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3 **Diversity of weed communities in cereal crops of traditional dryland oases**  
4 **of SW Algeria (North Africa)**5  
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30 **ABSTRACT**

31 Cereals are among the most important crops in arid and semi-arid regions and are widely  
32 cultivated in the traditional oases of southwestern Algeria. However, their productivity is  
33 constrained by several biotic and abiotic factors, particularly weeds. This study aims to  
34 analyze weed communities associated with cereal crops in these oasis agroecosystems. Data  
35 were collected from 30 phytocological relevés and analyzed using species richness, density,  
36 frequency, importance value index, Shannon-Weaver diversity index, equitability, plant  
37 functional traits, and phytogeographic spectra. A total of 34 species belonging to 33 genera  
38 and 17 families were recorded. The most represented families were Asteraceae (17.6%),  
39 Amaranthaceae (14.7%), Poaceae (14.7%), and Brassicaceae (11.7%). The flora is dominated  
40 by eudicots (80.4%), while monocots represented 19.5%. Therophytes are the dominant life  
41 form (95%). The biogeographic analysis showed a predominance of cosmopolitan (48.6%)  
42 and Mediterranean (22.8%) species. Anemochory (50.4%) was the main dispersal mode, and  
43 C<sub>3</sub> species dominated (92.9%). The most damaging weeds with the highest importance values  
44 were: *Sonchus oleraceus*, *Anagallis arvensis*, and *Emex spinosa*. The results of this study  
45 provide valuable information for developing effective weed management strategies to help  
46 improve cereal yield and quality in oasis agro-systems.

47 **Keywords:** Biodiversity, cereal production, oasis, weed community, Algeria.

48

49 **INTRODUCTION**

50 The Algerian Sahara, covering more than 84% of the national territory (~2 million km<sup>2</sup>), is  
51 characterized by extreme aridity, scarce water resources, and sparse vegetation (Bessaoud et  
52 al., 2019). Vegetation is mainly confined to specific habitats where water availability allows  
53 plant establishment, particularly in oasis environments (Le Houérou, 1990; Bouallala et al.,

2020; Souddi and Bouallala, 2023). These oases represent traditional agroecosystems with high phytogenetic diversity, covering approximately 180,000 ha and hosting more than 18 million date palms (~950 cultivars), producing about one million tons annually (Rahal Bouziane et al., 2010; Moulai and Yahaya, 2020). Oasis agroecosystems are typically structured into three vertical layers: (i) an upper layer of date palms providing microclimatic protection, (ii) an intermediate layer of fruit trees (olive, pomegranate, fig, apricot, plum), and (iii) a lower layer of herbaceous crops such as cereals and vegetables (Allam et al., 2013; BenAradj et al., 2020). However, this organization varies with environmental and management conditions.

In the Algerian Sahara, the expansion of cereal cultivation has been supported by land and groundwater availability, suitable climatic conditions, and increasing market demand (Idder et al., 2011). Cereals occupy about 3.2 million hectares (~37% of the utilized agricultural area), with durum wheat dominating (47%), followed by barley (33%) and soft wheat (17%) (ONS, 2019). Oat (*Avena sterilis* L.), mainly grown for animal feed, is also cultivated in oasis systems due to its adaptability to harsh conditions. Despite their importance, cereal crops are strongly affected by weeds, which constitute a major biological constraint (Dangwal et al., 2010; Etiabi et al., 2021; Ibrahim et al., 2022). Weeds reduce productivity through competition for resources, allelopathy, rapid reproduction, and high adaptability (Andreasen et al., 1991; Yousaf et al., 2022). Yield losses can exceed 70% under poor control and range from 13.8% to 97% depending on infestation levels and environmental conditions (Tanji, 2005; Oerke, 2006). These losses depend on several factors, including crop variety, weed composition, infestation level, duration of competition, and environmental conditions (Tamado and Milberg, 2002). Effective weed management requires a thorough understanding of weed flora composition and its dynamics under different agricultural practices. Such

78 knowledge is essential for developing appropriate and sustainable control strategies (Chafik et  
79 al., 2013). Although numerous studies have addressed weed flora and their agronomic  
80 characteristics (Hanitet et al., 2021; Cherif et al., 2022; Deghiche-Diab et al., 2022), weed  
81 communities in oasis agroecosystems of southwestern Algeria remain poorly documented.  
82 However, the weed flora of the oasis agrosystems in southwestern Algeria remains poorly  
83 documented to this day. Therefore, the present study aims to study weed communities in  
84 wheat and oat fields in arid zone oasis agrosystems.

## 85 MATERIAL AND METHODS

### 86 Description of the study area

87 The study area is located in the Wilaya of Adrar in the Algerian Sahara. This wilaya is limited  
88 to the north by the Wilaya of Timimoune, to the east by the Wilaya of In Salah, to the west by  
89 the Wilaya of Tindouf, and to the south by the Wilaya of Bordj Badji Mokhtar (Fig. 1).  
90 Geographically, the study area lies between latitudes 27° and 29° North and longitudes 3°  
91 West and 1° East (Fig. 1), covering an area of approximately 20 970 km<sup>2</sup>. It is bounded to the  
92 north by the daïras of Adrar and Aougrou, to the south by the daïra of Zaouiet Kounta, to the  
93 east by the daïra of Aoulef, and to the west by the daïra of Tabelbala. The climate of this  
94 region is hyper-arid, characterized by very low and irregular rainfall (Bouallala et al., 2020;  
95 Souddi and Bouallala, 2021, 2022, 2023). According to meteorological data for the Wilaya of  
96 Adrar obtained from the ClimateCharts database (<https://climatecharts.net/>) for the period  
97 1990-2019, the maximum monthly rainfall recorded was 1.3 mm in April, while the minimum  
98 was 0.3 mm in December. The mean monthly temperature reached a maximum of 36.6°C in  
99 July and a minimum of 12.7°C in March. Based on the ombrothermic diagram of Bagnouls  
100 and Gaussen (1953), which defines the dry period according to the relationship between  
101 temperature and precipitation, the dry season extends throughout the entire year (Fig. 2). The

102 soil texture is predominantly sandy or sandy-loam, which contributes to low plant biomass  
103 (Berrached, 1996).

#### 104 **Sampling and phytoecological relevé**

105 The sampling is subjective for the wheat and oat plots selected in the agrosystems of  
106 southwest Algeria (Fig. 1). The floristic method adopted is the "field tour" which provides an  
107 exhaustive inventory of all the species present within a plot (Maillet, 1981; Le Bourgeois,  
108 1993; Chicouène, 2000). This method involves traversing the cultivated plot in different  
109 directions until no new species is discovered (Le Bourgeois 1993; Chicouène, 2000). This  
110 technique allows for the inclusion of rare species, which may have significant agronomic  
111 importance (Le Bourgeois and Guillerm, 1995), particularly species with rapid spread or  
112 those indicating specific environmental conditions. A total of 30 floristic relevés were  
113 conducted from February to May 2022 (15 relevés in wheat crop and 15 relevés in oat crop).  
114 Each relevé covered an area of 1 m<sup>2</sup>, which is considered sufficient to obtain an exhaustive  
115 representation of weed flora. The choice of this area is supported by several studies on weeds  
116 (Singh et al., 2018; Satriawan and Fuady, 2019; Pala et al., 2020; Yousaf et al., 2022). For  
117 each relevé, the abundance (number of individuals) of each species was recorded and used to  
118 calculate absolute and relative densities (Shukla and Chandel, 1989). Species identification  
119 was carried out using the floras of Quézel and Santa (1962-1963) and Ozenda (2004).

#### 120 **Ecological groups**

121 To obtain floristically homogeneous ecological groups, a hierarchical ascending classification  
122 based on species abundance was applied to define survey groups (Souddi and Bouallala,  
123 2022). This classification considers the similarities among relevés within the same dataset in  
124 order to identify subsets of similar relevés (Bouallala et al., 2020). This approach has been

125 widely used in numerous phytoecological studies conducted in arid and semi-arid regions  
126 (Macheroum et al., 2021; Souddi and Bouallala, 2022, 2023; Belhadj et al., 2023).

### 127 **Diversity Index**

128 The characterization of floristic diversity is a key component of ecosystem assessment (Le  
129 Floc'h and Aronson, 1995). For each phytoecological group, weed diversity was evaluated  
130 using species richness (S), the Shannon-Weaver index (H'), and evenness (E) (Magurran,  
131 2004). Species richness (S) is defined as the total number of species present within each  
132 phytoecological group and across the entire study area.

133 The Shannon diversity index (H') is widely used to compare diversity among different  
134 habitats. It is calculated using the formula:  $H' = -\sum p_i \log_2 p_i$ , where  $p_i = n_i / N$  represents the  
135 relative abundance of species  $i$  in the sample,  $n_i$  is the number of individuals of species  $i$ ,  $i$   
136 ranges from 1 to S (the total number of species), and N is the total number of individuals of  
137 all species. The Shannon index is sensitive to the diversity of common species (Shannon and  
138 Weaver, 1949); higher values of H' indicate greater diversity (Kent and Coker, 1992).

139 The evenness index (E) was used to quantify the regularity component of diversity and was  
140 calculated as follows:  $E = H' / H_{max}$ , where  $H_{max} = \log_2 S$  represents the theoretical  
141 maximum diversity (Piélou, 1966). The value of E ranges from 0 to 1, with E = 1 indicating a  
142 completely even distribution of individuals among species (Kent and Coker, 1992).

### 143 **Frequencies, densities and importance value index**

144 For species within each phytoecological group, several relative indices were calculated:  
145 frequency (F), relative frequency (RF), density (D), relative density (RD), and relative  
146 abundance (RA), which were subsequently used to compute the Importance Value Index (IVI)  
147 (Concenço, 2013).

148 Species frequency (F) is defined as the number (n) of relevés in which a species occurs out of  
149 the total number (N) of relevés sampled. Five frequency classes were distinguished: Class I:  
150 very rare species ( $0 < F < 20\%$ ); Class II: rare species ( $20\% \leq F < 40\%$ ); Class III: frequent  
151 species ( $40\% \leq F < 60\%$ ); Class IV: abundant species ( $60\% \leq F < 80\%$ ); Class V: constant  
152 species ( $80\% \leq F \leq 100\%$ ) (Duretz, 1920).

153 Relative frequency (RF) is defined as the proportion of the frequency of a given species  
154 relative to the sum of frequencies of all species, expressed as:  $RF = (\text{frequency of species} /$   
155  $\text{total frequency of all species}) \times 100$ .

156 Density (D) is expressed as the number of individuals per unit area and represents a key  
157 parameter in sustainable weed management (Odum and Barrett, 1971).

158 Relative density (RD) represents the numerical contribution of a species relative to the total  
159 number of individuals of all species and is calculated as:  $RD = (\text{density of species} / \text{total}$   
160  $\text{density of all species}) \times 100$ .

161 Relative abundance (RA) refers to the proportion of individuals of a given species relative to  
162 the total number of individuals of all species. It is calculated as:  $RA = (Aa / N) \times 100$ , where  
163 Aa is the absolute abundance and N is the total number of individuals (Triplet, 2023).

164 The dominant weed species within each phytoecological group were identified using the  
165 Importance Value Index (IVI) (Abd El-Hamid and Kamel, 2010; Ahmed and Shaukat, 2012;  
166 Ibrahim et al., 2022). This index provides an estimate of the overall ecological importance of  
167 each species within a plant community (Brower and Zar, 1990). Higher IVI values indicate a  
168 greater ecological role. The IVI is calculated as the sum of relative frequency, relative density,  
169 and relative abundance of each species (Concenço, 2013; Pala et al., 2020).

## 170 **Functional traits of weed groups studied**

171 The floristic composition of weed communities was analyzed using functional traits. These  
172 traits are essential for a better understanding of the relationships between plant communities  
173 and their environment (McGill et al., 2006). Functional traits of weeds were determined for  
174 each phytoecological group and for the entire study area based on the following references:  
175 Quézel and Santa (1962-1963), Ozenda (2004), and the Tela-Botanica database. Both raw  
176 spectra (species richness) and real spectra (density) of weed functional traits were used to  
177 characterize each phytoecological group.

### 178 **Life Forms**

179 The classification of taxa according to their growth form or morphology is crucial for the  
180 physiognomic description of vegetation, as these traits reflect the evolutionary adaptations of  
181 plants to their environment (Orshan, 1953). According to Raunkiaer (1934), plant adaptation  
182 strategies to environmental conditions, particularly climatic factors, can be better understood  
183 through the biological spectrum. This classification is based on the position of survival organs  
184 (persistent buds) relative to the soil surface during unfavorable periods of the year. It  
185 distinguishes five biological types: phanerophytes, chamaephytes, hemicryptophytes,  
186 geophytes, and therophytes.

### 187 **Dispersion types**

188 Plant dispersal strategies represent a set of adaptations that ensure species propagation.  
189 Depending on the internal and external factors involved, as well as the biotic and abiotic  
190 agents responsible for diaspore dissemination, Van der Pijl (1982) distinguished five main  
191 dispersal types: anemochory, hydrochory, zoochory, barochory, and autochory. In this study,  
192 dispersal types were determined based on reference works (Quézel and Santa, 1962-1963;  
193 Ozenda, 2004; Bouallala et al., 2020; Souddi and Bouallala, 2022, 2023) and the Tela-  
194 Botanica database.

**195 Life cycle**

196 Each species was classified according to its life cycle (annual or perennial), based on the  
197 persistence of the aerial vegetative parts during the unfavorable season (Bouallala et al.,  
198 2020). This classification was based on the works of Quézel and Santa (1962-1963) and  
199 Ozenda (2004).

**200 Photosynthetic metabolism**

201 The spectrum of photosynthetic metabolism refers to the diversity of metabolic pathways used  
202 by plants during photosynthesis. Plants can be classified according to the type of pathway  
203 used to fix carbon dioxide (CO<sub>2</sub>) from the atmosphere (Sage, 2004). C<sub>3</sub>, C<sub>4</sub>, and CAM plants  
204 represent the three main types of photosynthetic metabolism, depending on their  
205 photosynthetic pathways. Species were classified according to their photosynthetic pathway  
206 based on information reported by Wang (2005) and Rauber et al. (2018).

**207 Morphotype**

208 The morphotypes of the species recorded in the study area were determined based on the  
209 works of Quézel and Santa (1962-1963), Ozenda (2004), and the Tela Botanica database.

**210 Phytogeographic types**

211 The phytogeographic types of the taxa recorded in the study area were determined based on  
212 the works of Quézel and Santa (1962-1963), Ozenda (2004), and Bučar et al. (2022).

**213 *Statistical tests and multifactorial analysis***

214 Before each test, normality and homogeneity of variances were assessed using the Shapiro-  
215 Wilk and Bartlett tests, respectively. Analysis of variance (ANOVA) was used to evaluate  
216 differences between groups in terms of plant abundance (N), species richness (S), Shannon  
217 diversity index (H'), and evenness (E). Tukey's honestly significant difference (HSD) post  
218 hoc test was applied for pairwise comparisons when significant differences were detected ( $p <$

219 0.05). When the assumptions of normality and homogeneity of variances were not met, the  
220 non-parametric Kruskal-Wallis test was used instead. In addition, Pearson's chi-square ( $\chi^2$ )  
221 test was performed to examine the null hypothesis of independence between plant density and  
222 species richness across the categories of each functional trait within groups. Multiple factor  
223 analysis (MFA) was conducted to explore the relationships between the three phytoecological  
224 groups and plant functional traits. All statistical analyses were performed using R version  
225 4.2.2 (R Core Team, 2022).

## 226 RESULTS

### 227 Floristic composition

228 A total of 34 weed species belonging to 33 genera and 17 families were recorded (Table 1).  
229 Monocots comprise 2 families, 6 genera, and 6 species (17.65%), whereas eudicots are  
230 represented by 15 families, 27 genera, and 28 species (82.35%). The most species-rich family  
231 is Asteraceae (6 species), followed by Amaranthaceae and Poaceae (5 species each),  
232 Brassicaceae (4 species), and Apocynaceae (2 species). Twelve families are monospecific.

### 233 *Weed Community Characterization*

234 The ascending hierarchical classification identified three functionally and ecologically distinct  
235 weed groups (communities), namely G1, G2, and G3 (Fig. 3).

### 236 *Group 1 (G1)*

237 The first group includes 16 species recorded across 10 relevés, with a total weed density of  
238 150 individuals (Table 2). The highest species densities were observed for *Anagallis arvensis*  
239 (66 individuals), followed by *Sonchus oleraceus* (44 individuals). Seven species -*Bassia*  
240 *muricata*, *Brassica rapa*, *Calotropis procera*, *Chenopodium album*, *Launaea glomerata*,  
241 *Pergularia tomentosa*, and *Veronica anagallis-aquatica*, consistently showed the lowest  
242 density and importance values (IVI = 3.56). Frequency analysis placed these seven, along

243 with *Fumaria numidica*, into Class I (very rare), while Class II (rare) included five other  
244 species (Table 2). Class III (common) was represented by a single species (*Emex spinosa*),  
245 whereas Class V (constant) included two species (*Anagallis arvensis* and *Sonchus oleraceus*).  
246 The importance value index (IVI) indicated that *Anagallis arvensis* (IVI = 110.22) and  
247 *Sonchus oleraceus* (IVI = 80.88) are the most important species in this group.

#### 248 *Group 2 (G2)*

249 In the second group, 25 species were recorded across ten relevés, with a total weed density of  
250 280 individuals (Table 3). Species abundance was highly uneven, with *Sonchus oleraceus* (49  
251 individuals) and *Anagallis arvensis* (29 individuals) were the most abundant. Six species  
252 occurred as single individuals; all were classified in frequency Class I (very rare), along with  
253 nine additional species (Table 3). Species were distributed across five frequency classes. Class  
254 I included 15 very rare species (*Bassia muricata*, *Beta vulgaris*, *Brassica tournefortii*,  
255 *Chenopodium album*, *Galium aparine*, *Launaea glomerata*, *Launaea resedifolia*, *Leontodon*  
256 *muelleri*, *Lobularia libyca*, *Lolium multiflorum*, *Melilotus indicus*, *Polypogon monspeliensis*,  
257 *Senecio massaicus*, *Silene rubella* and *Sisymbrium irio*). Class II (rare) comprised four species  
258 (*Adonis dentata*, *Asphodelus tenuifolius*, *Chenopodium murale* and *Cynodon dactylon*). Class  
259 III (common) included two species (*Calendula aegyptiaca* and *Phalaris minor*), while Class  
260 IV was represented by a single species (*Malva parviflora*). Class V (constant) included *Emex*  
261 *spinosa* and *Anagallis arvensis*. The highest importance values were recorded for *Sonchus*  
262 *oleraceus* (IVI = 47.82), *Anagallis arvensis* (IVI = 32.26) and *Emex spinosa* (IVI = 30.1). The  
263 lowest IVI values (IVI = 2) were observed for *Bassia muricata*, *Beta vulgaris*, *Galium*  
264 *aparine*, *Launaea resedifolia*, *Lobularia libyca* and *Sisymbrium irio*.

#### 265 *Group 3 (G3)*

266 In the third group, 22 weed species were recorded across 10 relevés (Table 4). The highest  
267 density was observed for *Sonchus oleraceus* (32 individuals), followed by *Melilotus indicus*  
268 (23 individuals). The lowest densities were recorded for *Beta vulgaris*, *Brassica rapa*,  
269 *Chenopodium murale*, *Launaea resedifolia*, *Lolium multiflorum*, *Senecio massaicus*, *Silene*  
270 *rubella* and *Spinacia oleracea*. Species were distributed across five frequency classes. Class I  
271 included 15 very rare species (Table 4). Class II (rare) comprised four species (*Chenopodium*  
272 *album*, *Leontodon muelleri*, *Malva parviflora*, and *Sisymbrium irio*). Class III (frequent)  
273 included *Anagallis arvensis* and *Emex spinosa*. Class V (constant) included *Melilotus indicus*  
274 and *Sonchus oleraceus*. The highest importance values were recorded for *Sonchus oleraceus*  
275 (IVI = 60.32) and *Melilotus indicus* (IVI = 47.38).

#### 276 **Structure and diversity of weed groups studied**

277 In terms of species richness, G2 and G3 are the richest groups, with 25 and 22 species,  
278 respectively, whereas G1 is the least rich group, with 16 species. The highest mean richness is  
279 recorded in G2 and G3, with  $7.8 \pm 2.20$  and  $6.3 \pm 1.34$  species per relevé, respectively (Fig.  
280 4). ANOVA revealed a significant difference in species richness among the phytoecological  
281 groups ( $F(2, 27) = 10.81, p < 0.001$ ). Additionally, G1 and G3 showed much lower mean  
282 abundances ( $15 \pm 2.40$  and  $13.9 \pm 5.63$  individuals, respectively), whereas G2 exhibited a  
283 higher mean abundance ( $28 \pm 12.40$  individuals). The Kruskal-Wallis test indicated a  
284 significant variation in abundance among the phytoecological groups ( $\chi^2 = 14.24, p = 0.0008$ ).  
285 Groups G2 ( $H' = 1.85 \pm 0.28, E = 0.91 \pm 0.03$ ) and G3 ( $H' = 1.64 \pm 0.19, E = 0.90 \pm 0.05$ )  
286 displayed the highest mean Shannon diversity index and evenness values. The lowest values  
287 were recorded in G1 ( $H' = 1.23 \pm 0.19, E = 0.84 \pm 0.09$ ). ANOVA showed a significant  
288 difference in Shannon index values among the phytoecological groups ( $F(2, 27) = 20.1, p <$

289 0.001). The Kruskal-Wallis test also revealed significant differences in evenness among  
290 groups ( $\chi^2 = 7.49$ ,  $p = 0.02$ ) (Fig. 4).

### 291 **Functional traits of studied weeds**

#### 292 *Biological spectra*

293 Across all groups and at the study area level, both raw and real spectra showed a high  
294 dominance of therophytes (82.36% and 95.08%, respectively), followed by hemicryptophytes  
295 (8.82% and 4.22%). In contrast, chamaephytes (5.88% and 0.53%) and phanerophytes (2.94%  
296 and 0.17%) were poorly represented (Fig. 5a). The chi-square test revealed a significant  
297 difference in the distribution of biological types in the real spectrum among phytoecological  
298 groups ( $\chi^2 = 18.384$ ,  $p = 0.005$ ), whereas no significant difference was observed in the raw  
299 spectrum ( $\chi^2 = 4.701$ ,  $p = 0.583$ ).

#### 300 *Dispersion spectra*

301 In the raw spectrum, anemochorous species showed the highest proportions in G1 and G2  
302 (37.5% and 36%, respectively), whereas barochorous species were dominant in G3 and at the  
303 study area level (45.46% and 38.24%, respectively). In the real spectrum, anemochorous  
304 species dominated in G1 and G3 and at the study area level (77.33%, 56.11%, and 50.44%,  
305 respectively), while in G2, barochorous species were the most represented (33.58%) (Fig. 5b).  
306 The chi-square test indicated significant differences among phytoecological groups in the real  
307 spectrum ( $\chi^2 = 82.593$ ,  $p < 0.0001$ ), whereas no significant difference was found in the raw  
308 spectrum ( $\chi^2 = 1.722$ ,  $p = 0.787$ ).

#### 309 *Life cycle spectra*

310 Both raw and real spectra showed a clear dominance of annual species (85.29% and 95.25%,  
311 respectively) (Fig. 5c). The chi-square test indicated no significant differences among

312 phytoecological groups in either the real spectrum ( $\chi^2 = 5.486$ ,  $p = 0.064$ ) or the raw spectrum  
313 ( $\chi^2 = 2.471$ ,  $p = 0.291$ ).

#### 314 *Spectra of photosynthetic metabolism*

315 At the regional scale, the real spectrum showed a clear dominance of C<sub>3</sub> species (92.97%)  
316 (Fig. 5d). The chi-square test revealed significant differences among phytoecological groups  
317 in the real spectrum ( $\chi^2 = 11.058$ ,  $p = 0.004$ ), whereas no significant difference was found in  
318 the raw spectrum ( $\chi^2 = 0.109$ ,  $p = 0.947$ ).

#### 319 *Morphotype spectra*

320 Both raw and real spectra showed a strong dominance of eudicots (82.35% and 80.49%,  
321 respectively) (Fig. 5e). The chi-square test indicated significant differences among  
322 phytoecological groups in the real spectrum ( $\chi^2 = 68.773$ ,  $p < 0.0001$ ), but not in the raw  
323 spectrum ( $\chi^2 = 3.606$ ,  $p = 0.165$ ).

#### 324 *Phytogeographic spectra*

325 The raw phytogeographic spectra showed high proportions of Mediterranean species in G2  
326 and G3 and at the study area level (32%, 40.91%, and 32.35%, respectively), whereas  
327 cosmopolitan species dominated in G1 (25%). The real spectrum showed a high proportion of  
328 cosmopolitan species (48.69%) (Fig. 5f). The chi-square test revealed significant differences  
329 among phytoecological groups in the real spectrum ( $\chi^2 = 209.768$ ,  $p < 0.0001$ ), while no  
330 significant differences were observed in the raw spectrum ( $\chi^2 = 16.876$ ,  $p = 0.770$ ).

## 331 **DISCUSSION**

332 The weed flora of cereal crops in the study area comprises 34 species from 33 genera and 17  
333 families, a composition very similar to that reported by Yousaf et al. (2022) for wheat fields  
334 in the Sialkot agroecosystem (Pakistan). Conversely, it is relatively higher than  
335 the number recorded by Medjber-Teguig et al. (2018) in the palm groves of the Ouargla

336 region (27 species). However, the flora recorded in this study is less rich compared to that  
337 reported by Fertout-Mouri (2018) in cereal crops in the Tessala region (Sidi bel Abbés) (83  
338 species), Melakhessou et al. (2020) in wheat fields of Aurès (77 species) and Zedam et al.  
339 (2021) in the El-Maadher agrosystem (Boussaada Oasis) (41 species). The differences  
340 observed in floristic composition and biodiversity between the three individualized groups  
341 and those reported in other studies can be attributed to environmental conditions shaped by  
342 agricultural practices, such as tillage systems, herbicide use, crop history, soil types and the  
343 type and quality of irrigation water, as well as weed control methods and overall crop  
344 management (Martínez-Ghersa et al., 2000; Booth and Swanton, 2002; Chafik et al., 2010;  
345 Chafik et al., 2013; Rauber et al., 2018). In winter crops, weeds are mainly controlled through  
346 hand-pulling and manual hoeing (Abd El-Hamid and Kamel, 2010). Ghersa et al. (1996) and  
347 Ghersa and León (1999) explain that variations in weed community composition are  
348 influenced by seasonal changes, agricultural cycles, and long-term environmental processes  
349 such as soil erosion and climate change. Four families (Asteraceae, Amaranthaceae, Poaceae,  
350 and Brassicaceae) account for 58.84% of the total flora and are considered the most common  
351 in agroecosystems. These families are species-rich and include a large number of weed taxa  
352 (Abd El-Ghani et al., 2013). Tanji et al. (1984) attributed their importance to high seed  
353 production and long seed longevity. Several studies have reported that Asteraceae is the  
354 dominant weed family in cereal crops (Zidane et al., 2010; Hannachi and Fenni, 2011;  
355 Fertout-Mouri, 2018; Melakhessou et al., 2020). This family occurs in a wide range of  
356 habitats due to its broad ecological amplitude (Haq et al., 2023), as well as the production of  
357 small, lightweight seeds that are easily dispersed by wind (Akedrin et al., 2020).

358 The biological spectra reveal a high proportion of therophytes across all phytoecological  
359 groups in the study area. This predominance of therophytes in the weed flora is attributed to

360 their adaptations to agrosystem conditions (Nikolić et al., 2018; Ka et al., 2019), their very  
361 short life cycle (Kazi Tani et al., 2010; Chafik et al., 2013), the progressive elimination of  
362 perennial species (Noba et al., 2004), and their high seed production capacity (Fertout-Mouri,  
363 2018). Indeed, therophytes represent an adaptive strategy to harsh climatic conditions (El-  
364 Saied et al., 2015; Abbas et al., 2021) and serve as indicators of ecosystem disturbance  
365 (Mashaly et al., 2013; Al Shaye et al., 2020). Their dominance has been widely reported in  
366 several studies, including those by Boudjedjou and Fenni (2011), Bassence et al. (2012),  
367 Fertout-Mouri (2018), and Medjber-Teguig et al. (2018). Furthermore, Taleb et al. (1997)  
368 noted that agricultural practices promote the development of therophytes compared to other  
369 biological types. The presence of hemicryptophytes is associated with higher organic matter  
370 content and soil moisture (Floret et al., 1990). These species are well adapted to arid and  
371 semi-arid environments and persist through specialized vegetative organs such as bulbs,  
372 rhizomes, and stolons (Taleb et al., 1998; Souddi et al., 2022). The occurrence of  
373 chamaephytes in the study area is linked to their drought-adaptive strategies, including  
374 reduced leaf area and well-developed root systems (Bradai et al., 2015; Souddi and Bouallala,  
375 2023). Phanerophytes are rare and occur only sporadically, mainly in cleared areas,  
376 particularly along field margins and occasionally within fields under low mechanization  
377 conditions (Taleb and Maillet, 1994; BenSellam et al., 1997; Kazi Tani et al., 2010; Souddi et  
378 al., 2022). This low representation of phanerophytes may be related to intensive agricultural  
379 practices and frequent disturbance in cultivated areas (Al-Sherif et al., 2018).

380 Anemochorous species are dominant across all the phytoecological groups studied. The high  
381 number of anemochorous species can be explained by the frequently strong winds in arid  
382 environments and their role in plant dispersal (Bradai et al., 2015; Bouallala et al., 2020;  
383 Hussein et al., 2022; Souddi and Bouallala, 2022). The presence of zoochorous species

384 highlights the importance of animals in agricultural environments in maintaining seed  
385 dispersal. Animals can disperse seeds either by ingesting fruits or seeds (endozoochory) or by  
386 transporting them externally on their fur or feathers (epizoochory) (Calvino-Cancela, 2011).  
387 These animals transport and disperse diaspores during their movements between different  
388 sites, particularly while searching for water (Souddi and Bouallala, 2023). Plant dispersal by  
389 barochory is mainly related to the reproductive capacity of species (Abdourhamane et al.,  
390 2017).

391 Life cycle spectra reveal a dominance of annual species. This dominance is attributed to the  
392 short life cycle of annual plants, as well as to prevailing climatic conditions and water  
393 availability, which favor their frequent occurrence (Shaltout and El-Sheikh, 1991; Abd El-  
394 Hamid and Kamel, 2010). Annual plants exhibit high reproductive capacity and significant  
395 ecological, morphological, and genetic plasticity under high disturbance conditions such as  
396 agricultural practices (Grime, 1979; Abd El-Hamid and Kamel, 2010). The low number of  
397 perennial species may be attributed to intensive crop management practices, which negatively  
398 affect the vegetative growth of perennial weeds (Abd El-Ghani et al., 2013).

399 The distribution of plants according to photosynthetic metabolism shows high proportions of  
400 C<sub>3</sub> species across all phytoecological groups in the study area. This pattern may be explained  
401 by environmental conditions, including water and light availability, temperature, and  
402 evolutionary adaptations (Rauber et al., 2018). Morphotype spectra indicate a predominance  
403 of eudicot species. The dominance of eudicots, followed by monocots, has been reported  
404 throughout agrosystems and confirmed by several studies (Tanji and Ait Lhaj, 2010; Chafik et  
405 al., 2012; Zedam et al., 2021; Deghiche-Diab et al., 2022).

406 The phytogeographic spectrum based on species richness reveals a high proportion of  
407 Mediterranean species in groups 2 and 3, as well as in the overall study area. This reflects the

408 geographical location of the study area and confers a Mediterranean character (Zedam et al.,  
409 2021). However, the real spectrum shows high proportions of cosmopolitan species across all  
410 groups. Cosmopolitan species are considered indicators of changes in phytocenoses driven by  
411 human activities (Shochat et al., 2006; El-Saied et al., 2015; Eddoud et al., 2018). Their  
412 dominance in some Saharan habitats has been reported in several studies (Al-Sherif et al.,  
413 2020; Souddi et al., 2022; Souddi and Bouallala, 2023). The low representation of other  
414 phytogeographic elements may be explained by their gradual elimination due to cultivation  
415 practices, weed control, and poor adaptation to environmental conditions (Touré et al., 2008;  
416 Akedrin et al., 2020).

417 The weeds with the highest importance values (*Sonchus oleraceus*, *Anagallis arvensis*, and  
418 *Emex spinosa*) are recognized as major weeds worldwide, although their invasive status varies  
419 depending on the region (Eddoud et al., 2018). *Sonchus oleraceus* is widely distributed  
420 globally and is considered a difficult-to-control weed (Peerzada et al., 2019). It has been  
421 reported as a dominant species in crops such as wheat, millet, and alfalfa (Salama et al.,  
422 2016). Its high density and frequency are attributed to its strong adaptability to agricultural  
423 conditions, rapid reproduction, and ability to exploit soil disturbances associated with farming  
424 practices (Gomaa, 2012; Peerzada et al., 2019). Similarly, *Anagallis arvensis* and *Emex*  
425 *spinosa* showed high values of frequency, density, and Importance Value Index (IVI) in the  
426 studied crops. These patterns can be explained by the heterogeneity of soil properties and  
427 microclimatic conditions (Medjber-Teguig et al., 2018; Eddoud et al., 2018).

## 428 CONCLUSION

429 Weeds remain one of the major agronomic problems threatening cereal production. The  
430 results obtained in this study revealed the presence of 34 weed species belonging to 33 genera  
431 and 17 botanical families. The families Asteraceae, Amaranthaceae, Poaceae, and

432 Brassicaceae are the most represented, with a strong dominance of therophytes and  
433 hemicryptophytes, which are well adapted to the environmental conditions of cereal crops in  
434 arid areas. Cosmopolitan and Mediterranean species constitute key elements in the structure  
435 and floristic composition of the weed flora in the study area. The most problematic species,  
436 characterized by the highest importance values, pose a significant risk to cereal production,  
437 namely *Sonchus oleraceus*, *Anagallis arvensis*, and *Emex spinosa*. Therefore, effective  
438 control of these weeds is essential for developing a rational management approach to cereal  
439 crops in drylands, within a framework of more productive, cleaner, and sustainable  
440 agricultural systems.

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#### 444 **CRedit AUTHORSHIP CONTRIBUTION STATEMENT**

445 **Mohammed Souddi**: Conceptualization, Data curation, Formal analysis, Investigation,  
446 Methodology, Software, Resources, Supervision, Validation, Visualization, writing – original  
447 draft, Writing – review & editing. **M’hammed Bouallala**: Conceptualization, Investigation,  
448 Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing.

#### 449 **DECLARATION OF COMPETING INTEREST**

450 The authors declare that they have no known competing financial interests or personal  
451 relationships that could have appeared to influence the work reported in this paper.

#### 452 **ETHICS AND PERMIT APPROVALS**

453 Not applicable.

#### 454 **DATA AVAILABILITY STATEMENT**

455 Data will be made available on reasonable request from the corresponding author.

456 **USE OF ARTIFICIAL INTELLIGENCE (AI) TOOLS**

457 The authors declare that no AI tools were used.

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745 **Tables**

746 Table 1. List of species recorded in cereal crops of SW Algeria **Life forms** [Ther: therophyte, Hemi: hemicryptophyte, Cham: chamaephyte,  
 747 Phan: phanerophyte,] **Chorological types** [M-SA: Mediterranean Saharo-Arabian, Cosmop: cosmopolitan, Med-As: Mediterraneo-Asian, Med:  
 748 Mediterranean, PSTr: Paleo-subtropical, PTm: Paleo-temperate, SA: Saharo-Arabian, Tr-SA: Tropico-Saharo-Arabian, Euras-Med: Eurasian-  
 749 Mediterranean, Tr-SA: Tropical Saharo-Arabian, Med.-Iran-Tour: Mediterranean Irano Tour, Macar-Med: Macaroon-Mediterranean]

Family	Species	Life form	Dispersion types	Life cycle	Photosynthetic Metabolism	Morphotype	Chorological type	Relative abundance	Relative frequency	Relative density	IVI
Amaranthaceae (14.71%)	<i>Bassia muricata</i> (L.) Asch.	Ther	Zoochore	Annual	C4	Eudicots	M-SA	0,35	1,07	0,37	1,79
	<i>Chenopodium album</i> L.	Ther	Barochore	Annual	C3	Eudicots	Cosmop	1,4	3,22	1,42	6,04
	<i>Chenopodium murale</i> L.	Ther	Barochore	Annual	C3	Eudicots	Cosmop	2,81	3,76	2,79	9,36
	<i>Beta vulgaris</i> L.	Ther	Barochore	Annual	C3	Eudicots	Euras-Med	0,35	1,07	0,37	1,79
	<i>Spinacia oleracea</i> L.	Ther	Barochore	Annual	C3	Eudicots	Cosmop	0,17	0,54	0,16	0,87
Apocynaceae (5.88%)	<i>Calotropis procera</i> Ait.	Phan	Anemochore	Perennial	C3	Eudicots	Tr-SA	0,17	0,54	0,16	0,87
	<i>Pergularia tomentosa</i> L.	Cham	Anemochore	Perennial	C3	Eudicots	SA	0,17	0,54	0,16	0,87
Liliaceae (2.94%)	<i>Asphodelus tenuifolius</i> Cava.	Ther	Barochore	Annual	C3	Monocots	Macar-Med	4,57	2,15	4,59	11,31
Asteraceae (17.66%)	<i>Calendula aegyptiaca</i> Desf.	Ther	Zoochore	Annual	C3	Eudicots	SA	4,39	4,3	4,37	13,06
	<i>Launaea glomerata</i> (Cass.) Hook.	Ther	Anemochore	Annual	C4	Eudicots	M-SA	0,53	1,07	0,53	2,13
	<i>Launaea resedifolia</i> (L.) O. Kuntze.	Ther	Anemochore	Annual	C4	Eudicots	M-SA	0,35	1,07	0,37	1,79
	<i>Leontodon muelleri</i> Ball.	Ther	Anemochore	Annual	C3	Eudicots	Med	1,93	3,22	1,95	7,1
	<i>Senecio massaicus</i> Maire.	Ther	Anemochore	Annual	C3	Eudicots	SA	0,53	1,61	0,53	2,67
	<i>Sonchus oleraceus</i> L.	Ther	Anemochore	Annual	C3	Eudicots	Cosmop.	21,97	15,59	21,98	59,54
Brassicaceae (11.76%)	<i>Brassica rapa</i> L.	Ther	Barochore	Annual	C3	Eudicots	Med	0,35	1,07	0,37	1,79

	<i>Brassica tournefortii</i> Gouan	Ther	Barochore	Annual	C3	Eudicots	Med	0,53	0,54	0,53	1,6
	<i>Lobularia libyca</i> (Viv.) Webb.	Hemi	Anemochore	Annual	C3	Eudicots	Med	0,17	0,54	0,16	0,87
	<i>Sisymbrium irio</i> L.	Ther	Anemochore	Annual	C3	Eudicots	Med-Iran-Tour.	3,69	4,3	3,69	11,68
Caryophyllaceae (2.94%)	<i>Silene rubella</i> L.	Ther	Anemochore	Annual	C3	Eudicots	Med.	1,07	0,53	2,13	1,07
Fabaceae (2.94%)	<i>Melilotus indicus</i> (L.) All.	Ther	Zoochore	Annual	C3	Eudicots	Med. As.	5,1	6,44	5,11	16,65
Frankeniaceae (2.94%)	<i>Frankenia pulverulenta</i> L.	Ther	Barochore	Annual	C3	Eudicots	Med	0,7	0,54	0,68	1,92
Heliotropiaceae (2.94%)	<i>Heliotropium bacciferum</i> Forsk.	Cham	Barochore	Perennial	C3	Eudicots	SA	0,35	0,54	0,37	1,26
Malvaceae (2.94%)	<i>Malva parviflora</i> L.	Ther	Barochore	Annual	C3	Eudicots	Med	4,57	7,53	4,59	16,69
Fumariaceae (2.94%)	<i>Fumaria numidica</i> Pomel	Ther	Zoochore	Annual	C3	Eudicots	Circumboreal	0,88	0,54	0,9	2,32
Poaceae (14.71%)	<i>Cutandia dichotoma</i> (Forsk.) Trab.	Ther	Anemochore	Annual	C4	Monocots	Med	1,93	1,07	1,95	4,95
	<i>Cynodon dactylon</i> (L.) Pers.	Hemi	Barochore	Perennial	C4	Monocots	Cosmop	3,87	3,22	3,85	10,94
	<i>Lolium multiflorum</i> Lamk.	Ther	Barochore	Annual	C3	Monocots	Med	2,81	1,61	2,79	7,21
	<i>Phalaris minor</i> Link.	Ther	Zoochore	Annual	C3	Monocots	PSTr	4,22	2,69	4,22	11,13
	<i>Polypogon monspeliensis</i> (L.) Desf.	Ther	Zoochore	Annual	C3	Monocots	PSTr	2,11	1,07	2,11	5,29
Polygonaceae (2.94%)	<i>Emex spinosa</i> (L.) Campd.	Ther	Zoochore	Annual	C3	Eudicots	Med	7,38	10,21	7,38	24,97
Primulaceae (2.94%)	<i>Anagallis arvensis</i> L.	Ther	Anemochore	Annual	C3	Eudicots	Cosmop	18,45	13,44	18,45	50,34
Ranunculaceae (2.94%)	<i>Adonis dentata</i> Del.	Ther	Zoochore	Annual	C3	Eudicots	Med	2,28	2,69	2,27	7,24
Rubiaceae (2.94%)	<i>Galium aparine</i> L.	Ther	Zoochore	Annual	C3	Eudicots	PTm	0,17	0,54	0,16	0,87
Scrophulariaceae (2.94%)	<i>Veronica anagallis-aquatica</i> L.	Hemi	Barochore	Perennial	C3	Eudicots	Circumboreal	0,17	0,54	0,16	0,87

751 Table 2. Importance values of the weed species in group 1 (G1) of SW Algeria.

Species	Total density	Species frequency	Frequency class	Relative abundance	Relative frequency	Relative density	Importance Value Index
<i>Anagallis arvensis</i> L.	66	100	Classe V	44	22,22	44	110,22
<i>Bassia muricata</i> (L.) Asch.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Brassica rapa</i> L.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Calendula aegyptiaca</i> Desf.	4	20	Classe II	2,67	4,44	2,67	9,78
<i>Calotropis procera</i> Ait.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Chenopodium murale</i> L.	3	30	Classe II	2	6,67	2	10,67
<i>Chenopodium album</i> L.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Emex spinosa</i> (L.) Camp.	8	40	Classe III	5,33	8,89	5,33	19,55
<i>Fumaria numidica</i> Pomel	5	10	Classe I	3,33	2,22	3,33	8,88
<i>Launaea glomerata</i> (Cass.) Hook.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Malva parviflora</i> L.	6	30	Classe II	4	6,67	4	14,67
<i>Melilotus indicus</i> (L.) All.	4	20	Classe II	2,67	4,44	2,67	9,78
<i>Pergularia tomentosa</i> L.	1	10	Classe I	0,67	2,22	0,67	3,56
<i>Sisymbrium irio</i> L.	3	30	Classe II	2	6,67	2	10,67
<i>Sonchus oleraceus</i> L.	44	100	Classe V	29,33	22,22	29,33	80,88
<i>Veronica anagallis-aquatica</i> L.	1	10	Classe V	0,67	2,22	0,67	3,56

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Table 3. Importance values of the weed species in group 2 (G2) of SW Algeria.

Species	Total density	Species frequency	Frequency class	Relative abundance	Relative frequency	Relative density	Importance Value Index
<i>Adonis dentata</i> Del.	11	30	Classe II	3,93	3,85	3,93	11,71
<i>Anagallis arvensis</i> L.	29	90	Classe V	10,36	11,54	10,36	32,26
<i>Asphodelus tenuifolius</i> Cavan.	26	40	Classe II	9,28	5,13	9,28	23,69
<i>Bassia muricata</i> (L.) Asch.	1	10	Classe I	0,36	1,28	0,36	2
<i>Beta vulgaris</i> L.	1	10	Classe I	0,36	1,28	0,36	2
<i>Brassica toumefortii</i> Gouan	3	10	Classe I	1,07	1,28	1,07	3,42
<i>Calendula aegyptiaca</i> Desf.	21	60	Classe III	7,5	7,69	7,5	22,69
<i>Chenopodium murale</i> L.	12	30	Classe II	4,28	3,85	4,28	12,41
<i>Chenopodium album</i> L.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Cynodon dactylon</i> (L.) Pers.	19	40	Classe II	6,78	5,13	6,78	18,69
<i>Emex spinosa</i> (L.) Camp.	26	90	Classe V	9,28	11,54	9,28	30,1
<i>Galium aparine</i>	1	10	Classe I	0,36	1,28	0,36	2
<i>Launaea glomerata</i> (Cass.) Hook.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Launaea resedifolia</i> (L.) O. Kuntze.	1	10	Classe I	0,36	1,28	0,36	2
<i>Leontodon muelleri</i> Ball.	6	20	Classe I	2,14	2,56	2,14	6,84
<i>Lobularia libyca</i> (Viv.) Webb.	1	10	Classe I	0,36	1,28	0,36	2
<i>Lolium multiflorum</i> Lam.	15	20	Classe I	5,36	2,56	5,36	13,28
<i>Malva parviflora</i> L.	16	70	Classe IV	5,71	8,97	5,71	20,39
<i>Melilotus indicus</i> (L.) All.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Phalaris minor</i> Retz.	24	50	Classe III	8,57	6,41	8,57	23,55
<i>Polypogon monspeliensis</i> (L.) Desf.	7	10	Classe I	2,5	1,28	2,5	6,28
<i>Senecio massaicus</i> Maire	2	20	Classe I	0,71	2,56	0,71	3,98
<i>Silene rubella</i> L.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Sisymbrium irio</i> L.	1	10	Classe I	0,36	1,28	0,36	2
<i>Sonchus oleraceus</i> L.	49	100	Classe II	17,5	12,82	17,5	47,82

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Table 4. Importance values of the weed species in group 3 (G3) of SW Algeria.

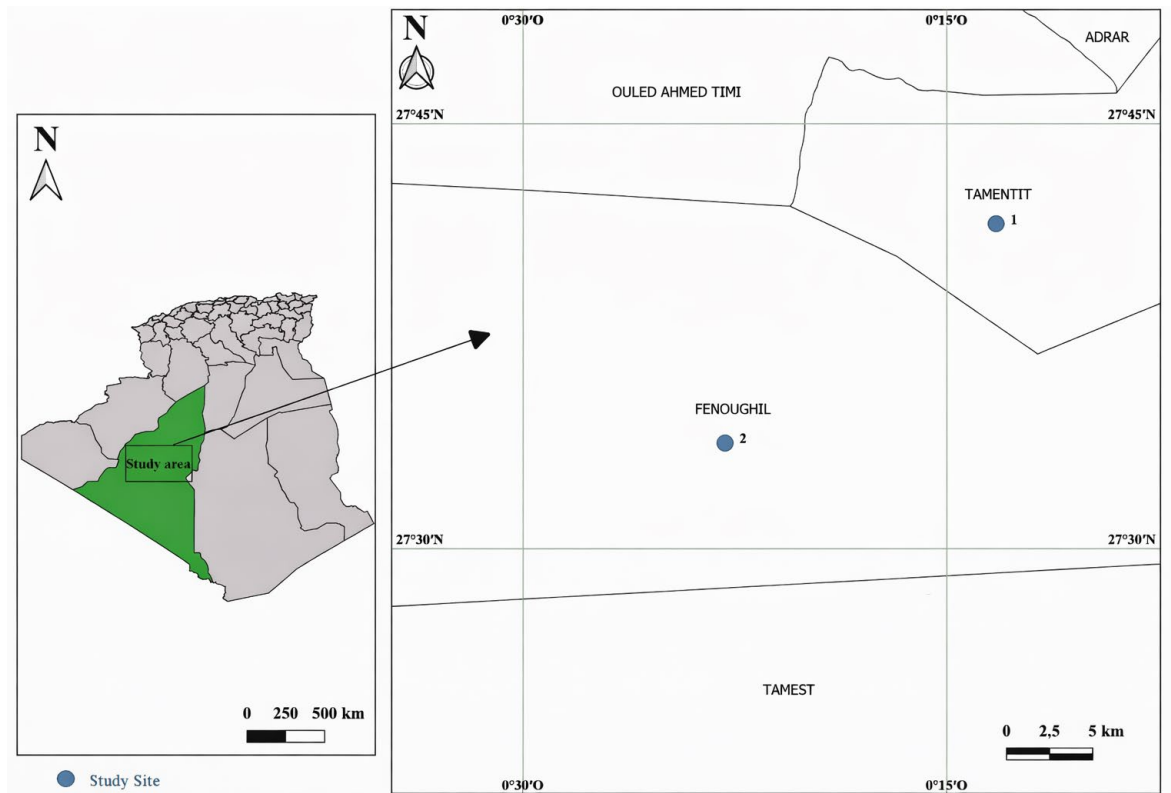
Species	Total density	Species frequency	Frequency class	Relative abundance	Relative frequency	Relative density	Importance Value Index
<i>Adonis dentata</i> Del.	11	30	Classe II	3,93	3,85	3,93	11,71
<i>Anagallis arvensis</i> L.	29	90	Classe V	10,36	11,54	10,36	32,26
<i>Asphodelus tenuifolius</i> Cavan.	26	40	Classe II	9,28	5,13	9,28	23,69
<i>Bassia muricata</i> (L.) Asch.	1	10	Classe I	0,36	1,28	0,36	2
<i>Beta vulgaris</i> L.	1	10	Classe I	0,36	1,28	0,36	2
<i>Brassica toumefortii</i> Gouan	3	10	Classe I	1,07	1,28	1,07	3,42
<i>Calendula aegyptiaca</i> Desf.	21	60	Classe III	7,5	7,69	7,5	22,69
<i>Chenopodium murale</i> L.	12	30	Classe II	4,28	3,85	4,28	12,41
<i>Chenopodium album</i> L.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Cynodon dactylon</i> (L.) Pers.	19	40	Classe II	6,78	5,13	6,78	18,69
<i>Emex spinosa</i> (L.) Camp.	26	90	Classe V	9,28	11,54	9,28	30,1
<i>Galium aparine</i>	1	10	Classe I	0,36	1,28	0,36	2
<i>Launaea glomerata</i> (Cass.) Hook.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Launaea resedifolia</i> (L.) O. Kuntze.	1	10	Classe I	0,36	1,28	0,36	2
<i>Leontodon muelleri</i> Ball.	6	20	Classe I	2,14	2,56	2,14	6,84
<i>Lobularia libyca</i> (Viv.) Webb.	1	10	Classe I	0,36	1,28	0,36	2
<i>Lolium multiflorum</i> Lam.	15	20	Classe I	5,36	2,56	5,36	13,28
<i>Malva parviflora</i> L.	16	70	Classe IV	5,71	8,97	5,71	20,39
<i>Melilotus indicus</i> (L.) All.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Phalaris minor</i> Retz.	24	50	Classe III	8,57	6,41	8,57	23,55
<i>Polypogon monspeliensis</i> (L.) Desf.	7	10	Classe I	2,5	1,28	2,5	6,28
<i>Senecio massaicus</i> Maire	2	20	Classe I	0,71	2,56	0,71	3,98
<i>Silene rubella</i> L.	2	10	Classe I	0,71	1,28	0,71	2,7
<i>Sisymbrium irio</i> L.	1	10	Classe I	0,36	1,28	0,36	2
<i>Sonchus oleraceus</i> L.	49	100	Classe II	17,5	12,82	17,5	47,82

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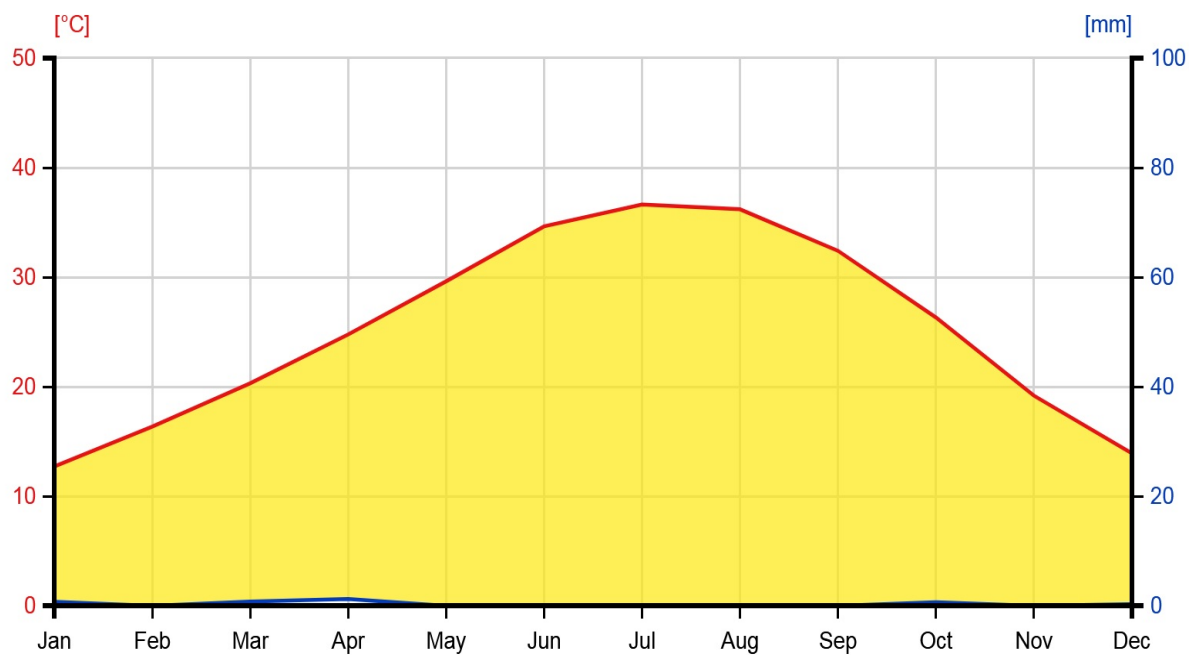
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771 **Figures**

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774 **Figure 1.** Location of the study area



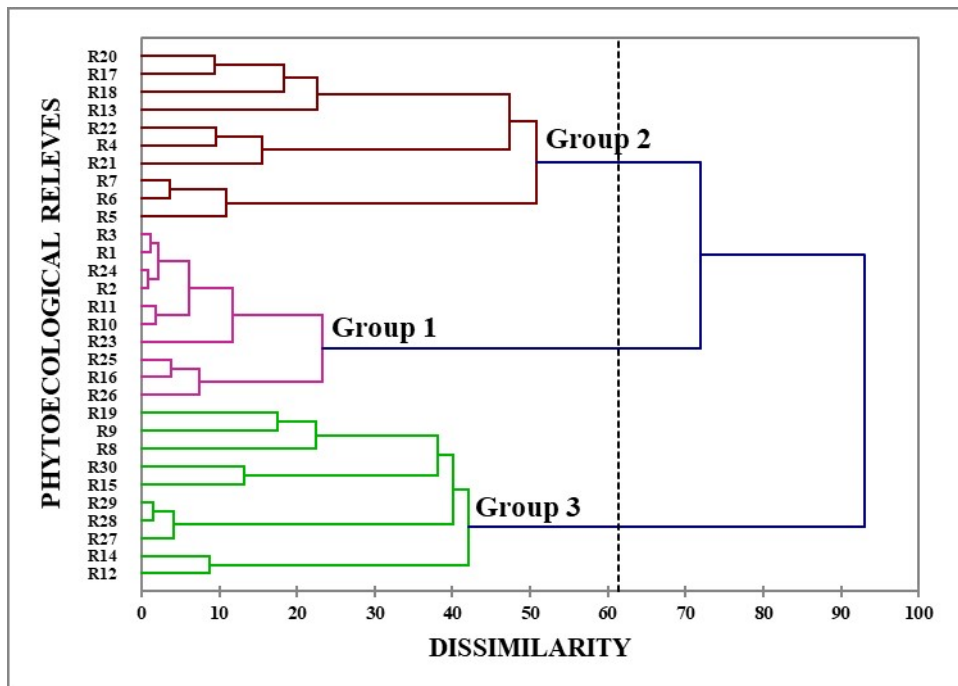
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776 **Figure 2.** Ombrothermic diagram of Bagnouls & Gausson (1953) of the Adrar region (1990-

777 2019) of SW Algeria

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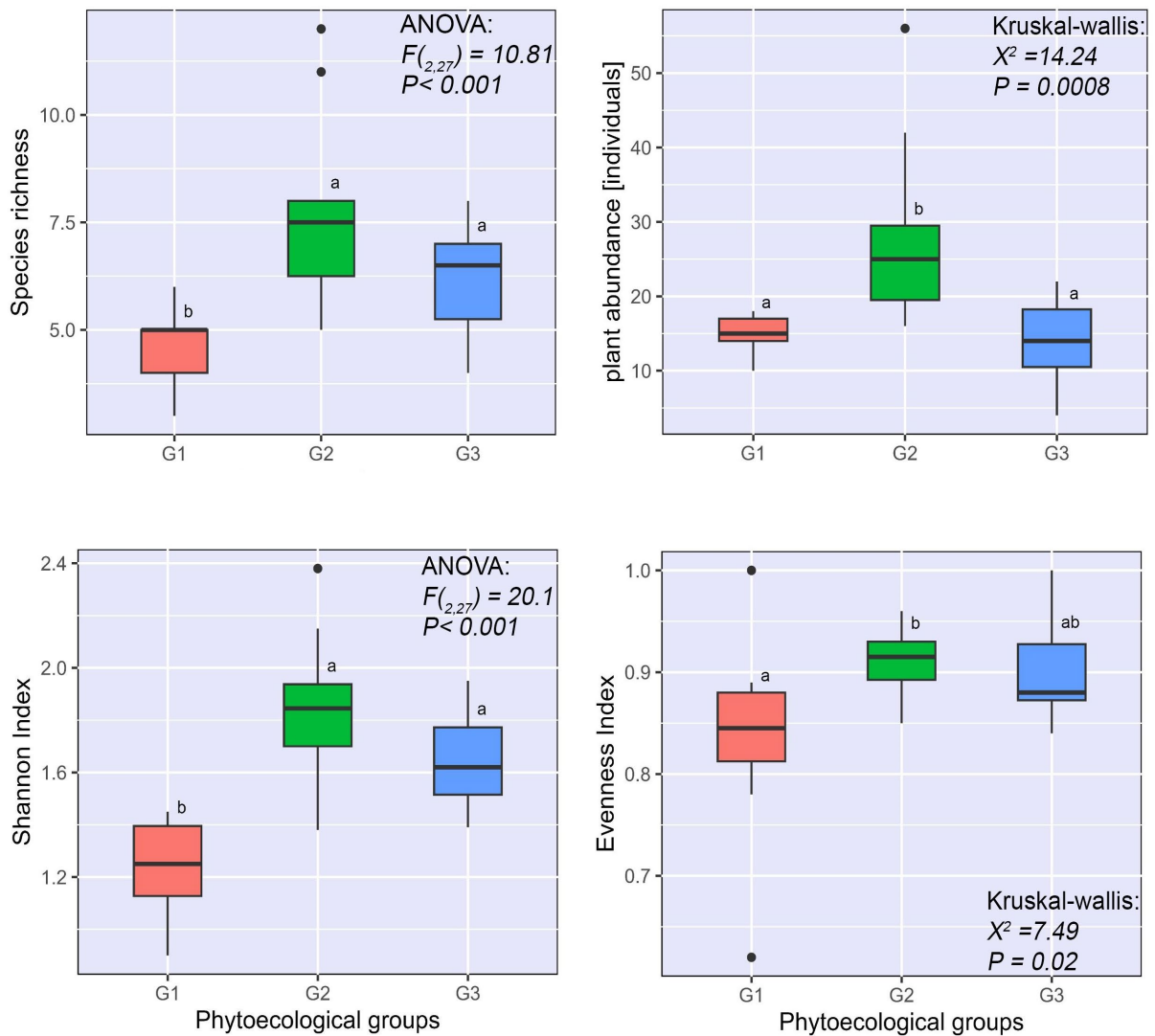
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781 **Figure 3.** Weed phytoecological groups of cereal crops of SW Algeria.

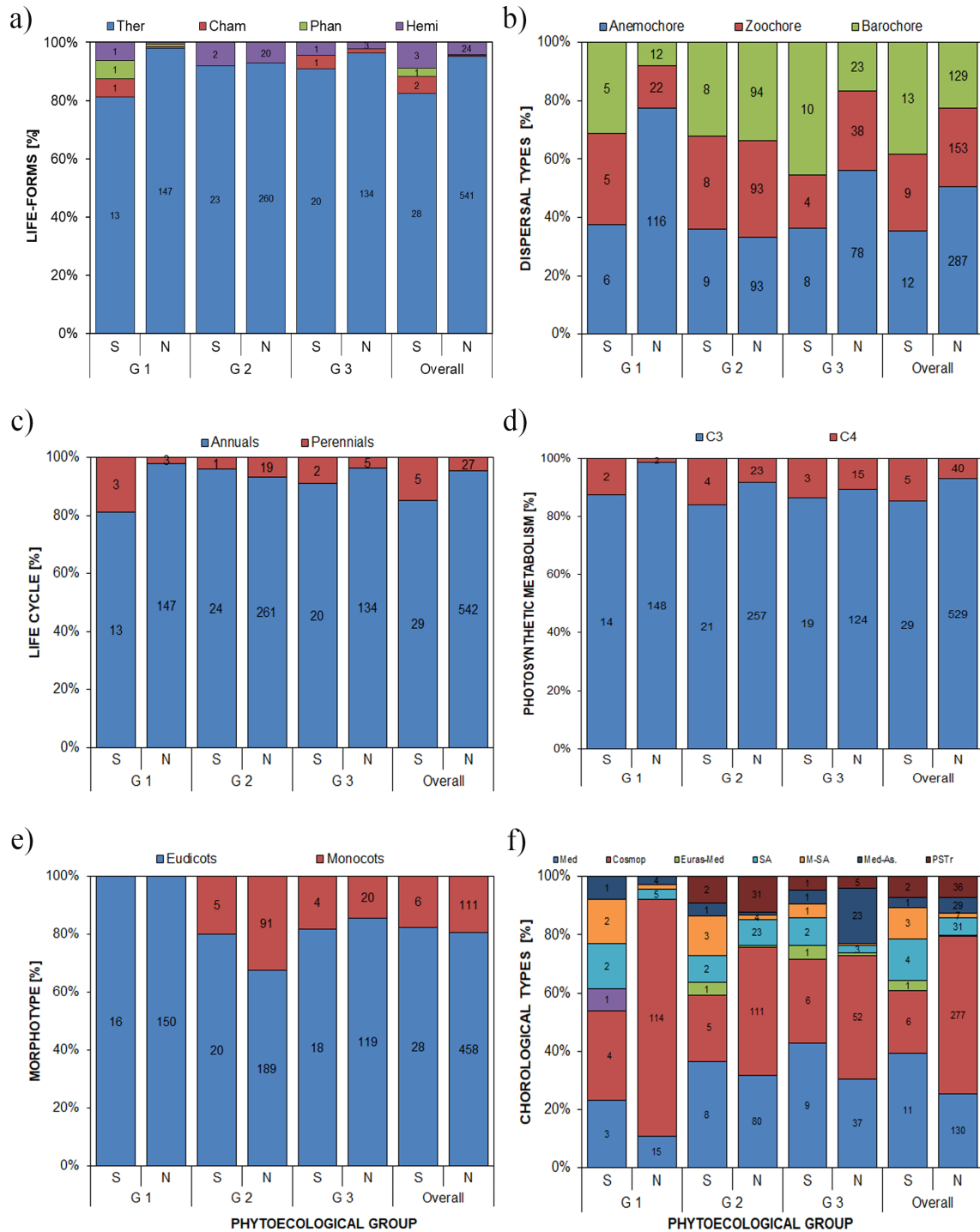
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784 **Figure 4.** Boxplots showing the variation of plant diversity parameters for different  
785 phytoecological groups of weed communities studied in the agrosystems of SW Algeria.

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788 **Figure 5.** Raw (based on specific richness “S”) and real (based on abundance “N”) spectra of  
789 functional plant traits of weed groups studied in SW Algerian agrosystems.

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