.

3.2 The varietal repertoire of the Taghit oasis system, today and in 1985

3.2.1 The current repertoire

Farmers in Taghit relied predominantly on leaflet-based recognition to identify date palm varieties in the field. Among the 39 palm groves, leaflet traits were the primary identification cue in 29 (74.4%), both fruit and leaflet traits were used in six (15.4%), and fruit traits alone in four (10.3%).

Across the 39 sampled palm groves, farmers reported cultivating a total of 30 varieties through our free listing (Fig. 4B; Additional file 2: Table S2). The 70 respondents produced 315 citations which, pooled at the palm grove level, yielded 1 to 11 varieties per palm grove, with a median of 4. Where several farmers were interviewed in the same palm grove ($n = 18$), their lists agreed almost entirely in content: the same set of varieties was given by all farmers in 16 of these 18 palm groves. In the two remaining palm groves, the varieties concerned were cited by all but one farmer: in one palm grove, three varieties

498 were each cited by two of the three farmers, and in the other, two varieties were cited by four of the five
499 farmers, the fifth listing only faqūs. The order of citation, in contrast, differed in all but one of these 18
500 palm groves, the position given to a variety varying by up to 5 ranks among the farmers of the same
501 palm grove (median 2).

502 To obtain a salience value per variety, salience was computed on each individual list before being
503 averaged over the farmers of a palm grove and then over the 39 palm groves. One named type, faqūs,
504 was ubiquitous and occurred in all sampled palm groves, with by far the highest salience value ($S =$
505 0.883) (Fig. 4B). A second tier of prominent named types included ḥarṭān ($S = 0.385$; $FC = 21/39$), raṭḥī
506 (also known as tarabbāḥ; $S = 0.305$; $FC = 20$), and ḥalt ($S = 0.246$; $FC = 19$). Beyond these leading
507 types, salience values declined sharply: 12 named types were each reported in a single palm grove, and
508 the median frequency of citation was 3 palm groves. This uneven distribution indicates a small core of
509 widely cultivated and readily recalled named types alongside a long tail of rarely reported ones.

510 Comparing the free lists with the labels reported for seed-derived palms (Fig. 3D) shows that the two
511 are almost disjoint. Asked for the varieties they cultivate, farmers did not volunteer any of the labels
512 given to seedlings, with one exception, ḥalt, which was cited as a variety in 19 of the 39 palm groves
513 and reported as the name given to seedlings in two of them. Male palms (ḍakkār) were likewise absent.
514 What farmers listed therefore shows where they draw the boundary of the category they were asked
515 about. It admits female palms bearing a name of their own, and leaves out both male palms, which are
516 not individually named, and seedling palms for as long as a collective label covers them. Ḥalt is the one
517 name that sits across that boundary, applied by some farmers to seedlings as a class and by others to a
518 variety they cultivate and cite alongside the rest.

519 The named types cited by farmers as resistant to Bayoud (Fig. 4A) were also the most prominent in the
520 free lists: the number of palm groves citing a named type as resistant increased with its salience
521 (Spearman $\rho = 0.75$, $p < 0.001$) and with its relative frequency of citation ($\rho = 0.77$, $p < 0.001$)
522 (Additional file 1: Fig. S1).

3.2.2 Spatial structure of the varietal repertoire among localities

Varietal richness per palm grove differed among localities (Fig. 5A, B; Poisson GLM, $p = 0.0038$). Palm groves of Bakhti held the largest number of named types (mean 7.00; 95% CI 4.85 to 10.10), those of Laouina and Zaouiya Foukaniya the smallest (2.67 and 3.14), with Taghit and Barbi in between (5.29 and 4.14). These differences followed neither palm grove size nor survey effort: area alone explained none of the variation in richness ($p = 0.656$) and adding it to locality left it non-significant ($p = 0.061$), while richness was unrelated to the number of farmers interviewed in a palm grove (Spearman $\rho = -0.10$, $p = 0.56$), which follows from the agreement among farmers of the same palm grove reported above.

Which varieties were grown also varied among localities (Fig. 5C; pseudo- $F = 2.79$; $df = 4, 33$; $R^2 = 0.253$; $p < 0.001$), and the effect held when the three palm groves holding fewer than three named types were excluded ($R^2 = 0.262$; $p < 0.001$). It did not reflect one locality being internally more variable than the others (betadisper, $F = 1.29$; $df = 4, 33$; $p = 0.294$). The principal coordinates analysis shows Taghit and Zaouiya Foukaniya as the two most contrasted localities, Bakhti standing apart from both, and Barbi and Laouina holding intermediate assemblages (Fig. 5C). Palm groves of the same locality nevertheless overlapped extensively, so localities differ in the named types they favour rather than in sharply distinct repertoires.

Three varieties were present in all six localities, faqūs, raṭbī/tarabbāḥ and ḥalt, and ḥarṭān in five, whereas 14 of the 30 were confined to a single locality. Indicator value analysis identifies those whose distribution is concentrated enough to characterise a locality. Restricting candidate groups to single localities, three of the 30 varieties tested were significant. Tākərbūš was found only at Taghit, in 10 of its 14 palm groves (IndVal = 0.845; $p < 0.001$), and šatwiyyah only at Bakhti, in 3 of its 7 palm groves (IndVal = 0.655; $p = 0.025$). Raṭbī/tarabbāḥ was associated with Bakhti on a different basis: grown throughout the oasis and present in all seven Bakhti palm groves but in only one of the seven of Zaouiya Foukaniya, it characterises that locality by its frequency there rather than by being confined to it (IndVal = 0.645; $p = 0.004$).

3.2.3 Changes in the varietal repertoire since the 1985 inventory

Brac de la Perrière and Ben Khalifa [33] recorded 31 “cultivars” at Taghit, given here under the spelling used by its authors (Fig. 6; Additional file 2: Table S1). They mentioned being able to collect seventeen of them; the remaining fourteen were said to be rare, often grown in a single garden. The authors reported four varieties as the most represented in the palm groves of Taghit, namely feggus (by far the most abundant), ghares, cherka and trabat, and four as the most appreciated, feggus, cherka, hartan and tiwraghin el horra. The authors also mention khalt, not as an oasis cultivar, it is excluded from the appendix listing them, but as a name used at Taghit for seed-derived palms.

In the present survey, farmers named 30 varieties across the 39 palm groves (Fig. 6; Additional file 2: Table S2). The 1985 report lists retbi and trabat as separate entries, whereas farmers in our survey consistently identified a single variety, using the names raṭbī and tarabbāḥ interchangeably. We therefore treated these entries as one variety. Ḥalt, conversely, is counted for the present survey but not for 1985, each side following the status the name holds in its own source: a name farmers list among their varieties today, whatever other use it also has (see 3.2.1), and in the earlier report solely a term for seed-derived palms only.

The comparison thus rests on 30 varieties for 1985 and 30 for the present survey (Fig. 6). The two repertoires are therefore of equal size, but they do not have the same composition. Of those recorded in 1985, 14 were reported again and 16 were not; conversely, 16 of the varieties documented in this study were absent from the 1985 inventory (Fig. 6). A little under half of the repertoire has therefore persisted over four decades, the rest having been replaced.

Persistence was related to how common a variety was in 1985, though the tests rest on very small groups and should be read as indicative. All four cultivars reported as the most represented at Taghit in 1985 were recorded again, against 10 of the 26 others (Fisher’s exact test, $p = 0.037$), and varieties from which a fruit sample could be collected in 1985, declared as more common than the unsampled ones, persisted more often than those recorded only, which existed in very small numbers (11 of 17 against 3 of 13, $p = 0.033$). In contrast, of the four cultivars reported as the most appreciated in 1985, two of which are

also among the four most represented, three were recorded again, a proportion close to that of the repertoire as a whole ($p = 0.315$). The one not recovered, tiwraghin el horra, may indicate that appreciation alone did not ensure persistence.

The 1985 report describes Bayoud as long established at Taghit, first recorded in 1920 and having destroyed 565 palms by 1953, with the gardens of Berrbi, Zaouia el Foggania and Taghit affected at the time of the survey [33]. All cultivars were reported as susceptible, ghares showing a tolerance that could last several years, and taqerbucht, introduced from the Touat around 1960, being the only variety described as resistant. Both were recorded again in the present survey and are still cited as resistant by farmers (Fig. 4A). Interestingly, taqerbucht was reported in 1985 as unknown to most farmers and as failing to ripen at Taghit, whereas our results show that tākarbūš today ranks seventh by salience, indicating that it has since been adopted. In addition to ġars, reported as tolerant in 1985, and tākarbūš, the only variety then described as resistant, ten other varieties are cited as resistant today (Fig. 4A). Counting ħalt, eight of the ten were already present in the oasis before, and two are new, mgarṣah and kuḥaylah, the latter reported by one farmer as of local origin in Taghit. Resistance is therefore attributed today to a broader set of varieties.

3.3 Morphological characterization of Taghit oasis system varieties

Complete fruit morphometric measurements are provided in Additional file 2: Table S4 and pictures of selected fruits for each variety are provided in Additional file 1: Fig. S2. Subsampling within named types confirmed that the sampling effort was sufficient: deviations of resampled trait means from the means computed on the full set of 20 fruits decreased steadily with subsample size and remained below 2.5 % for all ten traits at 19 fruits (Additional file 1: Fig. S3).

3.3.1 Description of fruit and seed traits

Fruit and seed morphology varied substantially across the 30 named types sampled, in colour and texture as well as in size and shape (Fig. 7; Additional file 2: Table S5). Qualitative traits, scored once per

named type, spanned a wide range of modalities. Fruit colour at the *tamr* stage spanned nine modalities, from black to yellow, with brown the most frequent (13 of the 30 named types, 43.3 %), followed by light brown and beige (4 each, 13.3 %) and dark brown (3, 10.0 %); the remaining modalities were each represented by one or two named types. Grouped into two broader categories, 19 named types (63.3 %) produced dark fruits and 11 (36.7 %) light fruits. Fruit texture was most often semi-soft (16 named types, 53.3 %), followed by soft (10, 33.3 %), while only 4 named types (13.3 %) produced dry dates.

Mean fruit weight per named type ranged from 2.9 g in ġbaybū to 25.9 g in al-ḥartān al-ḥurrah, an 8.8-fold difference, and pulp weight from 2.1 g to 24.9 g in the same two named types, an 11.6-fold difference. Variation was more contained for linear dimensions: fruit length ranged from 23.4 mm to 52.0 mm and fruit width from 14.4 mm to 27.0 mm, again with ġbaybū and al-ḥartān al-ḥurrah at the two extremes, while pulp thickness ranged from 1.2 mm to 7.6 mm.

Seed traits showed a markedly different pattern, with distributions marked by a tail of very low values and, for the pulp to seed ratio, a pattern driven entirely by two named types, šbaʿ sulṭān and ʿaẓm būlah (Fig. 7). Their fruits bore only a thin vestigial seed, with mean seed weights of 0.06 g and 0.05 g respectively, against 0.67 g in the lightest-seeded of the other named types, and mean pulp to seed ratios of 120 and 174, against a maximum of 24.5 elsewhere. Both named types are parthenocarpic, and this was the case for every palm sampled under these names rather than for isolated individuals. They were therefore excluded from all subsequent analyses.

Once these two named types were set aside, seed traits proved considerably more conserved than fruit traits across the remaining 28 named types. Mean seed length ranged from 16.6 mm in ġbaybū to 29.7 mm in ḥartān, seed width from 7.4 mm in šatwiyyah to 9.6 mm in ʿazīzah, seed thickness from 6.1 mm in ġars to 8.5 mm in ʿazīzah, and seed weight from 0.67 g to 1.44 g in bint aš-šark, corresponding to differences of 1.3 to 2.1-fold. The pulp to seed ratio then ranged from 2.4 in tināḍrār to 24.5 in al-ḥartān al-ḥurrah. Fruit traits therefore varied several times more widely among named types than seed traits.

Fruit and seed traits were not independent (Additional file 1: Fig. S4). Fruit traits formed a strongly integrated block, with coefficients ranging from 0.53 to 1.00. Fruit weight and pulp weight were almost

perfectly correlated ($r = 0.998$), a mechanical consequence of pulp weight being obtained by difference, and fruit weight was further correlated with fruit length ($r = 0.801$), pulp thickness ($r = 0.802$) and the pulp to seed ratio ($r = 0.800$), while fruit width was correlated with pulp thickness ($r = 0.877$), so that a single size axis linked most fruit traits. Seed traits, in contrast, did not form a comparable block: seed width and seed thickness were largely interchangeable ($r = 0.824$), but seed length was correlated with neither ($r = 0.12$ and $r = -0.07$ respectively) and instead tracked fruit length closely ($r = 0.79$). Overall fruit size was therefore associated with seed length but largely independent of seed width, seed thickness and seed weight, indicating that seed size is not a simple function of fruit size.

3.3.2 Varieties as morphological units

Morphological variation was structured almost entirely at the level of the variety rather than at the level of the individual palm (Additional file 1: Fig. S5). Across the ten descriptors, the variety accounted for 36.3 to 96.0 % of the total variance, with a median of 88.4 %, whereas the palm within variety accounted for 0 to 2.0 %, with a median of 0.4 %, and was estimated at zero for seed thickness, seed weight and the pulp to seed ratio. The remaining variation lay between fruits borne by the same palm. Multivariate analysis gave the same picture: variety explained 96.7 % of the variance among the 71 palm means (PERMANOVA, $F = 46.7$, $p < 0.001$). Palms bearing the same name were therefore morphologically almost indistinguishable, which supports treating varieties as morphological units despite the small number of palms sampled per variety.

The strength of this structuring differed markedly between fruit and seed traits. The variety accounted for 91.9 to 96.0 % of the variance of every fruit trait, with the palm component never exceeding 1.1 %, but for only 36.3 % of seed width, 46.2 % of seed thickness and 52.1 % of seed weight, for which most of the variation lay between fruits borne by the same palm (Additional file 1: Fig. S5B). Seed length was an exception, reaching 85.0 % and behaving like a fruit trait. This contrast follows directly from the narrow range of seed dimensions across varieties reported above: where varieties differ little, little variance remains to be attributed to them. Fruit traits, and pulp thickness in particular, therefore separate varieties far more effectively than seed transverse dimensions.

Varieties nevertheless differed in how internally variable they were (Additional file 1: Fig. S6). Morphological dispersion ranged from 0.74 in tīḥajāmīn to 2.01 in bint aš-šark, a nearly three-fold difference in how variable the fruits collected under a single name were. That variation, however, was almost entirely variation between fruits of the same palm rather than between palms: the share attributable to palm identity reached at most 25.4 %, and no variety showed a significant palm effect once p values were corrected across the 28 tests, although with two or three palms per variety these tests have little power. Ḥalt did not stand out: its dispersion of 1.07 placed it in the lower half of the range, and although the share of its internal variance attributable to palm identity was the highest of all varieties at 25.4 %, it was matched by ḥumayrah at 25.2 %. Palms sampled under this name therefore produced fruits no more variable than those sampled under any other, which does not settle whether the name covers a clonal lineage but is at least consistent with its being used and managed at Taghit as a variety in its own right.

3.3.3 Structure and distinguishability of the variety repertoire

The first two principal components accounted for 44.7 % and 26.0 % of the total morphological variation, and a third component for a further 16.4 % (Fig. 8; Additional file 1: Fig. S7). The first axis described overall fruit size, with loadings between 0.81 and 0.94 for the four fruit traits and 0.65 for seed length, the transverse seed dimensions contributing almost nothing. The second axis was defined by the transverse dimensions of the seed, seed width and seed thickness loading 0.87 and 0.89 while no fruit trait exceeded 0.30, and describes how wide and thick the seed is independently of fruit size. The third axis opposed seed length to fruit width and pulp thickness, and separates fruits that are elongated from those that are wide and fleshy at a given size.

Along the first axis, varieties formed a continuum rather than discrete groups, from ḡbaybū, am‘ā allāh and kuḥaylah at the small-fruited end to tākarbūš and bint aš-šark at the large-fruited end, with al-ḥartān al-ḥurrah standing well apart beyond all others. The positions of ḡbaybū and al-ḥartān al-ḥurrah were consistent with farmers’ descriptions of their fruits as exceptionally small and large, respectively. Along the second axis, ‘azīzah, kssabah and bayḍ ad-dajāj had wide and thick seeds relative to their fruit size,

while ġars, šatwiyyah and šayḥ an-naḥl had comparatively narrow and thin ones. Fruit colour and texture, shown on the same plot so that quantitative and qualitative descriptors can be read together, showed no correspondence with this morphometric structure: dark and light varieties, and soft, semi-soft and dry ones, were interspersed throughout the space.

We then tested how far the quantitative descriptors distinguish the varieties, by assigning each fruit to a variety on the basis of its measurements alone (Additional file 1: Fig. S8). Under a cross-validation scheme in which all fruits of a palm were set aside and assigned by a classifier trained on the remaining palms, 392 of the 560 fruits, or 70.0 %, were assigned to the variety they came from, against 3.6 % expected by chance. Success varied widely among varieties. Six were recognised without a single error, al-ḥartān al-ḥurrah, bint aš-šark, tīmkūr, tīn yūnis, ġbaybū and ḥartān, and four more exceeded 90 %, whereas ḥumayrah and faqūs were correctly assigned for only 15 % and 20 % of their fruits. Errors were concentrated in a few reciprocal pairs rather than spread across the repertoire (Additional file 1: Fig. S8).

4. Discussion

This study examined date palm agrobiodiversity in the Taghit oasis system by combining ethnobotanical surveys, fruit and seed characterisation, and comparison with a historical inventory. The findings highlight the central role of date palm cultivation in household provisioning and everyday life, alongside the diversity maintained across gardens through farmers' knowledge and practices. Bringing these dimensions together provides a basis for understanding both the diversity represented by local variety names and the practices through which farmers sustain it, while identifying possible pathways of renewal over time.

4.1 The date palm at the centre of the Taghit oasis system

Our survey highlights the multiple contributions of date palm cultivation to household provisioning and everyday life in the Taghit oasis system. Farmers reported consuming, storing and processing dates into

rob, while other palm products provided fodder and materials for construction. Reported medicinal uses relied predominantly on the fruit, with preparations associated with particular ailments. These multiple uses reflect the diverse livelihood functions of oasis agriculture described [12] and documented regionally for the Béchar date palm sector [32].

The cultivation practices reported by farmers reflect a sustained investment of labour in their gardens. Co-owners, sharecroppers and hired workers tended small gardens commonly held in undivided ownership. Respondents were almost exclusively men, consistent with the gendered division of agricultural labour described in oasis systems [16,43]. They reported regular grove maintenance and year-round irrigation, usually at weekly intervals, while hand pollination was practised in almost every surveyed grove. Farmers also maintained their own sources of pollen and planting material, retaining male palms for pollination and taking offshoots from established palms to renew their groves.

Continued cultivation nevertheless takes place under substantial constraints. Labour was the most frequently reported economic constraint in our survey, while drought, often combined with sand winds, dominated climatic concerns; Bayoud was the most frequently reported disease. These findings place farmers' investment within the broader context of environmental and socioeconomic pressures affecting oasis agriculture [6]. Such difficulties also have a long history locally: Brac de la Perrière and Ben Khalifa [33] described date palm cultivation as losing momentum after more than sixty years of Bayoud and the destruction of several hundred palms. Four decades later, cultivation continues in the surveyed gardens; however, we observed that some gardens in the traditional oasis have been abandoned, while new agricultural perimeters have developed outside it. Public support includes subsidies and the distribution of offshoots [37].

The future of date palm cultivation depends on both the transmission of knowledge and the involvement of younger generations. In our survey, horticultural knowledge was acquired from fathers in almost every case, and most respondents reported passing it on to younger generations. Together with the shared ownership of gardens, these findings situate cultivation within family relationships extending across generations. Work in Sidi Okba, in Algeria's Biskra region, further illustrates the social significance of

oasis agriculture, showing how attachment to a farming identity and social recognition can encourage investment in palm groves [44]. However, knowledge transmission does not necessarily ensure succession: only 10% of our respondents were aged 30 or younger. Concerns about succession have for instance been reported in Ouargla, where 46% of surveyed date palm farmers were over 60 [45]. Against the broader challenges of depopulation and declining knowledge transmission in oasis agriculture [6,11], supporting succession means enabling younger generations to turn inherited knowledge into a viable livelihood from cultivating the gardens.

4.2 The varietal repertoire and its structuring in the oasis

Asked to list the varieties (anwā') they cultivated, farmers collectively named thirty varieties across the thirty-nine surveyed groves. This repertoire combines a widely shared core of varieties with numerous less frequently recorded ones. Faqūs, al-ḥartān, raṭbī/tarabbāḥ and ḥalt were the most frequently recorded and salient varieties, with faqūs present in every surveyed grove and particularly prominent in farmers' lists. Its local importance is longstanding: it was already described among the oasis's most common and appreciated varieties in 1985 [33] and is valued for consumption and trade across the wider Saoura region [30,32].

Beyond the four prominent varieties, only three others occurred in more than 20% of surveyed groves: ḡars, šarkah and tākarbūš. The remaining twenty-three varieties were less frequently encountered, including twelve recorded in a single grove each. The Taghit oasis system thus comprises a mosaic of gardens whose varietal compositions overlap without being identical, with most of its documented richness concentrated in rare varieties. Differences among gardens were accompanied by contrasts among localities in both varietal richness per grove and repertoire composition. Some varieties showed marked geographical concentrations: tākarbūš, for instance, occurred in ten of the fourteen surveyed groves at Taghit locality but was not recorded in the other localities. Differences in varietal composition among gardens have also been described at Siwa [16] and Ouargla [45], illustrating how individual farms contribute differently to community-level varietal diversity [4]. Capturing the oasis repertoire

therefore requires inventories across multiple gardens and localities, particularly to document less frequently encountered varieties.

Laouina further illustrates how varietal richness may differ between established gardens and newer agricultural perimeters. Despite their larger size, its surveyed groves contained an average of 2.7 varieties, compared with 7.0 at Bakhti. Established through agricultural development programmes in the 1980s and 1990s, Laouina represents a more recent extension of cultivation beyond the traditional oasis [37]. Its lower varietal richness is consistent with the shift towards plantations centred on a limited number of elite cultivars [46], and with observations from modern plantations at al-‘Ulā, Saudi Arabia [11]. However, the six varieties recorded across the three surveyed gardens included both widely cultivated faqūs, raṭbī/tarabbāḥ and ḥalt and less widespread varieties such as ḥumayrah and al-ḥartān al-ḥurrah. Low richness per garden therefore did not imply cultivation restricted to the dominant varieties. Given that only three groves were surveyed at Laouina and their planting histories were not documented, further research in this and other recent agricultural perimeters could establish whether lower varietal richness is a general pattern and examine how varietal choices relate to public offshoot distribution, agricultural subsidies and production for sale or household consumption.

4.3 Local naming and categorisation of date palm diversity

The varietal repertoire described above captures only part of the date palm diversity maintained through farmers’ practices. As expected from the question about anwā‘, farmers listed female varieties, which they mainly propagated through offshoots. Complementary questions documented male palms and spontaneous seedlings in most surveyed gardens, despite the rarity of deliberate sowing. Farmers referred to males as ḍakkār and most commonly grouped seed-derived palms under the names ‘alfah or ‘aḏmah. Their retention shows that clonal propagation coexists with sexual reproduction, as in many clonally propagated crops [20], without all this diversity appearing in varietal lists. At al-‘Ulā, even when asked to list all palms present, farmers rarely mentioned sā’ir (seed-derived palms) and ḍakar without prompting, and generally placed them towards the end of their lists when they did, although direct questions confirmed their presence in the gardens [11]. Assessing agrobiodiversity therefore

requires complementary questions about the palms grouped under collective names and the practices through which they are retained, used or removed.

Including all categories of palms in an inventory is not sufficient: the names recorded must also be interpreted in their local context. The term *ḥalṭ* illustrates this at Taghit. Used as a collective designation for seed-derived palms in the Maghreb [5,22], it was recorded with this meaning at Taghit in 1985 [33]. In our survey, surprisingly, farmers reported *ḥalṭ* as a collective designation for seedlings in only two groves, yet listed it as a variety in nineteen of the thirty-nine groves. This varietal use is not unique to our survey, as *ḥalṭ* has also been recorded as a date palm variety elsewhere in Béchar Province [32]. Our morphological characterisation is also consistent with this interpretation: the three palms sampled as *ḥalṭ* were no more morphologically variable than palms sampled under other variety names. This does not establish that they belong to a single clonal lineage, which would require genetic characterisation, although greater heterogeneity might be expected among independently seed-derived palms, as documented among *ušik* seedlings at Siwa [47]. Across Taghit, the unqualified term *ḥalṭ* therefore occurs in two usages: predominantly as a varietal name in our inventories, but in a small number of groves also as a collective designation for seed-derived palms.

These findings show that assessing agrobiodiversity requires understanding what local categories encompass and how their meanings vary within and between places and over time. In Ethiopian yams, for example, farmer-recognised names may designate individual varieties, sub-varieties or broader groups [48]. Even when farmers distinguish varieties from collective categories of seedlings and males, the varieties themselves need not represent single clonal lineages. At Siwa, ethnographic and genetic research showed that some named varieties encompass several clonal lineages, as seed-derived palms may be assigned to an existing variety on the basis of perceived resemblance and subsequently propagated vegetatively [47]. A comparable process has been reported in oca, where farmers' apparently unintentional incorporation of seed-derived plants contributes to genetic diversity within clonally propagated varieties [49]. Recognising a palm as belonging to a variety therefore does not establish its clonal identity. While genetic analyses are needed to establish whether palms sharing a name belong to

the same clonal lineage, phenotypic characterisation can reveal how variation within and among named varieties relates to farmers' distinctions.

4.4 Phenotypic diversity of the cultivated repertoire

Our phenotypic characterisation focused on the thirty varieties listed by farmers, rather than the broader categories of seed-derived palms. Within this repertoire, fruit and seed measurements showed little differentiation among palms bearing the same varietal name. In the variance partitioning analysis, differences among palms within varieties accounted for 0–2% of total variance across the ten descriptors, whereas differences among varieties accounted for 36.3–96%. This indicates consistency among the sampled palms in the measured fruit and seed traits, without establishing clonal identity. It does not imply uniformity among individual fruits: for some seed traits, much of the variation occurred among fruits collected from the same palm.

Between varieties, the measured traits revealed substantial phenotypic diversity, with mean fruit weight ranging from 2.9 to 25.9 g. Differentiation among date palm cultivars has also been documented in Biskra, Ghardaïa and Saudi Arabia [27,28,50]. In the Taghit oasis system, varieties formed a continuum rather than discrete morphological groups, but the classifier correctly assigned 70% of individual fruits to their variety under palm-level cross-validation. The measured traits thus provided substantial but incomplete discrimination, showing that differentiation among named varieties can coexist with overlap in morphological space.

The extent of varietal differentiation also depended on the characters considered. Several fruit traits were strongly structured by variety, whereas some seed dimensions showed greater variation among fruits from the same palm. This contrast accords with the greater discriminatory value of reproductive traits relative to seed traits reported for Biskra cultivars [27]. Distinctive phenotypes also included the nearly vestigial seeds of 'aẓm būlah and šba' sultān. The 1985 report mentioned varieties reputed to produce parthenocarpic fruits, although under different names [33].

Some measured differences accorded with farmers' descriptions, notably the small fruits of ḡbaybū and the exceptionally large fruits of al-ḥartān al-ḥurrah. Fruit and seed characterisation nevertheless covers only part of the variation potentially relevant to local recognition: most respondents reported using leaflet traits, alone or together with fruit characteristics. Vegetative characters have also proved informative in date palm characterisation. Elhoumaizi et al. [51] identified characters differentiating Moroccan cultivars before fruiting, while Alahyane et al. [40] documented differentiation involving leaf and spine dimensions alongside fruit traits. Field identification exercises conducted with farmers would help establish which features they use and relate these criteria to measurable variation, complementing our characterisation of the cultivated repertoire.

4.5 Historical comparison of the varietal repertoire

The comparison between the 1985 inventory at Taghit and our survey reveals similar varietal richness but substantial differences in repertoire composition. After harmonising the names and categories, each inventory comprises thirty varieties, but only fourteen are shared: sixteen earlier names were not recovered, while sixteen currently recorded types were absent from the earlier inventory [33]. These differences likely reflect changes in the cultivated repertoire, although changes in nomenclature and differences in survey coverage may also contribute.

Recovery of varieties recorded in 1985 was associated with their reported frequency at the time. We recorded all four varieties then described as prevalent, compared with ten of the other twenty-six. Recovery in our survey was also higher among the varieties sampled in 1985, described by the authors as common, than among those listed but not sampled, described as rare. By contrast, we recovered three of the four varieties described as most appreciated in 1985, although this small number limits conclusions about the role of appreciation. Less widespread varieties may be both more vulnerable to loss and more easily missed in surveys. Targeted enquiries using the historical names would help establish whether varieties not recovered in our survey remain cultivated in other gardens or are now known under different names.

The historical records also offer insights into how varieties may enter and become established in the repertoire. The varietal use of *ḥalt*, not documented in 1985, suggests that some seedlings bearing desirable fruits may subsequently have been retained and clonally propagated under this name, allowing a designation recorded only as a collective seedling category to become one of the most salient varietal names in the oasis. This trajectory remains hypothetical, as the propagation histories of the palms concerned are unknown. Alongside this possible recruitment from local seedlings, *tākarbūš* provides a documented case of external introduction: brought from the Touat around 1960 for its reputed resistance to Bayoud, it was still unfamiliar to most farmers and reportedly failed to ripen locally in 1985 [33]. Its current presence in ten of the fourteen surveyed gardens in Taghit locality indicates establishment despite these earlier difficulties.

Stable varietal richness does not therefore imply an unchanged repertoire or exclude erosion of agrobiodiversity. Although the number of varieties recorded in the Taghit oasis system has not declined, changes in composition may involve losses, local recruitment or introductions whose effects are not captured by the total count. This distinction reflects the broader finding that assessments of crop genetic erosion depend on the dimensions and scales of diversity examined [3]. New varieties may enrich the repertoire, whereas replacement of locally restricted varieties by widely cultivated ones could contribute to homogenisation without reducing richness. Names introduce a further uncertainty: recovering a historical name does not establish continuity of the same genotype, while a newly recorded name need not represent previously absent genetic material. Establishing whether these differences represent renewal, erosion or homogenisation therefore requires linking historical nomenclature and planting histories with the identity and distribution of the palms cultivated today.

4.6 Local knowledge, Bayoud and the conservation of date palm agrobiodiversity

Bayoud, caused by *Fusarium oxysporum* f. sp. *albedinis*, was the most frequently reported biotic constraint in our survey, consistent with its major historical contribution to palm mortality, economic losses and varietal decline in North Africa [14,52,53]. The soil-borne pathogen is particularly difficult

880 to manage, surviving in infected tissue and soil and spreading via root contact, irrigation water, tools
881 and plant material movement [14,29,54]. These losses have particularly affected highly valued but
882 susceptible cultivars, contributing to the decline of varietal diversity in affected oases [14].

883 Farmers in thirty-five of the thirty-nine surveyed groves named at least one variety they considered
884 resistant, principally ḥalt, faqūs and tākarbūš, followed by ġars. These citations were associated with
885 varietal frequency and salience, but it remains unclear whether perceived resistance encourages
886 cultivation or whether widely cultivated, familiar varieties are more readily cited as resistant. Since
887 renewal relies overwhelmingly on offshoots from farmers' own groves, such judgements could shape
888 which palms are retained as mother palms and selected for propagation. Bayoud may therefore influence
889 agrobiodiversity through farmers' decisions as well as through mortality. In particular, the trajectories
890 discussed above suggest that reputed resistance may have contributed to the establishment of tākarbūš
891 and, potentially, to the selection and clonal propagation of ḥalt. This is consistent with the emphasis
892 placed on resistant cultivars for restoring Bayoud-affected groves [29,55,56], and with evidence that
893 farmer management shapes date palm diversity in Algerian oases more broadly [57].

894 Farmers' perceptions of Bayoud resistance show both agreement and disagreement with published
895 assessments. In the Saoura, Takarbouch, Figuig and Tenguigh are described as resistant, Hartan, Hmira
896 and Charka as tolerant, and Feggous as susceptible [29]. In our survey, farmers likewise considered
897 tākarbūš (Takarbouch) resistant. However, they also cited faqūs (Feggous) as resistant, contrary to its
898 classification as susceptible in that publication. Al-ḥartān (Hartan) and šarkah (Charka), described there
899 as tolerant, were only rarely cited as resistant by the farmers we interviewed. These differences suggest
900 that local assessments may reflect particular experiences of disease exposure and management, while
901 also raising questions about how farmers recognise Bayoud and distinguish resistance from tolerance.
902 Investigating their assessment criteria alongside the exposure histories and growing conditions of the
903 palms concerned would help explain these contrasts. Comparing these assessments of Bayoud resistance
904 also requires establishing the identity of the palms concerned, since a shared varietal name does not
905 necessarily imply a shared genotype. This is particularly important for ḥalt, the name most frequently
906 cited as resistant, which can designate either a variety or seed-derived palms collectively. Joint field

observations with farmers could guide the selection of material for phytopathological evaluation, while genetic characterisation would clarify its identity and relationships. Farmers' assessments can thus inform the investigation of disease responses without substituting for experimental evaluation.

Beyond Bayoud resistance, our findings support in situ conservation across complementary gardens, including those maintaining less widespread varieties, alongside attention to seed-derived palms and males outside varietal inventories. Further searches for the twelve varieties recorded in a single surveyed grove could guide farmer-led efforts to maintain mother palms and multiply uncommon material, with phytosanitary safeguards governing offshoot movement [29]. Ex situ collections could complement this approach, while continued cultivation sustains the selection, propagation and knowledge transmission through which diversity is maintained and potentially renewed [58]. This connects conservation with the food and other household needs served by date palms [1], recognising farmers' practices as integral to agrobiodiversity and agricultural landscapes [2]. Supporting small-scale farming in the Taghit oasis system therefore means sustaining both cultivated diversity and the activities that keep the oasis landscape productive.

Conclusion

Our study of the Taghit oasis system shows how smallholders maintain date palm agrobiodiversity through practices and knowledge embedded in household provisioning and everyday life. This diversity is distributed across complementary gardens, where the vegetative propagation of recognised varieties coexists with the retention of seed-derived palms. Combining ethnobotanical surveys, fruit and seed characterisation and historical comparison reveals both the phenotypic diversity associated with local variety names and the limits of inventories restricted to those names. The findings thus contribute to understanding how farmers maintain diversity in perennial crops combining clonal and sexual reproduction.

The comparison with 1985 further shows that similar varietal richness can accompany substantial differences in the recorded repertoire. Continued cultivation therefore does not imply an unchanged

932 assemblage, and monitoring should consider varietal composition and distribution alongside richness.
933 Conservation in the Taghit oasis system should encompass complementary gardens and the diversity
934 they contain, including less widespread varieties and palms outside varietal lists. Supporting their
935 continued cultivation also means sustaining the knowledge, propagation practices and generational
936 succession on which garden management depends. This approach connects the conservation of crop
937 diversity with the livelihoods of the smallholders who maintain it and the continuity of the cultivated
938 oasis landscape.

939 **Ethics approval and consent to participate**

940 This study adhered to the International Society of Ethnobiology (ISE) Code of Ethics. Before each
941 interview, the aims of the study, the voluntary nature of participation, and the intended use of the
942 information were explained in Algerian Arabic (dialect). Participants were given the opportunity to ask
943 questions, and free and informed oral consent was obtained prior to data collection. No financial
944 incentives were provided, and participants could decline to answer any question or withdraw at any time
945 without consequence. In the small number of cases involving underage participants, interviews were
946 conducted only after parental or legal guardian permission and after the participant's assent.

947 According to the institutional framework governing this non-invasive ethnobiological study, formal
948 ethics committee approval was not required. Fieldwork was conducted under an official mission order
949 issued by the University Akli Mohand Oulhadj. In addition to interviews, date fruits were sampled for
950 morphological characterization with the farmers' permission. This was a non-invasive field-based
951 ethnobiological study and did not involve biological sampling of human subjects.

952 All records were anonymized prior to analysis. Care was taken not to report information in a form that
953 could identify individual participants, households, or specific shared groves. All participants consented
954 to the use of anonymized information for scientific publication.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and its additional files. Additional file 1 contains the semi-structured questionnaire (Text S1), the glossary of local terms (Text S2) and the supplementary figures (Fig. S1 to Fig. S8). Additional file 2 contains the underlying data: the date palm named types recorded at Taghit by Brac de la Perrière and Ben Khalifa [33] and their status in the present survey (Table S1), the raw survey data collected from the interviewed farmers (Table S2), the raw survey data recorded at the palm grove level (Table S3), the raw morphometric measurements of the sampled fruits (Table S4), and the morphological characterisation of the named types (Table S5).

Competing interests

The authors declare no competing interests.

Fundings

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' contributions

RBo, NB and MGB designed the study. RBo carried out the ethnobotanical survey and the fruit sampling. RBo and MGB performed the analyses and wrote the manuscript, with inputs from NB, MSB and RBk. All authors read and approved the final manuscript.

Acknowledgements

The authors wish to thank the farming communities of the Taghit oasis system across the localities of Taghit, Bakhti, Barbi, Zaouiya Foukaniya, Laouina, and Zaouiya Tahtaniya for their generous participation, their time, and for sharing their knowledge of local date palm diversity. We are also grateful to the staff of the Forest District of Taghit for their institutional support and assistance in facilitating access to the field sites. This work would not have been possible without the openness and cooperation of all those who welcomed us into their groves.

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Tables and Figures

Table 1. Overview of the six study localities and sampling design in the Taghit oasis. The table reports, for each locality, the number of surveyed palm groves, interviewed respondents, date palm named types selected for morphological analyses, and individual palms sampled for these analyses.

Locality	Latitude	Longitude	Altitude (m)	Palm groves (n)	Respondents (n)	Named types sampled (n)	Palms sampled (n)
Taghit	30°55'22" N	2°01'52" W	~622	14	22	9	17
Bakhti	30°50'51" N	1°59'58" W	~587	7	13	16	25
Barbi	30°53'03" N	2°00'57" W	~591	7	9	8	19
Zaouiya Foukaniya	30°56'22" N	2°02'54" W	~601	7	11	1	3
Laouina	31°04'54" N	2°02'45" W	~631	3	13	4	8

Table 2. Date palm sampling for fruit morphometric analyses. For each named type, the number of sampled palms and the total number of fruits collected are reported, together with the localities where sampling took place.

Named type (DIN31635 transliteration)	Local name in Arabic	Palms sampled	Fruits sampled	Zaouiya Foukaniya	Taghit	Barbi	Bakhti	Zaouiya Tahtaniya	Laouina
‘uṣṣ al-ḥummā	عش الحمي	2	20				X		
‘azm būlah	عظم بولة	2	20		X		X		
al-ḥartān al- ḥurrah	الحرطان الحررة	3	20				X		X
am‘ā allāh	أمعي الله	2	20		X				
‘azīzah	عزيزة	2	20		X				
bayḍ ad-dajāj	بيض الدجاج	3	20		X	X	X		
bint aš-šark	بنت الشرك	2	20		X	X			
būgallū	بوقلو	3	20		X	X			
būmlāl	بوملال	2	20				X		
ṣatwiyyah	سنتوية	2	20				X		
šarkah	شركة	3	20		X	X	X		X
šayḥ an-naḥl	شيخ النخل	2	20			X			
faqūs	فقوس	3	20	X	X	X	X	X	X
ḡars	غرس	3	20	X	X	X	X		
ḡbaybū	غبيبو	2	20				X		
ḥartān	حيطان	3	20	X	X	X	X	X	
ḥumayrah	حميرة	3	20	X	X		X		X
ḥalt	خلط	3	20	X	X	X	X	X	X
kuḥaylah / kuḥayliyyah	كحيلة / كحيلية	3	20		X		X		
kssabah	كسبة	3	20		X				
mgarṣah	مقرصة	2	20				X		
ratbī / tarabbāh	رطبي / ترباح	3	20	X	X	X	X	X	X
šba‘ sulṭān	صبع سلطان	2	20				X		
tākarbūš	تاكربوش	3	20		X				
tīḥajāmīn	تيحجامين	2	20		X		X		
tīksks	تيكسكس	2	20				X		
tīmkūr	تيمكور	2	20				X		
tīn yūnis	تين يونس	3	20			X	X		
tīnādrār	تيناضرار	2	20		X				
tīwriḡīn	تيوريغين	3	20	X		X	X		

Table 3. Socio-demographic profile of interviewed date palm farmers (n = 70).

Variable	Category	Total	Percentages (%)
Gender	Male	68	97.1
	Female	2	2.9
Age groups (years)	≤30	7	10.0
	31–50	30	42.9
	51–70	24	34.3
	≥71	9	12.9
Educational level	No formal education	9	12.9
	Primary	17	24.3
	Middle school	22	31.4
	Secondary	15	21.4
	University	7	10.0
Status	Owner	64	91.4
	Sharecropper	1	1.4
	Farm worker	5	7.1
Years of experience	≤10	9	12.9
	11–20	4	5.7
	21–30	23	32.9
	>30	34	48.6

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Table 4. Cultivation practices recorded in 39 surveyed palm groves.

Variables	Category	Total	Percentages (%)
Maintenance and irrigation			
Maintenance frequency	Once a year	13	33.3
	Twice a year	25	64.1
	Three times a year	1	2.6
Irrigation source	Spring	4	10.3
	Well	24	61.5
	Well + foggara	1	2.6
	Well + spring	10	25.6
Irrigation method	Drip	7	18.0
	Flood	28	71.8
	Both	4	10.3
Pollination of female palms			
Pollination method	Manual	37	94.9
	Natural (wind)	2	5.1
Pollen origin	Own male palms	32	82.1
	Other growers	5	12.8
	Both	2	5.1
Male palm selection criteria	ḍakkār abyāḍ	1	2.7
	No criterion	6	16.2
	Pollen-rich	30	81.1
Propagation of palms			
Propagation of females	Offshoots	37	94.9
	Offshoots + seeds	2	5.1
Propagation of males	Offshoots	12	30.8
	Seeds	25	64.1
	Offshoots + seeds	2	5.1

Table 5. Post-harvest management, consumption, and traditional uses of date palms in the Taghit oasis recorded in 39 palm groves.

Variables	Category	Total	Percentages (%)
Conservation method	Jar storage	1	2.6
	Freezing	3	7.7
	Both far storage and freezing	34	87.2

	Direct sale	1	2.6
Date consumption	Fresh	3	7.7
	Fresh and dried	36	92.3
Rob preparation	Yes	34	87.2
	No	5	12.8
Use	Animal feed	33	84.6
	Construction	24	61.5
	Handicraft	1	2.6
	Medicinal	29	74.4
	Cosmetic	11	28.2

Table 6. Main biotic, abiotic and climatic constraints reported recorded in 39 palm groves of the Taghit oasis.

Variables	Category	Total	Percentages (%)
Economic constraints	Labour	24	61.5
	No economic problem	12	30.8
	Market access	2	5.1
	Lack of resources	1	2.6
Biotic constraints	Bayoud disease	25	64.1
	Date palm mite	20	51.3
	Date palm scale	14	35.9
	Black ants	6	15.4
	Red palm weevil	4	10.3
	Brown blotch	2	5.1
Climatic constraints	Drought + sand winds	16	41.0
	Drought	12	30.8
	Sand winds	4	10.3
	No climatic problem	4	10.3
	Drought + wadi flooding	3	7.7

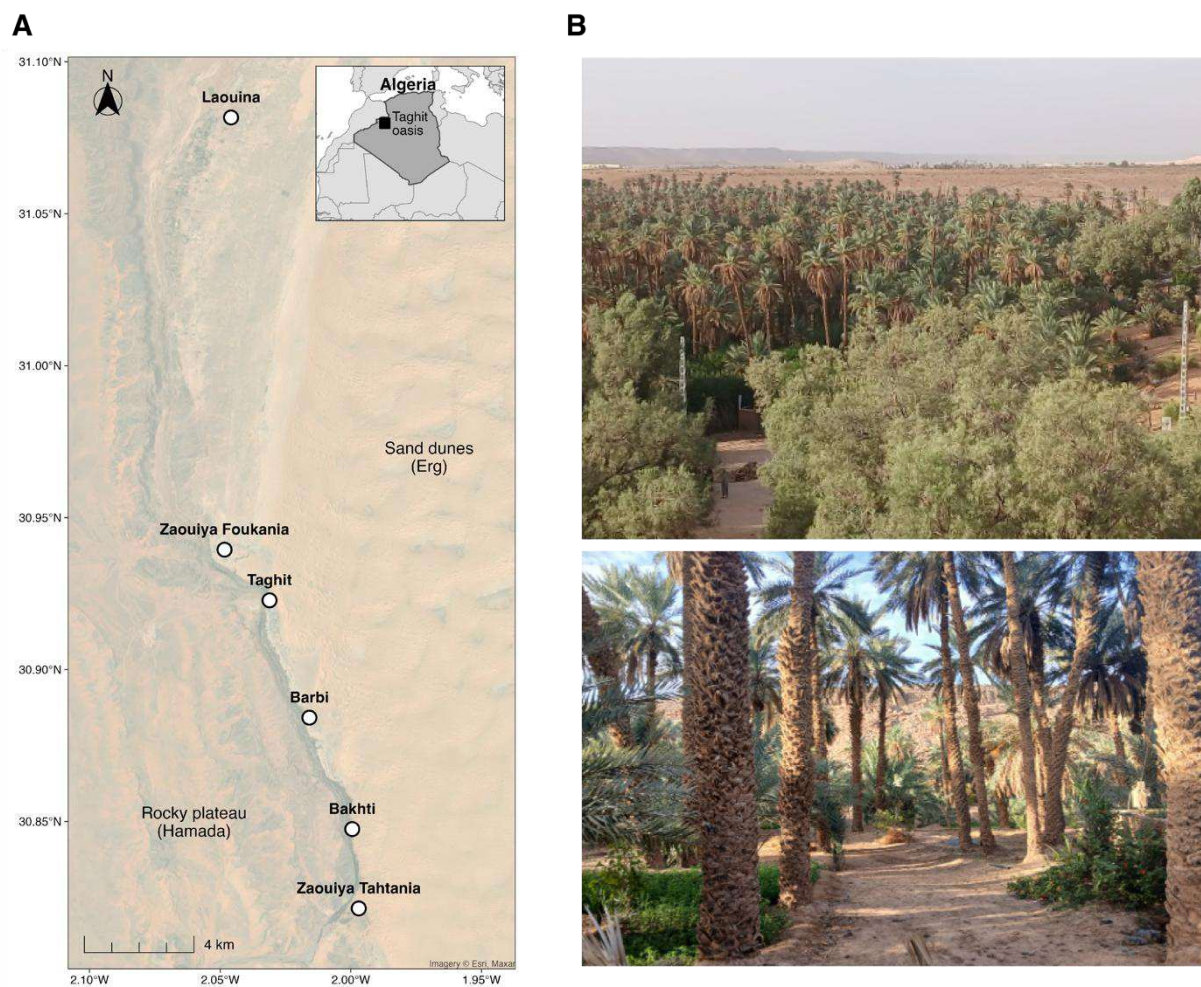


Fig. 1. The Taghit oasis (Béchar Province, southwestern Algeria). (A) Location of the oasis and of the six study localities. (B) General view over the oasis at Taghit (top) and a palm grove at Bakhti (bottom). Photographs by R. Boumendjel.

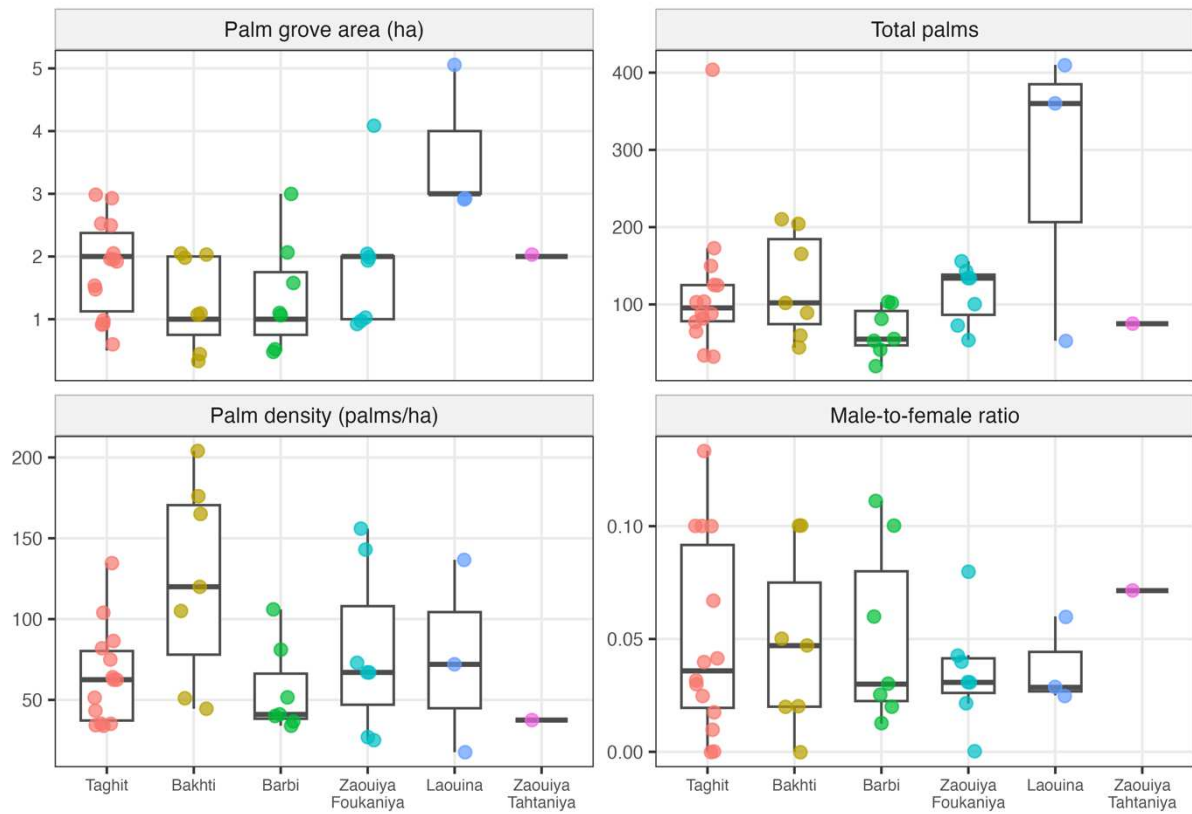


Figure 2. Structure of the 39 surveyed palm groves, by locality. Palm grove area, total number of palms, palm density and the male-to-female ratio are shown for each of the six localities. Boxes show the median and interquartile range, whiskers extend to 1.5 times the interquartile range, and individual palm groves are shown as points.

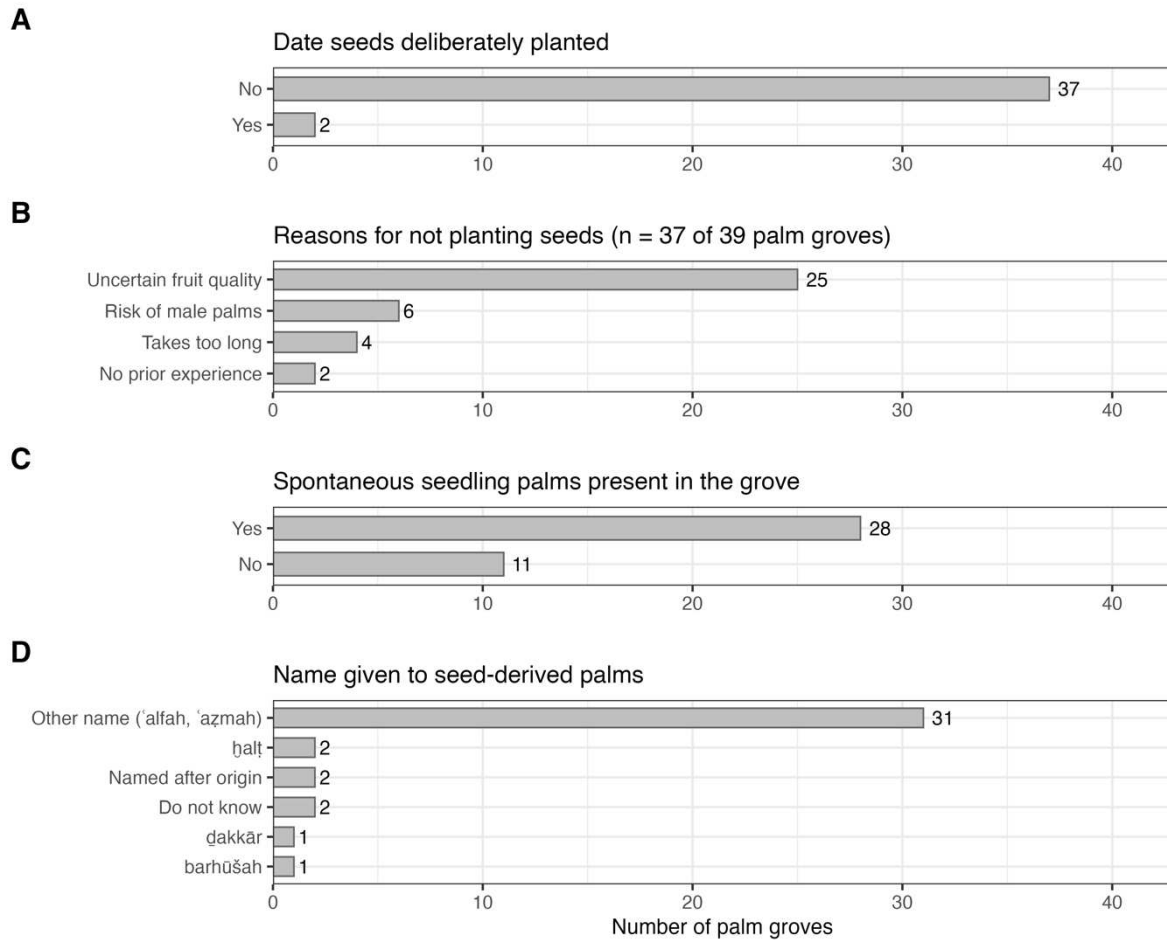


Figure 3. Seed-derived date palms in the 39 surveyed palm groves. (A) Whether date seeds were deliberately planted. (B) Reasons given for not planting date seeds, among the palm groves where seeds were not planted (n = 37). (C) Whether spontaneous seedlings, germinated without intentional planting, were present. (D) Name given locally to palms that germinated from seed; "named after origin" means that the palm is given the name of the variety whose fruit was sown, that is of its presumed mother. Bars show the number of palm groves.

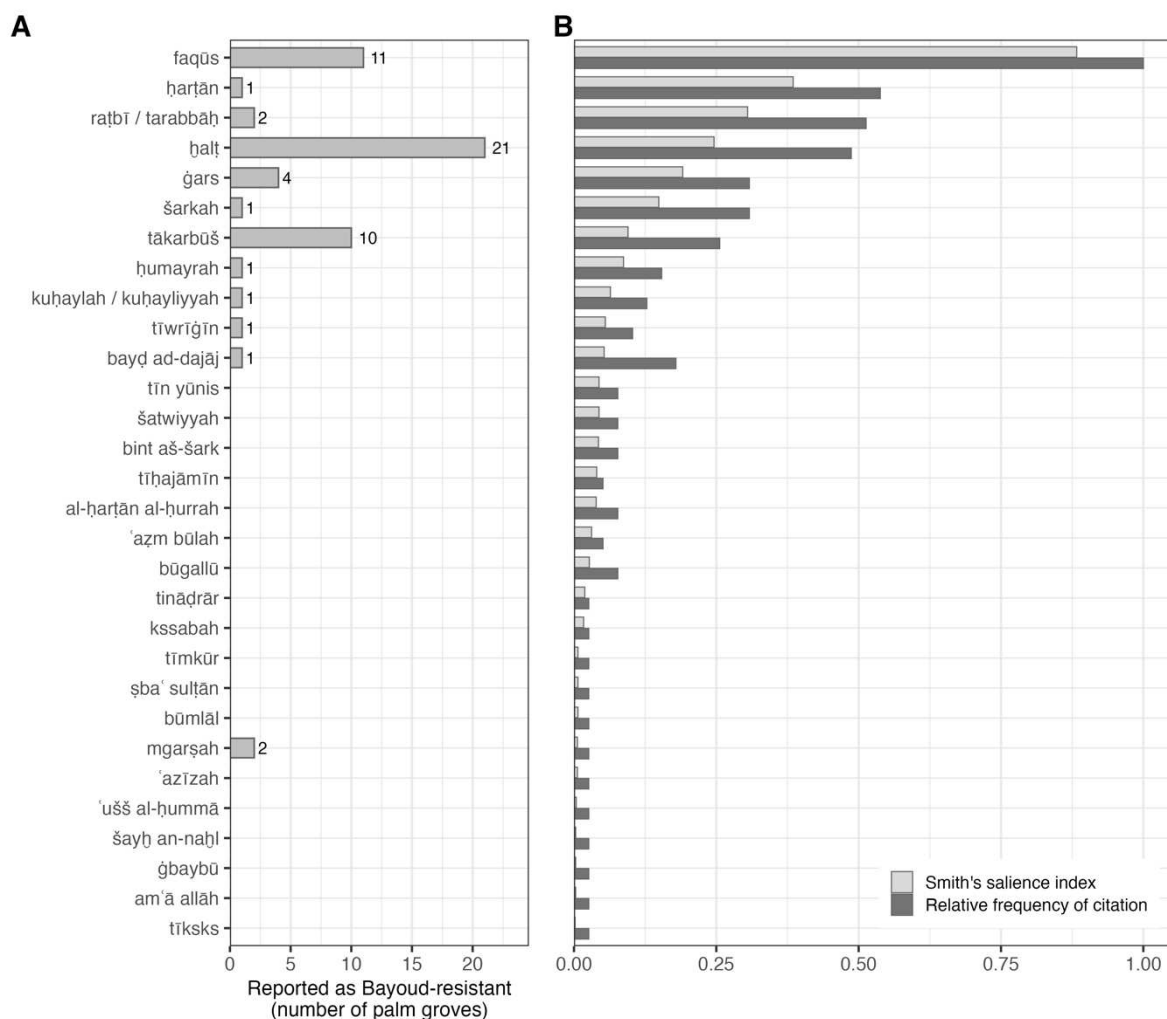


Figure 4. Prominence of the date palm varieties recorded at Taghit and their perceived resistance to Bayoud disease. (A) Number of palm groves in which farmers cited the named type as resistant to Bayoud, among the 35 palm groves where at least one resistant type was named; several named types could be cited per palm grove. (B) Relative frequency of citation, that is the proportion of the 39 palm groves in which the varieties were reported, and Smith’s salience index, which additionally accounts for its position in the free lists.

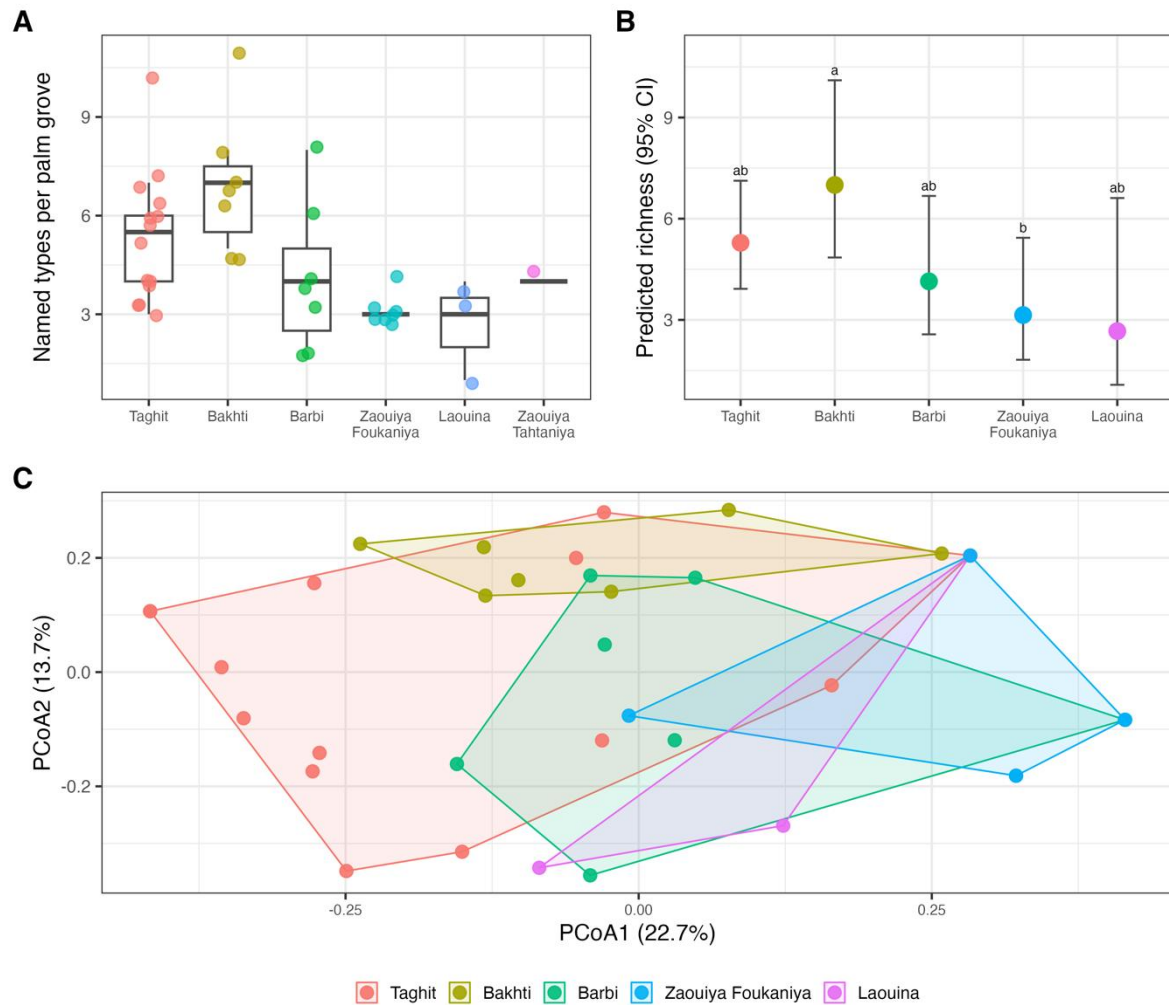
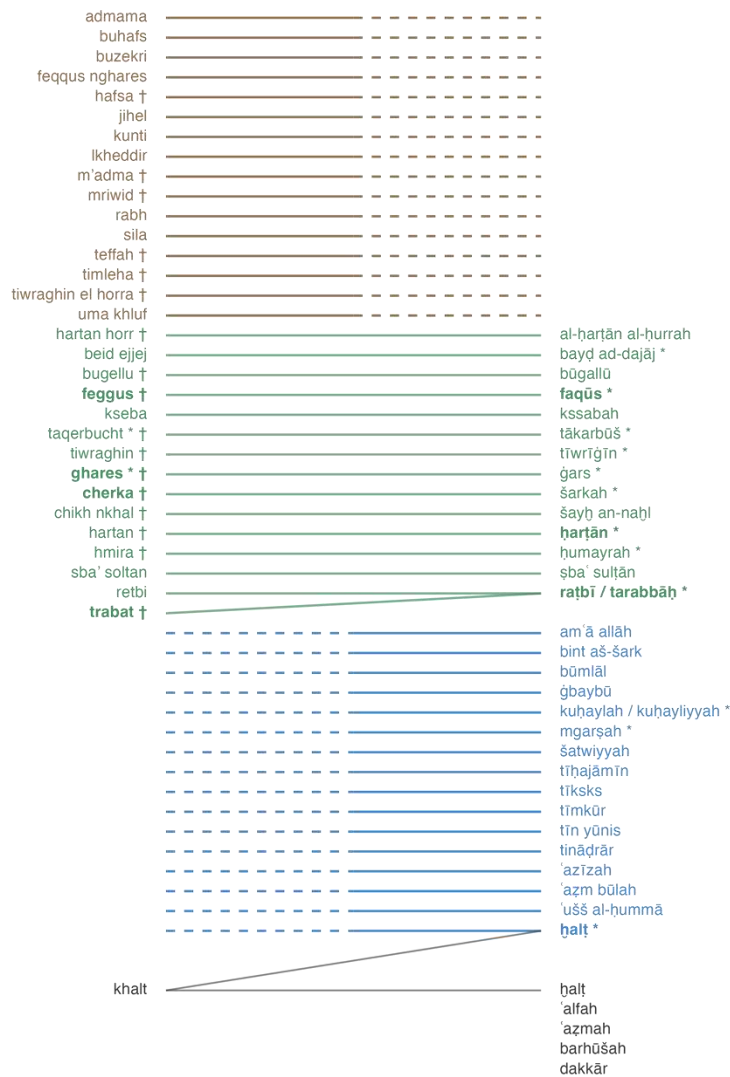


Figure 5. Varietal richness and composition of the surveyed palm groves. (A) Number of varieties per palm grove, by locality; boxes show the median and interquartile range, whiskers extend to 1.5 times the interquartile range, and individual palm groves are shown as points. (B) Mean richness estimated from a Poisson generalized linear model, with 95% confidence intervals; localities sharing a letter did not differ significantly (Šidák-adjusted contrasts). Zaouiya Tahtaniya, represented by a single palm grove, is shown in (A) but was excluded from the model. (C) Principal coordinates analysis of named-type composition, computed from Jaccard dissimilarities; each point is a palm grove and hulls enclose the palm groves of a locality.

Brac de la Perrière
and Ben Khalifa (1985)

Present survey



Bold: four most prominent named types
*: reported as Bayoud-resistant
†: sampled in 1985

Figure 6. Continuity and turnover in the date palm named-type repertoire of the Taghit oasis between 1985 and the present survey. Varieties recorded only in 1985 appear at the top in brown, those recorded in both surveys in the middle in green, and those recorded only today at the bottom in blue. Names on the left follow the spelling of Brac de la Perrière and Ben Khalifa (1985), those on the right the transliteration adopted here. Two of the 1985 entries, retbi and trabat, are considered here as synonyms. Shown separately in black are the terms used for palms grown from seed rather than for a variety: khalt in the 1985 report, and the labels reported by farmers in the present survey (Fig. 3D). Ḥalt appears twice on the right, since farmers report it both as a named type and as a designation for seed-derived palms. Bold names are the four most prominent named types on each side, as reported by the authors for 1985 and as measured by salience for the present survey (Fig. 4B). An asterisk marks those reported as resistant to Bayoud, by the authors for 1985 and by the interviewed farmers for the present survey. A dagger marks the named types from which the authors were able to collect a fruit sample in 1985; the others were recorded from farmers but existed in very small numbers, often in a single garden.

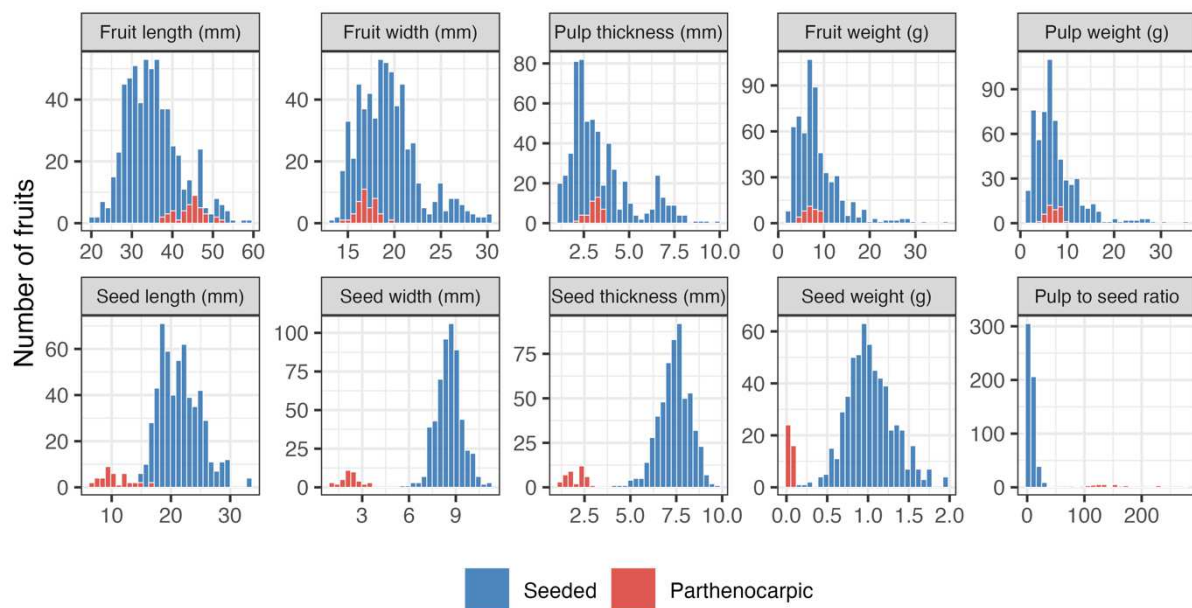


Figure 7. Range of morphological variation in fruit and seed traits across the 30 date palm varieties of Taghit (n = 600 fruits). Histograms of the ten fruit and seed traits measured on 20 fruits from each of the 30 varieties. Fruits of the two parthenocarpic varieties, şba' sulţān and 'aẓm būlah, are shown in a distinct colour: they occupy the extreme lower end of all seed-related distributions and were excluded from subsequent analyses.

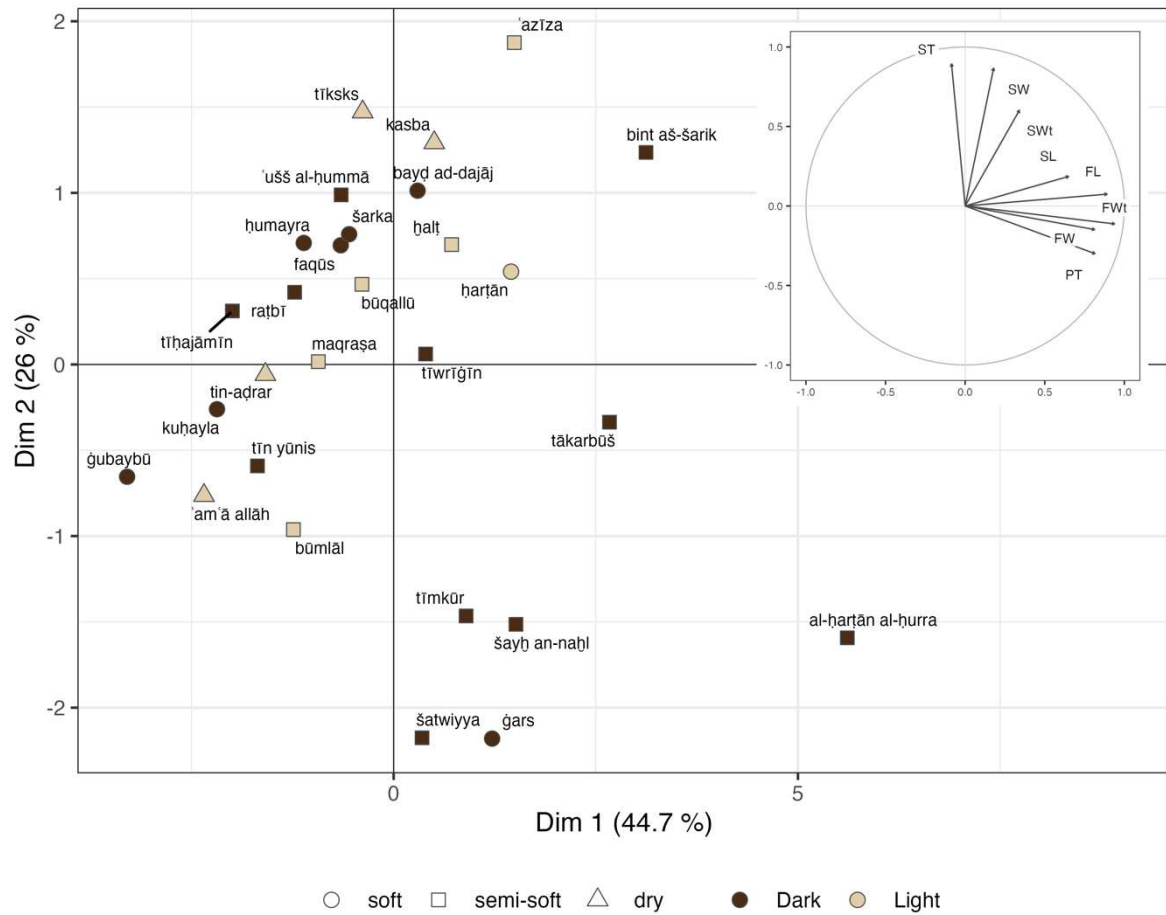


Figure 8. Principal component analysis of fruit and seed morphology across the 28 varieties. Each point is the centroid of a variety in the space defined by the first two principal components, computed on the eight non-redundant morphometric descriptors measured on 560 fruits. Point fill indicates the colour group of the fruit and point shape its texture. The inset shows the correlation circle of the descriptors: FL, fruit length; FW, fruit width; PT, pulp thickness; FWt, fruit weight; SL, seed length; SW, seed width; ST, seed thickness; SWt, seed weight.

Supplementary Files

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