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Floristic Diversity and Demographic Structure of Ouled Bechih Forest (Algeria)

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ABSTRACT

In context of global change, biodiversity loss poses a serious problem in the Mediterranean basin. In Algeria, degradation problems (logging, deforestation, bush fires and agriculture) affect vegetation. Knowledge of vegetation characteristics is necessary to manage disturbed areas. That is why this study focused on demographic structure of main species of Ouled Bechih forest (Quercus canariensis and Quercus suber). On eight plots representing this forest of 900 m^2, chosen at random, dendrometric and phytosociological parameters were collected. The results obtained reveal a total specific richness of 41 species. Principal families are Asteraceae (21.95%) and Fabaceae (7.32%). Average woody density is 154 individuals/ha with an average basal area of 27.33 m^2/ha. Variance analysis shows that there is a high significant difference between the dendrometric parameters ($p<0.001$). Diameter and height structures are consistent with Weibull distribution. These structures indicate that trees are moderately stable with predominance of large diameter individuals. The results obtained will allow monitoring the vegetation dynamics and will help foresters to put in place a management plan to preserve this forest.

Keywords: Ouled Bechih forest, floristic richness, demographic structure, variance analysis.

INTRODUCTION

Various recent studies have drawn the attention of biologists and geneticists to remarkable interest of Mediterranean forests in terms of their specific plant richness [Médail, 2018]. Thus, these forests are composed by 250 species of trees which 150 are highly preferential against 135 in the European region and 14 genera. These forests are threatened with extinction, losing 1.2% of their surface area each year. Oak forests are one of the most fragile ecosystems due to pressure of many factors, impact of which is exacerbated by human activity [Prévosto et al., 2015]. Algeria has a forest resource characterized by great variability associated with the entire range of Mediterranean bioclimates, from the humid to the Saharan bioclimate. Algerian forests have a low diversity of plants, some of them are highly endemic [Derbal et al., 2015]. Oak forests are particularly important in Algeria due to their ecological and economic roles in rural areas [Toubal et al., 2014]. Sustainable use of these important forest ecosystem services requires sustainable forest management. In-depth, knowledge of structural and ecological characteristics is essential for this purpose [Ahononga et al., 2020]. Density, diameter structure, height structure and distribution of trees are important parameters to characterize the population's demographics [Herrero-Jáuregui et al., 2012]. Population's structure and biodiversity are two important characteristics of forest [Pastorella & Paletto, 2013]. This structure has an effect on aesthetic values and biodiversity [Su et al., 2012; Tan et al., 2011; Lee et al., 2022]. This research aimed to assess the woody diversity and demographic structure of the Oued Bechih forest.

MATERIAL AND METHODS

Study area

The study region (Ouled Bechih) is located in high plateaus of eastern Algeria, near Tunisian-Algerian border (Fig. 1). Two species are the main components of this forest over an area 6582 ha. Forest extreme altitudes range from 400 m-1050 m, with geographic coordinates of 36° 21' 26" N and 7° 50' 08" E. Slopes have a range of steepness from 15 to 25%. Climate of region is subhumid (16°C and 625 mm) and atmospheric humidity of 68% [Ganaoui et al., 2019; Touafchia et al., 2022].

Selection of study plots

Random sampling method was adopted. Inventory plots of 30 m × 30 m are installed. To characterize woody vegetation, a forest inventory was carried out and only adult individuals are measured [Hounto et al., 2017; Rached-Kanouni et al., 2020]. Diameter at breast height (1.30 m) and total height of trees are measured in this study [Goba et al., 2019].

Phyto-sociological surveys and analysis of floristic data

For data collection, Braun-Blanquet abundance-dominance method is adopted [Savadogo et al., 2011; Hounto et al., 2017]. Five main life forms are considered in this study (therophytes, hemicryptophytes, geophytes, chamaephytes and phanerophytes) to draw up the overall spectrum of biological types.

Dendrometric parameters

Calculated dendrometric parameters are: density (N), basal area (G) and volume (V) in order to compare the stands. Density N is average number of trees per hectare, given by following formula:

$$N = \frac{n}{s} \qquad [1]$$

where: *n* – number of trees, *s* – area in hectares.

Basal area (*G*) in m²/ha, is the sum of cross-sections at 1.30 m height from ground of all trees:

$$G = \frac{\pi}{4s} \sum_{i=1}^{n} d_i^2 \qquad [2]$$

where: *di* – the diameter of tree *i*, and *s* area (ha) [Rabiou et al., 2019].

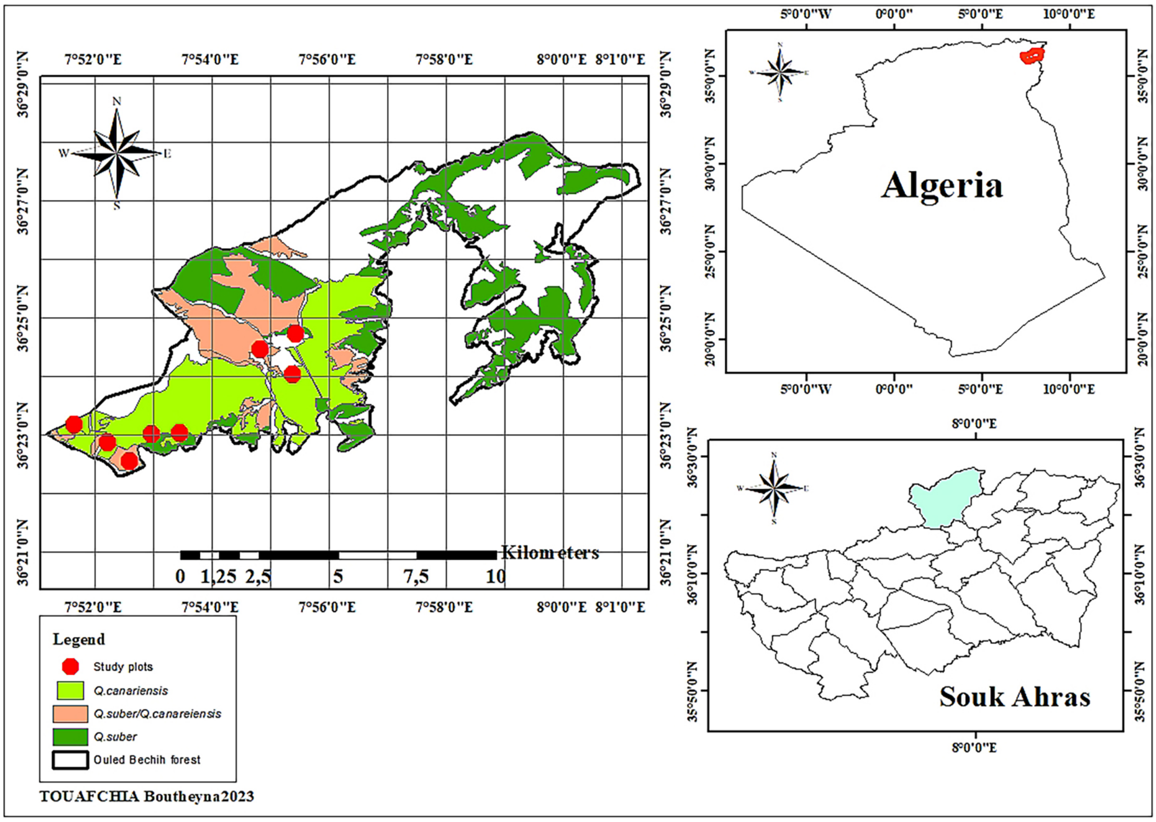

Figure 1. Study area

Volume is a particularly important dendrometric criterion for characterizing a stand. It is important to many foresters because it is related to commercial transactions. Indeed, knowing the volume present on a plot can help to deduce potential harvest. It is dependent on stand area and height of trees, is given by formula of:

$$V = \sum vi = [gi * hi] * 0.53 \quad [3]$$

where: gi –basal area of individual i, hi –height of individual i, 0.53 – shape coefficient.

In order to process the data collected on diameter structures and stand densities, a statistical analysis of variance is used, a parametric test to compare the means, including height, diameter, stand area and volume. Newman-Keuls test was applied for this comparison at the significance level of 0.05.

Demographic structure

According to diameter and height classes, the demographic structure of forest was analyzed. These classes are used to build distribution histograms. A goodness-of-fit test to theoretical Weibull distribution using Minitab 16 software [Abdourhamane et al., 2013; Laouali et al, 2016; Garba et al., 2020]

Corresponding probability density function f(x) is given by the following expression:

$$f(x) = \frac{c}{b}(x - a/b)^{c-1}\, exp\left[-\left(\frac{x-a}{b}\right)^{c}\right] \quad [4]$$

where: x – diameter or height of trees.

RESULTS

Floristic richness

Floristic richness is 41 species, belonging to 23 families and 39 genera (Table 1). Asteraceae family is most represented (21.95%, or 8 genera) followed by µ Fabaceae family (7.32%, or 3 genera). Other families include species very poorly represented (≤ 2 species, or 4.88% and 2.44%). Flora is essentially composed of woody plants, which constitute a large number of adult trees. With 41 species, hemicryptophytes are the best represented biological type in this forest (31.71%). After hemicryptophytes, geophytes come in second place (24.40% of the specific set). Chamaephytes are very poorly represented (4.88%). Chorological analysis shows that Mediterranean species dominate flora inventoried (41.46%), following by Southern European species (17.07%), western Mediterranean species (12.20%) and cosmopolitan species (9.76%). Other chorological types are the least represented for inventoried species (19.51%).

Dendrometric parameters

In total, 1233 trees are inventoried in study area, with 278 trees/ha of Q. suber, 589 individuals/ha of Q. canariensis and 367 individuals/ha for mixed plots. A comparison of means to dendrometric parameters by ANOVA indicates a very significant difference into these parameters ($p<0.0001$) (Table 2). Basal area determines state of forest species in stand. Average basal area is 27.33 m^2/ha with the highest in plot P5 (40.67±1.40 m^2/ha), while the lowest was found in plot 2 (19.51±0.84 m^2/ha). From a specific point of view, this parameter varies from 37.53 m^2/ha to 25.51 m^2/ha for Q.suber and Q.canariensis, respectively, and to 10.38 m^2/ha in mixed plots. Volume (total /exploitable) is a particularly important dendrometric parameter for characterizing a stand. Quality of wood can affect the exploitable potential of stands. The latter is defined in relation to a context of use, in this study threshold of exploitability is diameter strictly greater than 40 cm. Depending on basal area and height of trees, there is a difference significant between values of total and exploitable volumes between species and plots. Plots studied offer a total volume of 208.90 m^3/ha or an exploitability of 41.89 m^3/ha (Table 2). Two plots (P8, P1) show a superiority in volume (respectively 349.13 m^3/ha and 62.16 m^3/ha; 278.95 m^3/ha and 54.92 m^3/ha). A high height and a significant basal area characterize these two plots, compared to the other plots.

Demographic structure

Diameter of trees is considered an integral parameter for describing structural and demographic properties of a forest stand. Average trees diameter is estimated at 43.06 cm. Diameter structures of trees species are illustrated in Figure 2. The analysis of these parameters shows that most of the diameter structures present a left-skewed distribution (negatively), characteristic trees with large diameters. These represent 43.40% of stands, of which 18.05% represent diameters >50 cm. With exception of plot 1 which has a shape parameter c

Table 1. Flora inventoried in Ouled Bechih forest

Family	Genre	Species	Biological type	Chorological type
Araceae	Arum	*Arum italicum* Mill.	GE	Med
	Arisarum	*Arisarum vulgare* O.Targ.Tazz.	GE	Med
Apiaceae	Daucus	*Daucus carota* L	HE	Eur
	Scandix	*Scandix pecten-veneris* L	TH	Sou- Eur
Asparagaceae	Charybdis	*Charybdis maritima* (L.) Speta.	GE	Med
Asteraceae	Hypochaeris	*Hypochaeris glabara* L	TH	Sou- Eur
	Hyoseris	*Hyoseris radiate* L	HE	Med
	Bellis	*Bellis sylvestris* Cirillo.	HE	Med
		Bellis prennis L	HE	Med
	Artemisia	*Artemisia arborescens* (Vaill.) L.	CH	Wes-Med
	Galactites	*Galactites tomentosus* Moench.	HE	Med
	Notobasis	*Notobasis syriaca* (L.) Cass.	TH	Med
	Heiracium	*Heiracium pilosella* (Willd.) Arv.-Touv	HE	Eur
	Taraxacum	*Taraxacum erythrospermum* Andrs. ex Besser	HE	Eur
Caryophyllaceae	Stellaria	*Stellaria media* (L.) Vill.	HE	Cos
	Silene	*Silene coronaria* (L.) Claiv.	CH	Sou- Eur
Convolvulaceae	Calystegia	*Calystegia sepium* (L.) R.Br.	HE	Cos
Crassulaceae	Umbilicus	*Umbilicus horizontalis* (Gess.) DC.	GE	Med
Dennstaedtia	Pteridium	*Pteridium aquilinum* (L.) Kuhn.	GE	Cos
Ericaceae	Erica	*Erica arborea* L.	PH	Cos
Euphorbiaceae	Euphorbia	*Theligonum cynocambe* L.	TH	Med
Fabaceae	Calicotume	*Calicotume spinose* (L.) Link	PH	Cen-Med
	Lotus	*Lotus corniculatus* L.	HE	Sou- Eur
	Cytisus	*Cytisus villosus* Pourr.	PH	Wes-Med
Fagaceae	Quercus	*Quercus canariensis* Willd.	PH	Wes-Med
		Quercus suber L.	PH	Wes-Med
Iridaceae	Romulea	*Romulea bulbocodium* (L.) Sebast. & Mauri	GE	Med
Lamiaceae	Glechoma	*Glechoma hederacea* L.	HE	Eura
Liliaceae	Gagea	*Gagea pratensis* (Pers.) Dumort.	GE	Sou- Eur
	Asphodelus	*Asphodelus albus* Mill.	GE	Med-Atl
Myrtaceae	Myrtus	*Myrtus communis* L.	PH	Med
Oleaceae	Phillyrea	*Phillyrea angustifolia* L.	PH	Med
Primulaceae	Cyclamen	*Cyclamen hederifolium* Aiton.	GE	Sou- Eur
Polygonaceae	Rumex	*Rumex acetosa* L.	HE	Cir
Ranunculaceae	Ranunculus	*Ranunculus muricatus* L.	TH	Med
	Ficaria	*Ficaria verna* Huds.	GE	Sou- Eur
Rosaceae	Rubus	*Rubus ulmifolius* Schott	HE	Med-Atl
	Carataegus	*Carataegus monogyna* Jacq.	PH	Eura
Rubiaceae	Theligonum	*Theligonum cynocambe* L.	TH	Med
	Galium	*Galium verrucosum* Huds.	TH	Med
Thymelaeaceae	Daphne	*Daphne gnidium* L.	PH	Med

of 3.33; the stands with a dominant medium-height population have a bell-shaped height structure and positive skewed distribution. Height structure analysis of forest shows that the c value is always greater than 3.6. This result attests to a predominance of tall individuals. The trees in height classes between 8 and 20 m are most common with a percentage of 92.07% (Fig. 3).

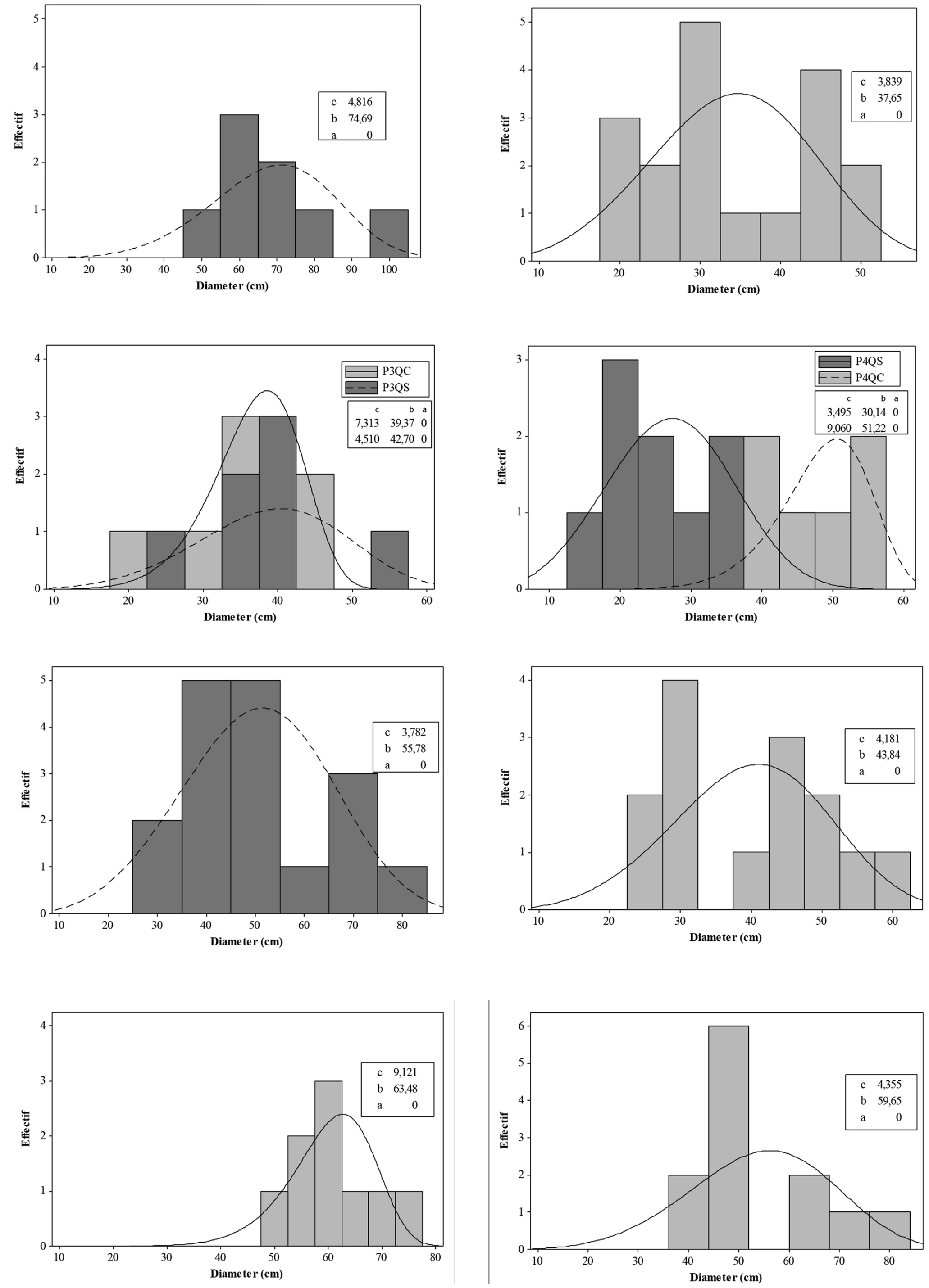

Figure 2. Diameter structure of study plots

DISCUSSION

The forest of Ouled Bechih includes 41 species with 39 genera and 23 families. Most important families are Asteraceae and Fabaceae (Table 1). The obtained results are in perfect agreement with those of several authors who made same observations on the entire vegetation of North Africa [Miara et al., 2017; Guit et Nedjimpi, 2019]. Asteraceae family has a remarkable ecological importance; it is present in Polar Regions to tropics, colonizing all available habitats. Strong presence of this family is due to their high resistance and adaptation to climatic variations [Kargar Chigani et al., 2017]. Kuster et al. [2016] noted that the abundance of Asteraceae family may be due to morphological, anatomical and physiological

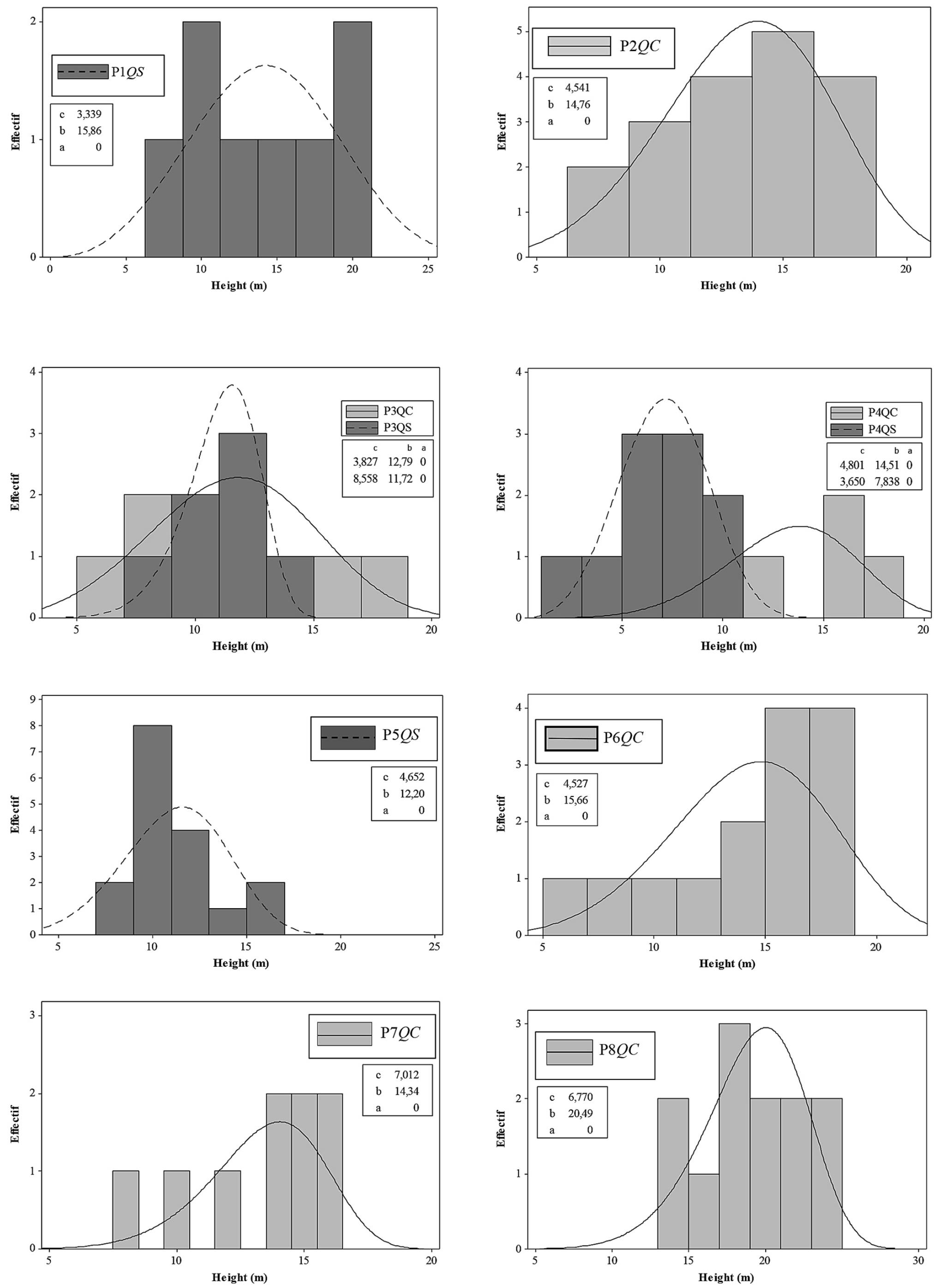

Figure 3. Height structure of study plots

characteristics of his species. Mota et al., [2017] added that Asteraceae are highly adaptable to local stationary conditions.

Biological type is morphological and physiological adaptation form of a category of plants to ecological constraints and disturbances. Hemicryptophytes, therophytes and geophytes represent a majority category compared to other biological types. This type of vegetation is characteristic of Mediterranean bioclimatic environments that are located below the sub-humid bioclimatic stage with a cold winter. The resistance of Hemicryptophytes to the cold of manganese regions explains their high dominance [Mota et al., 2017]. Indeed, high coverage of forest by study species allows a large amount accumulation of organic matter. Geophytes are therefore quite common in study area. They are persistent plants during bad season in form of renewal organs buried in soil. The percentage

Table 2. Dendrometric parameters of adult trees

Plot	H (m)	D (cm)	G (m^2/ha)	Vtot (m^3/ha)	Vexp (m^3/ha)
P1	14.19^{b} ±5.10	68.71^{a} ±15.46	34.40^{b} ± 2.02	278.95^{a} ± 22.56	54.92^{b} ± 3.08
P2	13.44^{b} ± 3.56	33.95^{c} ± 10.14	19.62^{c} ± 0.62	149.91^{b} ± 5.46	27.93^{c} ± 1.39
P3	11.35^{bc} ± 2.81	37.75^{c} ± 7.88	22.00^{c} ±0.54	137.86^{b} ± 4.63	33.14^{c} ± 1.55
P4	9.38^{c} ± 4.15	35.15^{c} ±13.15	19.51^{c} ±0.84	122.17^{b} ± 7.77	23.99^{c} ± 0.99
P5	11.21^{bc} ±2.49	50.39^{b} ± 14.69	40.67^{a} ± 1.40	255.70^{a} ± 10.88	60.24^{a} ± 2.34
P6	14.23^{b} ± 4.01	39.81^{c} ± 10.80	20.67^{c} ± 0.79	168.91^{b} ± 8.27	32.98^{c} ± 1.72
P7	13.34^{b} ± 2.68	60.33^{ab} ± 7.35	28.95^{b} ± 0.79	208.55^{b} ± 8.13	39.78^{bc} ± 1.43
P8	19.12^{a} ± 3.42	54.46^{b} ± 13.50	32.79^{b} ± 1.41	349.13^{a} ± 18.78	62.16^{a} ± 3.92
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

of phanerophytes and therophytes remains quite average at the level of Mediterranean plant formations [Abdelmoumen et Zoheir, 2015]. Therophytes adapt better to environmental conditions. Indeed, they complete their cycle during rainy season and pass dry season in seed state, so they are less affected by harsh environmental conditions [Idrissa et al., 2010]. Chamaephytes are least represented kind of vegetation in study area. The low number of these plants may indicate a good state of health in the forest and pre-forest formations [Miara et al., 2017]. Regarding phytogeographic types, Mediterranean is most dominant. For forest formations in Algeria, they seem to be in line with observations for the Maghreb [Beghami et al., 2015]. Phytogeographic types are good indicators of dynamism or stability of plant communities. However, high proportion of species with a wide distribution is an indicator of disturbance and indicates that flora is losing its specificity [Thomas et al., 2023]. The structure of vegetation and its variability are functioning indicators of ecosystem and its state [Ostertag et al., 2014]. It has been shown that the patterns of structural composition and distribution of forest plant communities depend on ecological characteristics of vegetation, not just listing a series of plant species, but exploring different mechanisms that allow their coexistence [Alves et al., 2010; Biresaw et Pavliš, 2010; Mangambu et al., 2015]. Density and canopy cover are two structural attributes that provide the information about forest cover and its state [Khalid et al., 2015].

Overall analysis of main species in study area reveals a density that is average 154 individuals/ha (Table 2). This result is more or less similar to those of forest formations of Hafir and Zariffet forests for western region of Algeria [Letreuch-Belarouci et al., 2010]. This observed difference may be due to sample size. From a specific point of view, density of the *Q. suber* formation (278 individuals/ha) is lower than the density of the *Q. canariensis* formation (589 individuals/ha). This low density is linked to anthropogenic actions (fires, logging, grazing…). Diameter structures of trees in study forest show that their future is not guaranteed. This situation occurs when the frequency of small-diameter stems (young individuals) is lower than that of large-diameter individuals (old individuals) in natural populations [Hounkpèvi et al., 2011].

Diameter and height structures are often fitted to theoretical models to simplify analyses and interpretations. The diameter structure of forest formations in Ouled Bechih generally presents a left-skewed or negatively skewed distribution, characteristic of monospecific stands by majority of old or large-diameter individuals, with a dominance of trees with a diameter between 27.5 cm and 47.5 cm (589 trees/ha). The trees with large diameters represent 43.40%, while individuals with diameters >50 cm represent 18.05% of two populations. In addition, height structures analysis of trees shows a predominance of size individuals between 10 and 20 m (844 individuals/ha). On the basis of the previous results, it is noted that there are no small-diameter classes of study tree species. Climatic variations in recent years (decrease in precipitation during winter and increase in summer temperatures) may explain the absence of some diameter classes in the study area [Rached-Kanouni et al., 2020]. According to literature, adaptations to ecological conditions, competition for resources, anthropogenic activities and exploitation would be at base of structural variability [Herrero-Jáuregui et al., 2012; Sandjong Sani et al., 2017].

CONCLUSIONS

This study focused on Ouled Bechih forest, which is composed specifically of *Q. suber* and *Q. canariensis*, covering an area of 6582 hectares and presents a major ecological and economic interest for the region. The data collected in this study made it possible to analyze the floristic diversity and describe demographic structure of trees in this forest. For floristic diversity, Asteraceae and Fabaceae are dominant. Mediterranean hemicryptophyte species constitute most represented chorological and biological types. The analysis state of populations trees revealed that they are unstable, characterized by the predominance of large-diameter trees. Under these conditions, the results of this research are useful for the management of *Q. suber* and *Q. canariensis* populations.

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