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Cover: A male Scarlet Skimmer perching on vegetation by the banks of a waterbody. Ink and watercolour illustration by Anandita Pascal.

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ARTICLE

An updated floral diversity of Tal Chhapar Wildlife Sanctuary, Rajasthan, India

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Abstract: Tal Chhapar Wildlife Sanctuary, located on the eastern edge of the Thar Desert, supports higher floristic diversity and structural complexity compared to other arid zone ecosystems. A comprehensive floristic survey conducted from 2022 to 2024 recorded 211 angiosperm species belonging to 146 genera and 49 families, including one species from the magnoliids, 44 eudicots, and four monocots. Poaceae emerges as the dominant family with 49 species, followed by Asteraceae and Amaranthaceae, each contributing 17 species. Herbaceous plants were predominant, accounting for 40% of the flora, followed by grasses 23%, trees 12%, and shrubs 12%. Therophytes were the most common life form (105 species), followed by phanerophytes (55), hemicryptophytes (38), chamaephytes (11), and geophytes (2). The number of perennial plants (106 species) was almost equal to that of annuals (105 species), suggesting increased resilience to climate variability. Additionally, the survey identified one 'Endangered' species, *Tecomella undulata*, and one 'Critically Endangered' species, *Commiphora wightii*. Overall, this study provides a comprehensive floristic inventory of Tal Chhapar Wildlife Sanctuary, revealing its rich floral diversity and highlighting key species of conservation concern.

Keywords: Angiosperms, checklist, climatic variability, conservation, flora, floristic survey, inventory, life forms, plants, vegetation.

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Author contributions: Concept and design: SS and OI; Data collection: SS; Analysis: SS and OI; Manuscript writing: SS; Supervision: OI. Manuscript review and comments: SS and OI

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INTRODUCTION

Biodiversity refers to the variety and variability of biological organisms. It is a fundamental indicator of ecosystem health, directly reflecting its vitality, resilience, and stability (Byrnes et al. 2015; Wagg et al. 2022). The richness of plant diversity within an ecosystem not only enhances the aesthetic value of the landscape but also significantly contributes to the overall productivity of the ecosystem by providing essential resources such as food, medicine, fuel, and shelter that are crucial for the survival and well-being of both wildlife and humans (Singh et al. 2005). In arid and semi-arid regions, plant diversity is essential for regulating the water cycle, stabilizing soil, and combating desertification, thereby maintaining ecological balance (Ayangbenro & Babalola 2021). The loss of biodiversity in such fragile environments could lead to severe environmental degradation and disrupt ecosystem services that sustain local communities. Therefore, preserving plant diversity is essential for maintaining ecological balance and ensuring the long-term sustainability of human life in these regions. In recent years, increased anthropogenic activities, including mining, agricultural expansion, habitat fragmentation, and changes in land use, have been observed in these regions, underscoring the urgent need for conservation efforts (Islam & Rahmani 2011; Ram 2021).

Arid and semi-arid ecosystems exhibit pronounced spatiotemporal variability in vegetation composition due to changes in rainfall, temperature, and grazing pressure, making them highly vulnerable to climatic variability (Chapungu et al. 2020; Wu et al. 2023; Sur et al. 2024; Al-Mutairi 2025). These environmental factors strongly influence net primary productivity and ecosystem CO_2 exchange, affecting vegetation dynamics across temporal scales (Knapp & Smith 2001; Huxman et al. 2004a,b). Continuous, systematic plant monitoring in such landscapes provides essential time-series data to track changes in community composition and species resilience (Bagchi et al. 2017; Reddy et al. 2020; Tiruvaimozhi 2024). Such periodic assessments also effectively capture ephemeral species limited to short favourable conditions and enable early detection of invasive species like *Prosopis juliflora,* facilitating timely management interventions in these ecosystems (Kumar et al. 2021; Burke 2023).

To date, numerous studies across western Rajasthan have significantly contributed towards understanding regional plant diversity, including notable works by Gupta & Sharma (1977), Singh et al. (1997), Sharma & Aggarwal (2008), Sharma & Purohit (2013), Parihar & Choudhary (2017), Meena & Khan (2023), and Sanadya et al. (2023). Moreover, in the past five years, three floristic surveys have been conducted in the Tal Chhapar Wildlife Sanctuary representing a significant shift in shrub and herbaceous plant diversity within the sanctuary from 2015 to 2023. These are Kaur et al. (2020) reporting 78 species, Bagoriya et al. (2021) 139 species, and Karel & Gena (2023) 132 species. These changes are likely driven by environmental factors (Wu et al. 2021, 2023) and adaptive management practices. Despite this evidence of ecological dynamism, long-term and repeated monitoring remains limited, constraining our understanding of species turnover, vegetation resilience, and ecosystem stability. The present study therefore aims to bridge this gap through a biennial floristic reassessment of Tal Chhapar, focusing on documenting current plant diversity, detecting species additions or losses relative to prior records, and revalidating taxonomic designations under the APG IV classification. This study aims to provide a comprehensive checklist of angiosperm diversity within the sanctuary, offering valuable insights to inform conservation efforts and management strategies that preserve biodiversity and promote the well-being of local communities.

MATERIALS AND METHODS

Study area

Tal Chhapar Wildlife Sanctuary (TWS) (27.840° N, 74.484° E), situated in Sujangarh Tehsil of Churu District in northwestern Rajasthan, covers an area of 719 ha, as shown in Figure 1. It is divided into two unequal halves by the Chhapar-Sujangarh state highway. Located within the 3-A Thar Desert (Rodger et al. 2002), the sanctuary experiences extreme temperatures, ranging from -1 °C in December–January to 50 °C in May–June, with 95% of its annual rainfall occurring during the monsoon season, July–September. According to Champion & Seth (1968), the vegetation of the study area is classified as “the desert thorn forest (6B/C1).” The sanctuary landscape features grass species such as *Cenchrus setigerus*, *Cynodon dactylon*, *Desmostachya bipinnata*, *Dichanthium annulatum*, *Lasiurus scindicus*, and *Sporobolus marginatus*, interspersed with tree species like *Acacia nilotica*, *Azadirachta indica*, *Capparis decidua*, *Prosopis cineraria*, *Neltuma juliflora*, *Salvadora persica*, and *Ziziphus mauritiana* creating a savannah-like ecosystem (Kaur et al. 2020).

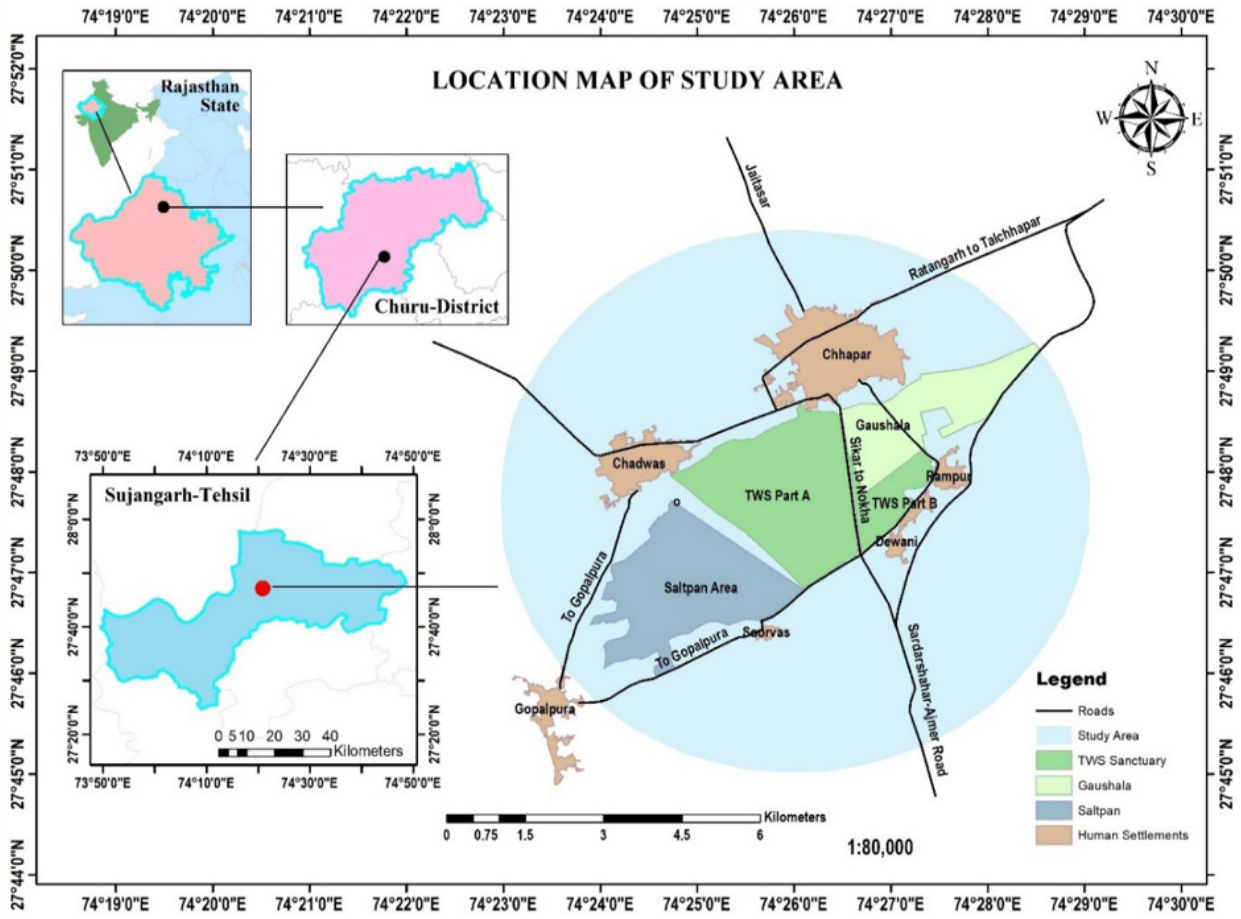

Figure 1. Location map of the study area: Tal Chhapar Wildlife Sanctuary, Churu, Rajasthan.

Methods

The present study was conducted from August 2022–March 2024, spanning the post-monsoon, winter, and spring seasons, which are known for peak plant diversity in this region. This time frame was strategically chosen to capture maximum diversity, as species diversity is typically lowest during the summer, while evenness remains relatively stable throughout the year (Kaur et al. 2020). The sanctuary was surveyed every 15 days using a random search approach to collect plant samples. The researcher moved systematically through the study area without following predetermined routes or fixed sampling points, ensuring unbiased sampling across diverse microhabitats. The voucher specimens were tagged, prepared as herbarium specimens following the standard procedure (Rao & Sharma 1990), and deposited at the Herbarium of the Department of Wildlife Science, Aligarh Muslim University, Uttar Pradesh. Plant specimens were identified in the field using the existing Flora of Rajasthan and relevant published literature (Shetty & Singh 1987, 1991, 1993; Bhandari 1995; Peddi et al. 2014; Charan & Sharma 2016; Sanadya et al. 2023). The species nomenclature was updated according to the latest standards of the International Plant Name Index (IPNI), with binomial names and author citations sourced from trusted databases such as Plants of the World Online (POWO 2025) and World Flora Online (WFO 2025). Angiosperm classification followed the Angiosperm Phylogeny Group IV (2016) system, with plants categorized into magnoliids, monocots, and eudicots. To ensure clarity and ease of reference, families, their respective genera, and the species within each genus have been organized in alphabetical order in each angiosperm group. A comprehensive checklist of the flora in TWS Sanctuary was compiled, detailing species' vernacular names, angiosperm types, growth habits, plant life forms as classified by Raunkiaer's system (Raunkiaer 1934), and their distribution.

RESULTS

Floristic diversity of TWS

Table 1 summarizes the findings from the floristic survey carried out in TWS, revealing a total of 211 identified species belonging to 49 families and 146 genera. Eudicots dominated the flora, with 44 families, 116 genera, and 154 species. Asteraceae emerges as the most diverse eudicot family, with 16 genera and 17 species, followed by Amaranthaceae (10 genera, 17 species), and Fabaceae (13 genera, 16 species). Monocots were represented by only four families, contributing significantly to the flora, with 29 genera and 56 species. Within monocots, Poaceae stands out as the dominant family, with 26 genera and 49 species, thereby enriching the sanctuary's floristic diversity, as illustrated in Figure 2. In the present survey, the family Annonaceae was the sole representative of the magnoliids, comprising a single species.

Furthermore, *Eragrostis* was identified as the most diverse genus, comprising eight species, followed by *Amaranthus,* with six species, and *Cyperus* and *Sporobolus,* each with five species. These four genera together accounted for 11.37% of the total flora, highlighting the sanctuary's ecological complexity and plant diversity across various genera, as shown in Table 1.

Classification of plants based on their growth habits and Raunkiaer's Life forms

The composition and adaptation strategies of the sanctuary's flora were analyzed using growth habits and Raunkiaer's life form classification. Growth habit analysis revealed that herbaceous plants were the most dominant, accounting for 40% of the total flora (84 species), followed by grasses at 23% (49 species), trees 12% (26 species), and shrubs 12% (26 species) also contributed significantly, while climbers 5% (10 species), succulents 5% (11 species), and sedges 3% (two species) represented smaller proportions, as illustrated in Figure 3.

Similarly, Raunkiaer's classification, based on the position of perennating organs, identified therophytes (annuals surviving as seed) as the most prevalent category, constituting 49.8% (105 species) of the flora. Phanerophytes (perennial trees and shrubs with buds located over 25 cm above ground) accounted for 18% (38 species), while hemicryptophytes (buds at or just above the soil surface) represented 16.59% (35 species). Chamaephytes (buds up to 25 cm above ground) and geophytes (plants with underground storage organs) collectively formed 16% of the flora, with 11 and two species, respectively, as shown in Figure 4.

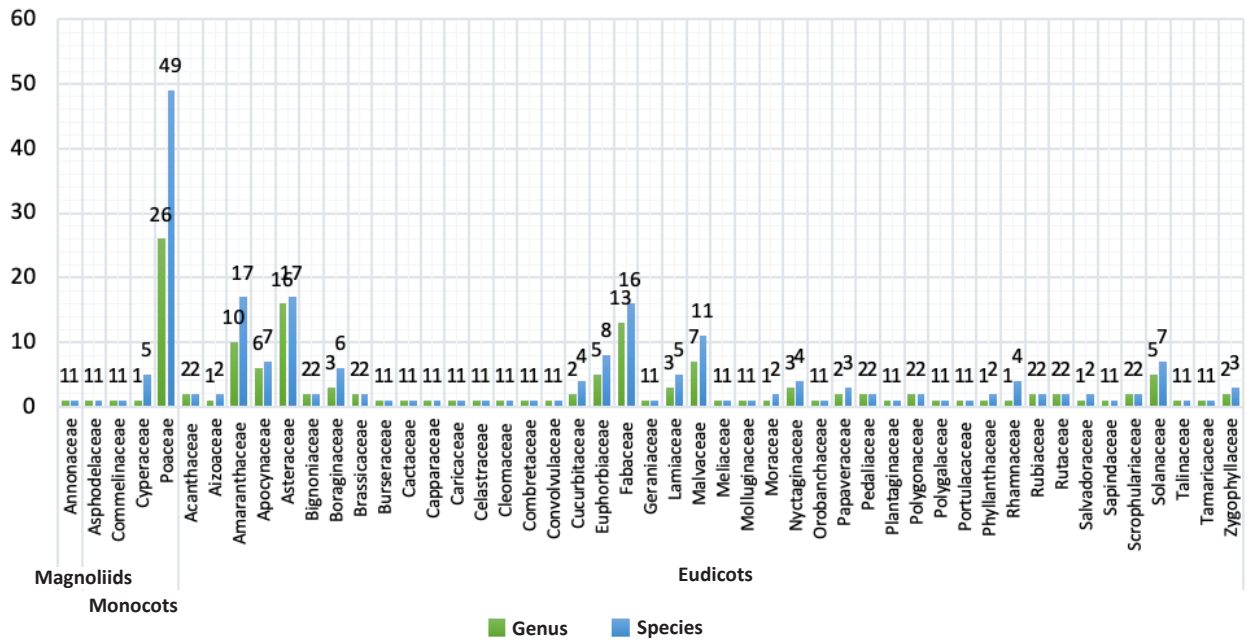

Figure 2. Angiosperm diversity of Tal Chhapar Wildlife Sanctuary, Rajasthan.

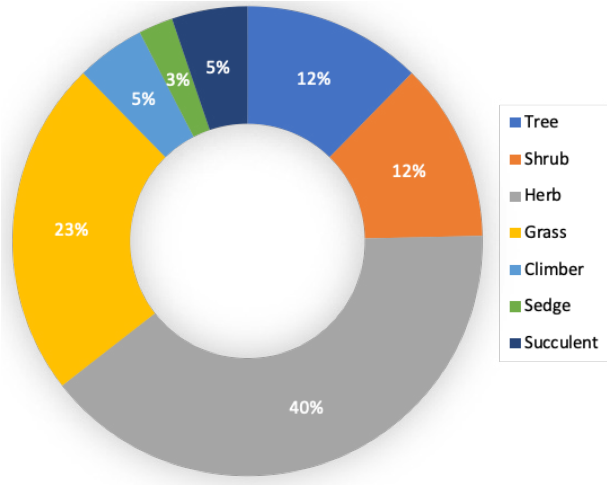

Figure 3. Vegetation composition of Tal Chhapar Wildlife Sanctuary, Rajasthan.

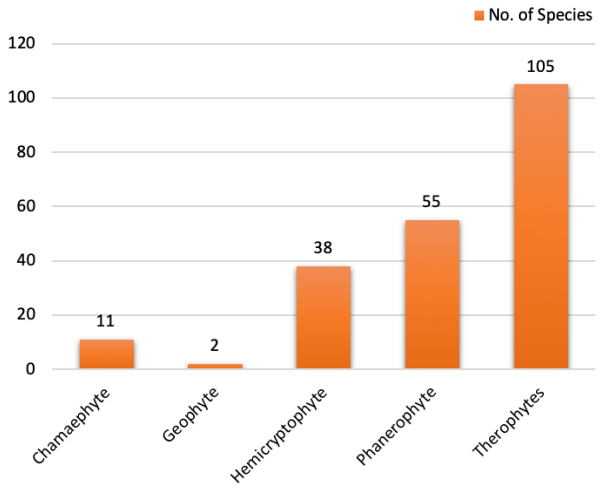

Figure 4. Classification of plants based on their Raunkiaer's Life forms.

Image 1. Plant species of conservation importance: a—*Commiphora wightii* | b—*Tecomella undulata*.

Ecological importance and conservation priorities of the sanctuary

As outlined in Table 1, the sanctuary is home to 211 identified species, of which 72.51% (153 species) are native and 27.49% (58 species) are introduced. The species are nearly evenly distributed, with 49.76% (105 species) being annuals and 50.24% (106 species) perennials, as shown in Figure 5. Additionally, the sanctuary hosts two IUCN Red Listed species: *Commiphora wightii*, classified as 'Critically Endangered' (Ved et al. 2015), and *Tecomella undulata*, classified as 'Endangered' (Plummer 2021), also depicted in Images 1a&b.

DISCUSSION AND CONCLUSION

This study recorded 211 angiosperm species within the sanctuary, showing a significant increase compared to previous reports of 78 species (Kaur et. al. 2020), 139 species (Bagoriya et al. 2020), and 102 species (Karel & Gena 2023). Among these, 108 species were recorded for the first time in the sanctuary. This increase in the species' number may be attributed to habitat changes influenced by management practices such as removing invasive species like *Neltuma juliflora,* maintaining waterholes during dry periods, implementing controlled burns, and

Table 1. Updated floristic diversity of Tal Chhapar Wildlife Sanctuary, Churu in Rajasthan.

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
1. Annonaceae						
Monoon longifolium (Sonn.) B.Xue & R.M.K.Saunders (2012) *	Ashok	Ma	P	T	Ph	N
2. Asphodelaceae						
Aloe vera (L.) Burm.f. (1768)	Guarpatta	M	P	Su	Ch	I
3. Commelinaceae						
Commelina benghalensis L. (1753)	Moriyabati, Bakhana	M	A	H	Th	N
4. Cyperaceae						
Cyperus bulbosus Vahl (1805)	Mothh	M	P	Se	Ge	N
Cyperus compressus L. (1753)	Mothio	M	A	Se	Th	N
Cyperus flavidus Retz. (1788)	Peeli-mutha	M	A	Se	Th	N
Cyperus iria L. (1753)	Moth	M	A	Se	Th	N
Cyperus rotundus L. (1753)	Motha	M	P	Se	Ge	N
5. Poaceae						
Acrachne racemosa (B.Heyne ex Roth) Ohwi (1947)	Jaran, Chinki	M	A	G	Th	N
Aristida adscensionis L. (1753)	Lampro	M	A	G	Th	N
Aristida funiculata Trin. &Rupr. (1842)	Lamp	M	A	G	Th	N
Aristida mutabilis Trin. & Rupr. (1842)	-	M	A	G	Th	N
Aristida setacea Retz. (1786)	Danta	M	A	G	Th	N
Bothriochloa pertusa (L.) A.Camus (1931)	Chhoti-jergi	M	P	G	He	N
Cenchrus biflorus Roxb. (1820)	Bhurut	M	A	G	Th	N
Cenchrus ciliaris L. (1771)	Dhaman, Anjan	M	P	G	He	N
Cenchrus prieurii (Kunth) Maire (1931)	Lambio-bhurut	M	P	G	He	N
Cenchrus setigerus Vahl (1806)	Kala Dhaman	M	P	G	He	N
Chloris barbata Sw. (1797)	Boj-patra	M	A	G	Th	N
Chloris flagellifera (Nees) P.M.Peterson (2015)	Ganthil Ghas	M	P	G	He	N
Chloris virgata Sw. (1797)	Gharniaghas	M	P	G	He	I
Cynodon dactylon (L.) Pers. (1805)	Doob	M	P	G	He	N
Dactyloctenium aegyptium (L.) Willd. (1809)	Makaro	M	A	G	Th	N
Dactyloctenium scindicum Boiss. (1859)	Mansa	M	P	G	He	N
Desmostachya bipinnata (L.) Stapf (1900)	Dab	M	P	G	He	N
Dichanthium annulatum (Forssk.) Stapf (1917)	Karad	M	P	G	He	N
Dichanthium aristatum (Poir.) C.E.Hubb. (1940)	-	M	P	G	He	N
Digitaria bicornis (Lam.) Roem. & Schult. (1817)	Jheranio	M	A	G	Th	N
Digitaria sanguinalis (L.) Scop. (1771)	Baans Ghas	M	A	G	Th	N
Echinochloa colonum (L.) Link (1833)	Soma, Phunkia	M	A	G	Th	N
Eleusine indica (L.) Gaertn. (1788)	Ghoda-doob	M	A	G	Th	N
Eleusine tristachya (Lam.) Lam. (1792)	-	M	A	G	Th	I
Enteropogon monostachyos (Vahl) K.Schum. (1894)	-	M	P	G	He	N
Eragrostis cilianensis (All.) Vignolo ex Janch. (1907)	-	M	A	G	Th	N
Eragrostis ciliaris (L.) R.Br.(1818)	Burbudi	M	A	G	Th	N
Eragrostis japonica (Thunb.) Trin. (1830)	-	M	A	G	Th	N
Eragrostis minor Host (1827)	Poongyo	M	A	G	Th	N
Eragrostis multiflora Trin. (1830)	Chuvalio	M	A	G	Th	N

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
Eragrostis pilosa (L.) P.Beauv. (1812)	Chidi-pinkhia	M	A	G	Th	N
Eragrostis tenella (L.) P.Beauv. ex Roem. & Schult. (1817)	Bharburo	M	A	G	Th	N
Eragrostis unioloides (Retz.) Nees ex Steud. (1854)	-	M	A	G	Th	N
Lasiurus scindicus Henrard (1941)	Sevan	M	P	G	He	N
Melanocenchris jacquemontii Jaub. & Spach (1851)	-	M	A	G	Th	N
Panicum turgidum Forssk. (1775)	Murantio Ghas	M	P	G	He	N
Perotis indica (L.) Kuntze (1891)	Lonki-puncho	M	A	G	Th	N
Polypogon viridis (Gouan) Breistr. (1966)	-	M	A	G	Th	N
Saccharum spontaneum L. (1771)	Kans	M	P	G	He	N
Schoenefeldia gracilis Kunth (1830)	Tarwaria	M	A	G	Th	N
Sporobolus airoides (Torr.) Torr. (1853)	-	M	P	G	He	I
Sporobolus coromandelianus (Retz.) Kunth (1829)	-	M	P	G	He	N
Sporobolus diandrus (Retz.) P.Beauv. (1812)	Chiria ka Dana	M	P	G	He	N
Sporobolus indicus (L.) R.Br. (1810)	-	M	P	G	He	I
Sporobolus ioclados (Nees ex Trin.) Nees (1841)	Poolongi	M	P	G	He	N
Tetrapogon tenellus (J.Koenig ex Roxb.) Chiov. (1907)	Lampada	M	A	G	Th	N
Tragus berteronianus Schult. (1824)	-	M	A	G	Th	I
Tripidium bengalense (Retz.) H.Scholz (2006)	Munja	M	P	G	He	N
Urochloa ramosa (L.) T.Q.Nguyen (1966)	Muret	M	A	G	Th	N
6. Acanthaceae						
Andrographis paniculata (Burm.f.) Wall. ex Nees (1832)	Kalpnath	E	A	H	Th	N
Dicliptera paniculata (Forssk.) I.Darbysh. (2007)	Kagjangha	E	A	H	Th	N
7. Aizoaceae						
Trianthema portulacastrum L. (1753)	Sato	E	A	Su	Th	N
Trianthema triquetrum Willd. ex-Spreng. (1825)	Dhedosanto	E	A	Su	Th	N
8. Amaranthaceae						
Achyranthes aspera L. (1753)	Chirchita	E	P	H	He	N
Aerva javanica (Burm.f.) Juss. ex-Schult. (1819)	Safed Bui	E	P	H	Ch	N
Aerva tomentosa Forssk. (1775)	Buari	E	P	H	Ch	N
Amaranthus blitum L. (1753) **	Lal Bhaji	E	A	H	Th	I
Amaranthus blitoides S.Watson (1877)	Chaulai	E	A	H	Th	I
Amaranthus hybridus L. (1753) **	Chaulai	E	A	H	Th	I
Amaranthus polygonoides L. (1759)	Kairee, Sevari	E	A	H	Th	I
Amaranthus spinosus L. (1753)	Chandelo	E	A	H	Th	I
Amaranthus viridis L. (1763)	Jangali Chaulai	E	A	H	Th	I
Atriplex halimus L. (1753)	-	E	P	Su	He	I
Chenopodiastrum murale (L.) S.Fuentes, Uotila & Borsch (2012)	Khartua	E	A	H	Th	N
Chenopodium album L. (1753)	Bathua	E	A	H	Th	N
Dysphania pumilio (R.Br.) Mosyakin & Clemants (2002)	-	E	A	H	Th	I
Haloxylon salicornicum (Moq.) Bunge ex Boiss. (1879)	Lana	E	P	S	Ph	N
Soda stocksii (Boiss.) Akhani (2020)	-	E	A	H	Th	N
Suaeda fruticosa Forssk. ex J.F.Gmel. (1776)	Lani	E	P	H	Ch	N
Suaeda monoica Forssk. ex J.F.Gmel. (1776)	-	E	P	S	Ch	N

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
9. Apocynaceae						
Calotropis gigantea (L.) W.T.Aiton (1811)	Safed Aak	E	P	S	Ph	N
Calotropis procera (Aiton) W.T.Aiton (1811)	Aakado	E	P	Su	Ph	N
Carissa carandas L. (1767) *	Karonda	E	P	S	Ph	N
Cascabela thevetia (L.) Lippold (1980) *	Peeli Kaner	E	P	T	Ph	I
Leptadenia pyrotechnica (Forssk.) Decne. (1838)	Khimp	E	P	S	Ph	N
Nerium oleander L. (1753) *	Kaner	E	P	T	Ph	N
Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult. (1819) *	Chandini	E	P	S	Ph	N
10. Asteraceae						
Blumea lacera (Burm.f.) DC. (1834)	Kukrondha	E	A	H	Th	N
Cyanthillium cinereum (L.) H.Rob. (1990)	Sahadevi	E	A	H	Th	N
Echinops echinatus Roxb. (1832)	Unt-kantalo	E	P	H	He	N
Eclipta prostrata (L.) L. (1771)	Jal Bhangro	E	A	H	Th	I
Erigeron bonariensis L. (1753)	-	E	A	H	Th	I
Helianthus annuus L. (1753)	Surajmukhi	E	A	H	Th	I
Lactuca serriola L. (1756)	-	E	A	H	Th	I
Launaea procumbens (Roxb.) Ramayya & Rajagopal (1969)	Janlee Gobi	E	P	H	He	N
Parthenium hysterophorus L. (1753)	Gajar Ghas	E	A	H	Th	I
Pluchea lanceolata (DC.) C.B.Clarke (1876)	Rasna	E	P	H	He	N
Pseudoconyza viscosa (Mill.) D'Arcy (1973)	Gandhana	E	A	H	Th	N
Pulicaria undulata (L.) C.A.Mey. (1831)	Sohanfali	E	A	H	Th	N
Pulicaria wightiana (DC.) C.B.Clarke (1876)	-	E	P	H	He	N
Tridax procumbens L. (1753)	Jayanti	E	A	H	Th	I
Sonchus oleraceus L. (1753)	Aakadio	E	A	H	Th	I
Verbesina encelioides (Cav.) Benth. & Hook.f. ex A.Gray (1876)	Jangali pSurajmukhi	E	A	H	Th	I
Xanthium strumarium L. (1753)	Aandheeda	E	A	H	Th	N
11. Bignoniaceae						
Tecoma fulva (Cav.) G.Don (1837) *	-	E	P	S	Ph	I
Tecomella undulata (Sm.) Seem. (1862)	Rohida	E	P	T	Ph	N
12. Boraginaceae						
Cordia dichotoma G.Forst. (1786) *	Goonda	E	P	T	Ph	N
Euploca marifolia (J.Koenig ex Retz.) Ancy &P.Javad (2020)	Choti Santari	E	P	H	He	N
Euploca ovalifolia (Forssk.) Diane & Hilger (2003)	Kunden	E	P	H	He	N
Euploca strigosa (Willd.) Diane & Hilger (2003)	Kamediya	E	A	H	Th	N
Heliotropium europaeum L. (1753)	-	E	A	H	Th	N
Heliotropium zeylanicum (Burm.f.) Lam. (1789)	-	E	A	H	Th	N
13. Brassicaceae						
Brassica juncea (L.) Czern. (1859) **	Rai	E	A	H	Th	I
Farsetia stylosa R.Br. (1826)	Hiran-chabo	E	A	H	Th	N
14. Burseraceae						
Commiphora wightii (Arn.) Bhandari (1965)	Guggal	E	P	S	Ph	N
15. Cactaceae						
Opuntia elatior Mill. (1768)	Nag-phani	E	P	Su	Ph	I

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
16. Capparaceae						
Capparis decidua (Forssk.) Edgew. (1862)	Kair	E	P	S	Ph	N
17. Caricaceae						
Carica papaya L. (1753) *	Papito	E	P	T	Ph	I
18. Celastraceae						
Gymnosporia senegalensis (Lam.) Loes. (1893) *	Kakero	E	P	T	Ph	N
19. Cleomaceae						
Cleome viscosa L. (1753)	Bagro	E	A	H	Th	N
20. Combretaceae						
Combretum indicum (L.) DeFilipps (1998)	Madhumati	E	P	C	Ph	N
21. Convolvulaceae						
Cressa cretica L. (1753)	Rudravanti	E	P	H	He	N
22. Cucurbitaceae						
Citrullus colocynthis (L.) Schrad. (1838) **	Tumba	E	A	C	Th	N
Citrullus lanatus (Thunb.) Matsum. & Nakai (1910) **	Matiro	E	A	C	Th	I
Cucumis melo L. (1753) **	Kaachri	E	A	C	Th	N
Cucumis prophetarum L. (1755)	Khat-khachro	E	P	C	Ch	N
23. Euphorbiaceae						
Acalypha indica L. (1753)	Khokali	E	A	H	Th	N
Croton bonplandianus Baill. (1864)	Kapur-kur	E	A	H	Th	I
Euphorbia caducifolia Haines (1914) *	Danda-thor	E	P	Su	Ph	N
Euphorbia hirta L. (1753)	Bara-dudhi	E	A	H	Th	I
Euphorbia prostrata Aiton (1789)	Dudhi	E	A	Su	Th	I
Euphorbia thymifolia L. (1753)	Choti-dudhi	E	A	H	Th	I
Jatropha gossypiifolia L. (1753)	Ratanjoti	E	P	S	Ph	I
Ricinus communis L. (1753)	Arandio	E	P	S	Ph	I
24. Fabaceae						
Clitoria ternatea L. (1753)	Koyalri	E	A	C	Th	I
Dalbergia sissoo Roxb. ex-DC. (1825) *	Sheesham	E	P	T	Ph	N
Medicago polymorpha L. (1753)	Ghasar	E	P	H	He	I
Neltuma juliflora (Sw.) Raf. (1838) *	VilaytiKikar	E	P	T	Ph	I
Parkinsonia aculeata L. (1753)	Rambaval	E	P	T	Ph	I
Pongamia pinnata (L.) Pierre (1898) *	Karanj	E	P	T	Ph	N
Prosopis cineraria (L.) Druce (1914)	Khejri	E	P	T	Ph	N
Tephrosia purpurea (L.) Pers. (1807)	Dhamasa	E	A	H	Th	N
Trifolium repens L. (1753)	Barseem	E	P	H	He	N
Senegalia senegal (L.) Britton (1930)	Kumta	E	P	T	Ph	N
Senna tora (L.) Roxb. (1832)	Phunwad	E	A	H	Th	I
Vachellia jacquemontii (Benth.) Ali (2014)	Bu-banwali	E	P	T	Ph	N
Vachellia leucophloea (Roxb.) Maslin, Seigler & Ebinger (2013)	Roonjh, Urajio	E	P	T	Ph	N
Vachellia nilotica (L.) P.J.H.Hurter & Mabb. (2008)	Banwal	E	P	T	Ph	N
Vachellia tortilis (Forssk.) Galasso & Banfi (2008)	Israeli Babool	E	P	T	Ph	I
Vigna trilobata (L.) Verdc. (1968)	Jangali Moth	E	A	C	Th	N

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
25. Geraniaceae						
Geranium rotundifolium L. (1753)	-	E	A	H	Th	N
26. Lamiaceae						
Leucas aspera (Willd.) Link (1822)	Thumbai	E	A	H	Th	N
Leucas martinicensis (Jacq.) R.Br. (1811)	Dargal	E	A	H	Th	N
Ocimum americanum L. (1755)	Bapchi	E	A	H	Th	N
Ocimum tenuiflorum L. (1753)	Ram Tulsi	E	P	H	Ph	N
Premna resinosa (Hochst.) Schauer (1847)	Ghitti	E	P	S	Ph	N
27. Malvaceae						
Abutilon indicum (L.) Sweet (1826)	Kanghi	E	P	S	Ch	N
Abutilon pannosum (G.Forst.) Schltdl. (1851)	Khareti	E	P	H	Ch	N
Abutilon ramosum (Cav.) Guill. & Perr. (1831)	Ramo-saag	E	P	H	Ph	N
Corchorus depressus (L.) Peterm. (1845)	Chamghas	E	A	H	Th	N
Corchorus tridens L. (1771)	Kagnasha	E	A	H	Th	N
Corchorus trilocularis L. (1767)	Kagaroti	E	A	H	Th	N
Gossypium arboreum L. (1753) *	Dharira	E	P	S	Ph	N
Grewia tenax (Forssk.) Fiori (1912)	Gangeran	E	P	S	Ph	N
Hibiscus × rosa-sinensis L. (1753) *	Gudhal	E	P	S	Ph	I
Malvastrum coromandelianum (L.) Garcke (1857)	Khariniti	E	A	H	Th	I
Sida cordifolia L. (1753)	Bal, Khariniti	E	P	H	Ch	N
28. Meliaceae						
Azadirachta indica A.Juss. (1831)	Neem	E	P	T	Ph	I
29. Molluginaceae						
Hypertelis cerviana L. (2016)	Chirmori	E	A	H	Th	N
30. Moraceae						
Ficus benghalensis L. (1753) *	Bar	E	P	T	Ph	N
Ficus religiosa L. (1753)	Pipal	E	P	T	Ph	N
31. Nyctaginaceae						
Boerhavia diffusa L. (1753)	Chinawari, Santhi	E	P	H	He	N
Boerhavia erecta L. (1753)	Saanth	E	P	H	He	I
Bougainvillea glabra Choisy (1849) *	Bogan Bel	E	P	C	Ph	I
Commicarpus plumbagineus (Cav.) Standl. (1916)	Lal Sakhari	E	P	C	He	N
32. Orobanchaceae						
Lindenbergia indica (L.) Vatke (1875)	-	E	P	H	Ph	N
33. Papaveraceae						
Argemone mexicana L. (1753)	Satyanashi	E	A	H	Th	I
Argemone ochroleuca Sweet (1828)	-	E	A	H	Th	I
Fumaria indica (Hausskn.) Pugsley (1919)	Pitpapro	E	A	H	Th	N
34. Pedaliaceae						
Sesamum indicum L. (1753) **	Jagali Til	E	A	H	Th	N
Pedalium murex L. (1759)	DakhaniGokhr	E	A	H	Th	N
35. Plantaginaceae						
Bacopa monnieri (L.) Wettst. (1891)	Brahmi	E	P	H	He	N

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
36. Polygonaceae						
Calligonum polygonoides L. (1753)	Phog	E	P	S	Ph	N
Polygonum plebeium R.Br. (1810)	Rakht-shankh Pushp	E	A	H	Th	N
37. Polygalaceae						
Polygala erioptera DC. (1824)	Johjhru, Boyasan	E	A	H	Th	N
38. Portulacaceae						
Portulaca pilosa L. (1753)	Lunkia	E	A	Su	Th	I
39. Phyllanthaceae						
Phyllanthus amarus Schumach. & Thonn. (1827)	-	E	A	H	Th	I
Phyllanthus urinaria L. (1753)	-	E	A	H	Th	N
40. Rhamnaceae						
Ziziphus glabrata (B.Heyne ex Schult.) B.Heyne ex Wight & Arn (1834)	-	E	P	T	Ph	N
Ziziphus mauritiana Lam. (1789)	Ber	E	P	T	Ph	N
Ziziphus nummularia (Burm.f.) Wight & Arn. (1833)	JhadBor	E	P	S	Ph	N
Ziziphus oenopolia (L.) Mill. (1768)	Eramdi	E	P	S	Ph	N
41. Rubiaceae						
Hamelia patens Jacq. (1760)	-	E	P	S	Ph	I
Spermacoce articularis L.f. (1782)	Agio	E	A	H	Th	N
42. Rutaceae						
Bergera koenigii L. (1767) *	Kadhi Patta	E	P	T	Ph	N
Citrus × aurantiifolia (Christm.) Swingle (1913) *	Nimboo	E	P	S	Ph	I
43. Salvadoraceae						
Salvadora oleoides Decne. (1844)	Kharo-jhaal	E	P	T	Ph	N
Salvadora persica L. (1753)	Peelu	E	P	T	Ph	N
44. Sapindaceae						
Cardiospermum halicacabum L. (1753)	Kanphuti	E	A	C	Th	N
45. Scrophulariaceae						
Anticharis senegalensis (Walp.) Bhandari (1965)	Dharno Ghas	E	A	H	Th	N
Verbascum coromandelianum (Vahl) HubMor. (1973)	-	E	A	H	Th	N
46. Solanaceae						
Datura innoxia Mill. (1768)	Daturo	E	A	S	Th	I
Datura stramonium L. (1753)	Bada Dhaturo	E	A	H	Th	I
Lycium barbarum L. (1753)	Morali	E	A	S	Th	I
Physalis angulata L. (1753)	Chipoti	E	A	H	Th	I
Solanum nigrum L. (1753)	Makoi	E	A	H	Th	N
Solanum virginianum L. (1753)	Adhkuntali	E	P	H	He	N
Withania somnifera (L.) Dunal (1852)	Asgandha	E	P	S	Ch	N
47. Talinaceae						
Talinum fruticosum (L.) Juss. (1789)	-	E	P	Su	He	I
48. Tamaricaceae						
Tamarix dioica Roxb. ex. Roth (1820)	Lai	E	P	S	Ph	N
49. Zygophyllaceae						
Balanites aegyptiaca (L.) Delile (1813)	Hingota	E	P	S	Ph	I
Balanites roxburghii Planch. (1854)	Ingoriyo	E	P	T	Ph	N

Name of species with its first publication year	Vernacular names	Angiosperm types	Nature	Growth habits	Life forms	Distribution
Zygophyllum creticum (L.) Christenh. & Byng (2018)	Dhamaso	E	P	Su	Ch	I
Angiosperm Type: M—monocot | E—eudicot | Ma—magnoliids						
Nature of Plant : A—annual | P—perennial						
Growth Habit : T—tree | S—shrub | H—herb | G—grass | C—climber | Su—succulent | Se—Sedge						
Life forms : Th—therophyte | Ph—phanerophyte | He—hemicryptophyte | Ch—chamaetophyte | Ge—Geophyte						
Distribution : N—native | I—introduced or non-native						
Note: (*)—Planted by Forest Department near Forest Rest House and along the sanctuary's boundaries.						
Note: (**)—Cultivated crops						

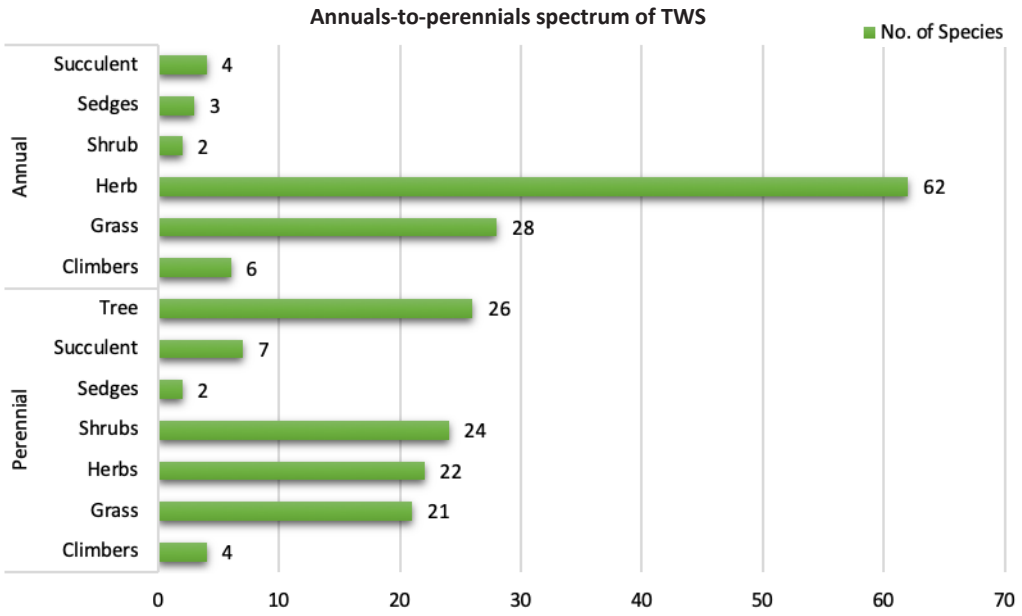

Figure 5. Habit and Nature of the plant species at Tal Chhapar Wildlife Sanctuary, Rajasthan.

regulating grazing. This warrants further investigation. This study also documented the absence of 51 species across 41 genera (Appendix I), comprising two aquatic plants, two ornamental plants, eight cultivated crops, and 40 wild species, which raises significant concern. This absence cannot be attributed to the exclusion of the summer season, as flowering and fruiting periods of these species overlapped with the study timeframe. If these species (particularly wild species) had been present in the sanctuary, they would have been observed during the study. Moreover, such patterns of species absence are not unprecedented in the sanctuary. Previous studies have also reported similar findings. For instance, Kaur et al. (2020) failed to document two previously recorded species, while Bagoriya et al. (2020), despite reporting 139 species, missed 27 species listed in earlier records. More alarmingly, Karel & Gena (2023) noted an increase in missing species, reporting the absence of 59 species. We hypothesized that environmental factors, such as fluctuations in rainfall and temperature, which are key drivers of grassland ecosystems (Wu et al. 2023), along with the inherent climatic instability of the Thar Desert, a critical factor in the region's ecology, have contributed to these variations in species compositions.

In this study, Poaceae with 26 genera and 49 species emerged as the most dominant family, followed by Asteraceae (16 genera, 17 species) and Amaranthaceae (10 genera, 17 species). These findings were consistent with those of Kaur et al. (2020), who identified these families as the most diverse and highlighted their functional role in shaping the sanctuary's ecological structure. It was observed that perennial species were equal to annuals in the sanctuary, with herbaceous plants dominating and grass species thriving in the semi-arid climate. This highlights the sanctuary's ability to support both short-term resilience and long-term

ecosystem stability, which are fundamental to the sustained growth and health of the ecosystem (Gou et al. 2023). This may also account for the sanctuary's high proportion of native species, over 70%. Additionally, the sanctuary's high ecological resilience is evident from the presence of 49.76% therophytes—plants that endure unfavourable conditions, such as droughts and extreme temperatures, by surviving in seed form. The occurrence of introduced species, including cultivated crops and ornamental plants, merits attention. These species are mainly the result of anthropogenic influences, driven by the proximity of agricultural fields and human settlements to the sanctuary. In addition, forest management practices have contributed to their presence, with ornamental plants being deliberately introduced along boundaries and near rest houses to enhance the aesthetic appeal for visitors. Given their potential influence on native flora, these species have also been included in the sanctuary's plant checklist.

In conclusion, the sanctuary's floral diversity, featuring both native and non-native species, is thriving, providing support to wildlife and local communities, while reflecting the sanctuary's strong ecological resilience. The absence of certain species suggests the need for further investigation. To sustain this growth and ensure the long-term stability of the ecosystem, ongoing conservation efforts by the forest department are essential.

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Appendix I. List of previously recorded plant species not encountered in surveys.

	Kaur et al. 2020	Bagoriya et al. 2020	Kare & Gena 2023	Present survey
1	*Portulaca oleracea*	*Balanites roxburghii*	*Ailanthus excelsa*	*Ailanthus excelsa* (W)
2	*Portulaca quadrifida*	*Blumea* spp.	*Albizia lebbeck*	*Albizia lebbeck* (W)
3		*Boerhavia elegans*	*Amaranthus spinosus*	*Arnebia hispidissima* (W)
4		*Celosia argentea*	*Anticharis senegalensis*	*Bergia odorata* (W)
5		*Cleome gracilis*	*Aristsida funiculata*	*Boerhavia elegans* (W)
6		*Cleome gynandra*	*Arnebia hispidissima*	*Celosia argentea* (O)
7		*Cleome viscosa*	*Bergia odorata*	*Cicer arietinum* (C)
8		*Commicapus verticillatus*	*Urochloa ramosa*	*Cistanche tubulosa* (W)
9		*Cressa cretica*	*Cassia tora*	*Citrullus fistulosus* (C)
10		*Crotalaria medicaginea*	*Cenchrus prieurii*	*Cleome gracilis* (W)
11		*Croton bonplandianus*	*Chenopodium album*	*Cleome gynandra* (W)
12		*Dactyloctenium scindicum*	*Chenopodiastrum murale*	*Commicarpus verticillatus* (W)
13		*Euphorbia prostrata*	*Cicer arietinum*	*Convolvulus arvensis* (W)
14		*Gnaphalium* spp.	*Cistanche tubulosa*	*Crotalaria burhia*(W)
15		*Heliotropium marifolium*	*Citrullus fistulosus*	*Crotalaria medicaginea* (W)
16		*Indigofera linnaei*	*Citrullus lanatus*	*Cuscuta hyaline* (W)
17		*Opuntia elatior*	*Clerodendrum phlomidis*	*Cuscuta reflexa* (W)
18		*Parthenium hysterophorus*	*Commicapus verticillatus*	*Cyamopsis tetragonoloba* (C)
19		*Portulaca pilosa*	*Convolvulus arvensis*	*Cyperus arenarius* (W)
20		*Pulicaria wightiana*	*Cucumis melo*	*Cyperus niveus* (W)
21		*Sporobolus marginatus*	*Cuscusta hyalina*	*Cyperus triceps* (W)
22		*Suaeda nudiflora*	*Cyamopsis tetragonoloba*	*Digera muricata* (W)
23		*Tamarix* spp.	*Cynodon dactylon*	*Gisekia pharnaceoides* (W)
24		*Trianthema triquetra*	*Cyperus iria*	*Gnaphalium* sp. (W)
25		*Tribulus terrestris*	*Dactyloctenium aegyptium*	*Grangea* sp. (W)
26		*Verbesina enceioloides*	*Dalbergia sissoo*	*Heliotropium curassavicum* (W)
27		*Zaleya govindia*	*Digera muricata*	*Heteropogon contortus* (W)
28			*Eleusine compressa*	*Hydrilla verticillata* (A)
29			*Eragrostis ciliaris*	*Imperata cylindrica* (W)
30			*Eragrostis tremula*	*Indigofera cordifolia* (W)
31			*Euphorbia hirta*	*Indigofera linnaei* (W)
32			*Euphorbia microphylla*	*Ipomoea purpurea* (O)
33			*Heliotropium curassavicum*	*Momordica balsamina* (W)
34			*Heliotropium ellipticum*	*Nymphaea nouchali* (A)
35			*Heteropogon contortus*	*Orobanche cernua* (W)
36			*Imperata cylindrica*	*Panicum antidotale* (W)
37			*Indigofera cordifolia*	*Pennisetum typhoideum* (C)
38			*Ipomoea purpurea*	*Phyllanthus niruri* (W)
39			*Maytenus emarginata*	*Polycarpaea corymbosa* (W)
40			*Nerium indicum*	*Salsola baryosma* (W)
41			*Nymphaea nouchali*	*Sonchus asper* (W)
42			*Orobanche cernua*	*Sorghum halepense* (C)
43			*Panicum antidotale*	*Striga angustifolia* (W)
44			*Panicum turgidum*	*Striga gesnerioides* (W)

	Kaur et al. 2020	Bagoriya et al. 2020	Kare & Gena 2023	Present survey
45			*Parkinsonia aculeata*	*Tribulus pentandrus* (W)
46			*Parthenium hysterophorus*	*Tribulus terrestris* (W)
47			*Pennisetum typhoideum*	*Urginea indica* (W)
48			*Phyllanthus niruri*	*Vigna aconitifolia* (C)
49			*Polycarpaea corymbosa*	*Vigna radiata* (C)
50			*Portulca oleracea*	*Vigna unguiculata* (C)
51			*Saccharum spontaneum*	*Zaleya govindia* (W)
52			*Sesamum indicum*	
53			*Sonchus asper*	
54			*Sorghum halepense*	
55			*Tridax procumbens*	
56			*Vigna aconitifolia*	
57			*Vigna radiata*	
58			*Vigna unquiculata*	
59			*Zaleya govindia*	

A—aquatic plants | C—cultivated crops | O—ornamental plants | W—wild plants.

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