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CONSIDERATION OF DENDROMETRIC AND ECOLOGICAL CHARACTERISTICS AS INDICATORS OF REHABILITATION OF ATLAS PISTACHIO STANDS (*PISTACIA ATLANTICA* DESF.): CASE OF THE SOUTHWESTERN REGION OF NAAMA (WESTERN ALGERIA)

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Abstract
As part of this research, we made a dendrometric and ecological characterization of the Atlas pistachio stands located in the Naâma region through a series of dendro-architectural measurements and observations and floristic surveys.
These stands are characterized dendrometrically by the presence of a pure stand with a regular structure dominated by very big wood (VBW) with 51,20%. The healthy tree and resilient tree ARCHI type are the most dominant with 65,10% and 23,20% respectively.
From an ecological point of view, the stands studied harbor a low floristic diversity, made up of 21 species belonging to 20 genera and 13 botanical families. This low richness which is characterized by the dominance of chamaephytes (47,62%) and therophytes (23,81%) is the result combined of anthropogenic pressure and climatic aridity.

Keywords: Atlas pistachio tree, dendro-architectural, floristic diversity, Naâma.

1. INTRODUCTION

Pistacia atlantica Desf. of the Anacardiaceae family is a woody and spontaneous species that can exceed 20 m in height (Zohary 1952; Belhadj et al., 2007; Guerine et al., 2020). This species is common to the two Mediterranean and Irano-Turanian regions, it is qualified as endemic to North Africa, where it constitutes tree steppes of the arid and semi-arid bioclimate (Monjause, 1980; Belhadj, 2002; Ozenda, 2004; Quézel and Médail, 2003; Belhadj et al., 2008).

This tree has a remarkable ecological amplitude and plasticity since it is found from the heart of the Sahara to the margins of the humid bioclimate (Quézel and Médail, 2003; Ifticene-Habani and Messaoudene, 2016). The species is characterized by very slow growth, but it has the advantage of being the only one that can organize forest ecosystems in arid and semi-arid regions (Yaaqobi et al., 2009).

The Atlas pistachio tree is a fairly common species in Algeria, but it finds its optimum in arid and semi-arid regions, notably the Hautes-Plaines where it thrives in the beds of wadis and Groves (Monjauze, 1980; Ifticene-Habani and Messaoudene, 2016).

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Our objective is to analyze the structure of the groves of *Pistacia atlantica* Desf. in the region of Gaâloul (Western Algeria) in order to have the necessary indicators for the development of an appropriate management plan for these settlements.

2. MATERIALS AND METHODS

2.1 Study area

The study area is part of the high steppe plains, it is administratively attached to the wilaya of Naâma (western Algeria) (Fig. 1). This is a region essentially with a pastoral vocation, which is characterized by its climatic aridity (Benhabyles, 2012). The region studied consists of a zone of plains represented by continental formations, a zone of relief represented by Jebel Gaâloul (1613 m) and a depression zone represented by alluvium and sand deposits (Benkheira et al., 2005; Bensaid and Nedjai, 2016; Guerine et al., 2020; Bensaid et al., 2021).

According to climatic data from the Naâma weather station (period 1984-2020), the study area is characterized by a continental climate, including a long dry season which lasts almost throughout the year. The average temperature is 16.63°C, and the average annual precipitation is 219 mm/year. The rainfall regime is of the APHE type (autumn, spring, winter, summer). Emberger's rainfall quotient is 21.31, which makes it possible to classify the study area in the lower arid bioclimatic stage with cool winters (DPSB, 2021; ONM, 2021).

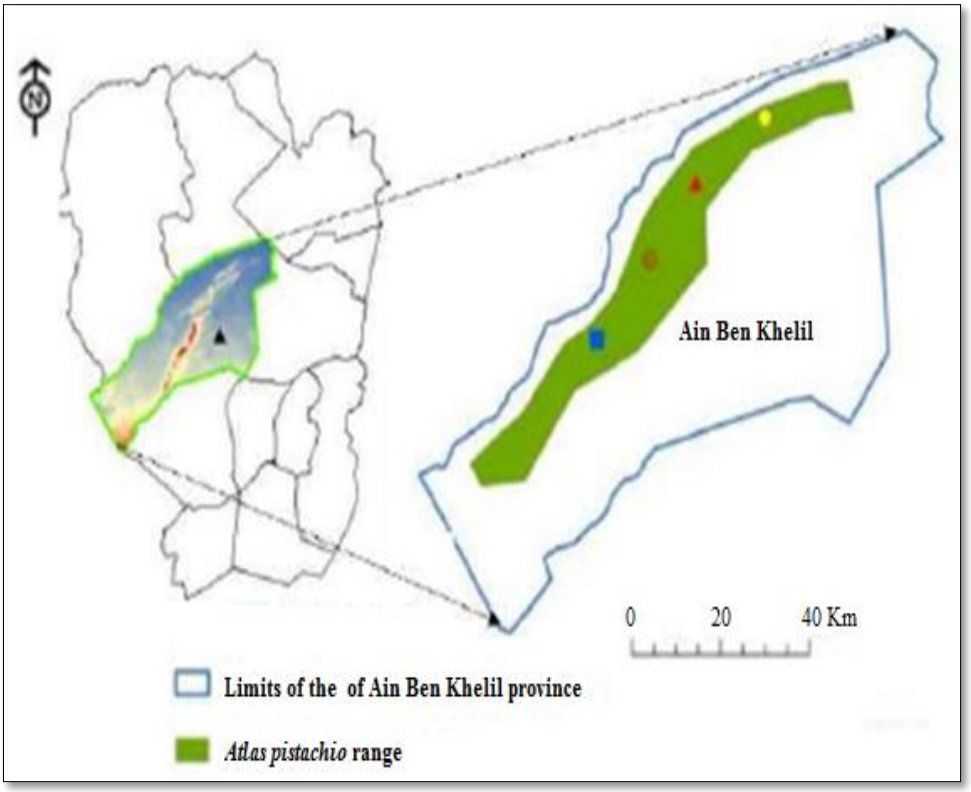

Figure 1. Location of study stations

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2.2 Methodological approach: collected parameters

A subjective sampling that takes into account the variability of Atlas pistachio stands is adopted to choose the Groves that best meet our work objective. For this purpose, four groves were chosen (Table 1).

Table 1. Geographic coordinates of selected groves

Groves	*Geographical coordinates*		*Altitude (m)*
	N	*W*	
1	*33.41 348*	*000.91 449*	*1116*
2	*33.39917*	*000.92723*	*1121*
3	*33.31 022*	*000.43 053*	*1092*
4	*33.20 035*	*001.04 235*	*1127*

Four groves of *Pistacia atlantica* were subjected to dendrometric measurements. The parameters measured were the diameter at 1.30 m and the total height. The diameter was measured with a tape measure. The total heights was measured with a Blum-Leiss or a graduated pole (trees located inside the jujube).

A total of 368 subjects underwent dendrometric characterization. In order to facilitate the analysis, we have grouped the stems studied by diameter classes and height classes.

The diameter classes used are: Ø ≤10 cm: Perche (PER), 10 <Ø≤ 22.5 cm: Small wood (PB), 22.5 <Ø≤ 42.5 cm: Medium wood (MB), 42 ,5 < Ø≤ 62.5 cm: Big wood (GB), 62.5 cm: Very big wood (TGB).

For the height classes, we have chosen: Class 1: h < 4 m, Class 2: 4 ≤ h ≤ 8 m, Class 3: 8 < h ≤ 12 m, Class 4: > 12 m.

From an architectural diagnostic point of view of *Pistacia atlantica*, we have adopted the ARCHI (Drénou, 2014; Drénou & Caraglio, 2019). The ARCHI observation keys are mentioned in the Table 2:

Table 2. ARCHI observation keys (Drénou, 2014)

ARCHI type	***Definition and prognosis of short-term development***
Healthy tree (Ht)	*Tree whose architecture is consistent with its development stage*
Stressed tree (St)	*Tree whose architecture deviates from the reference sequence. Uncertain future*
Resilient tree (Rt)	*Tree exhibiting reverting dynamics*
Tree with descending crown (TDC)	*Tree building a new crown under the original crown*
Tree in irreversible decline (TID)	*Tree stuck in a situation of no return to the reference sequence*
Dead tree (Dt)	*Tree whose cambium is dead 1.3 m above the collar*

The phytoecological characterization of the selected dayas was conducted according to the principles of the sigmatist phytosociological method. The finesse of this approach can only open up to the synusial phytosociological method (Kaabèche and De Foucault, 2010). The nomenclature of species is made according to Maire (1952-1987), Quézel and Santa (1962-1963) and Ozenda (2004).

The species inventoried were indicated by their stratum (Delassus, 2015) and biological type (Raunkiaer, 1934).

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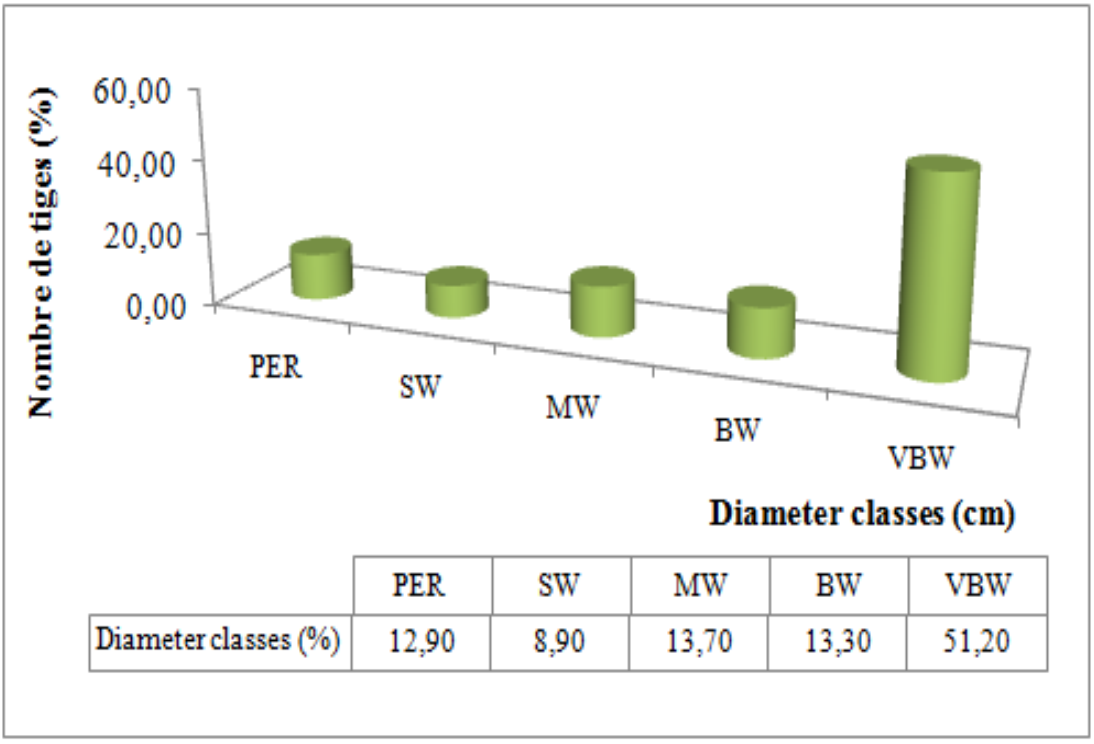
3. RESULTS AND DISCUSSIONS

3.1. Diameter classes

The overall analysis of the distribution of the number of trees by diameter category (Fig. 2) of the groves studied revealed a clear dominance of the category of very big trees (VBW) with a rate of 51,20%. This category represents more than half of the population of *P. atlantica* studied. The other diameter categories are represented by low proportions 13,70% (MW), 13,30% (BW), 12,90% (PER) and 8,90% (SW).

In general, we are in the presence of a pure stand of *P. atlantica*, with a regular structure dominated by very big wood.

We note here a variability between the measured diameters. This variability is explained by a coefficient of variation CV ≈ 49,81%.



	PER	SW	MW	BW	VBW
Diameter classes (%)	12,90	8,90	13,70	13,30	51,20

Figure 2. Distribution of Atlas pistachio tree diameters by category

3.2. Height classes

The height of the stand of *P. atlantica* varies from 1,70 m to 22 m. The average value for the entire stand is 9,20 m. The distribution of stems by height class shows the dominance of class 4 trees that exceed 12 m in height with 44,8% (Fig. 3). Class 3, whose tree height varies from 8 m to 12 m, represents 28%. Trees integrated into class 2 total a rate of 21,2%. Finally, class 1, made up of trees less than 4 m high, represents only 6% of the stand.

As in the case of the diameters, we note a heterogenity between the heights of the Atlas pistachio tree because the calculated coefficient of variation is CV ≈ 43,13 %.

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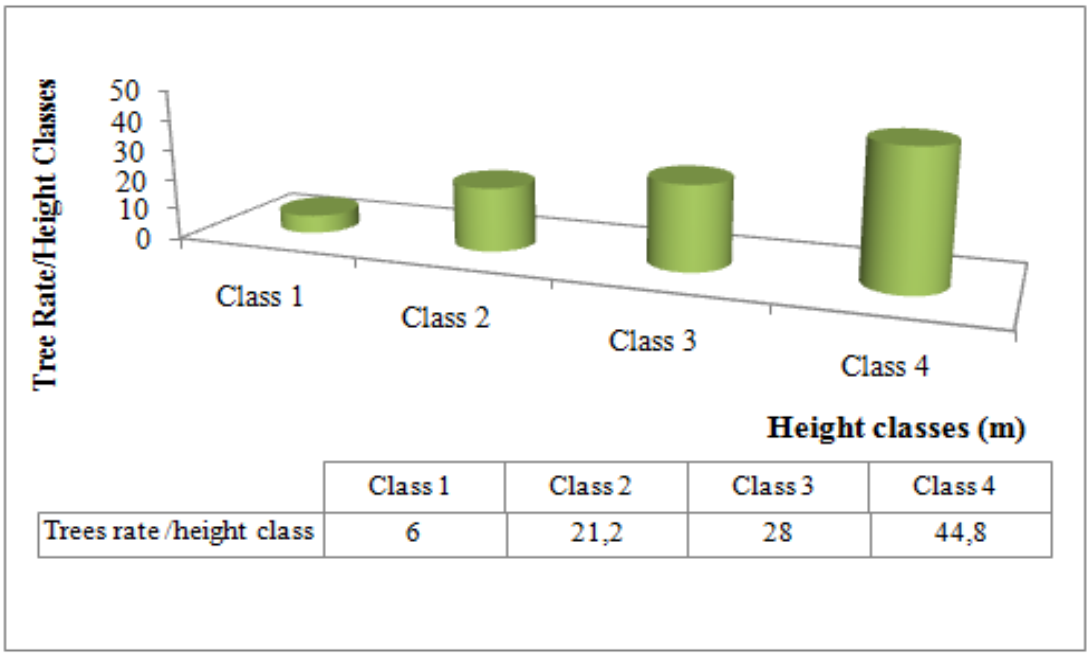

	Class 1	Class 2	Class 3	Class 4
Trees rate /height class	6	21,2	28	44,8

Figure 3. Distribution of Atlas pistachio tree heights by class

3.3. Natural regeneration

By convention, subjects whose diameter is less than or equal to 10 cm are considered as natural regeneration. In our case, the natural regeneration rate of *P. atlantica* is estimated at 12,90%. All of the regenerated plants were growing inside the tussocks of jujube (*Ziziphus lotus*). The seeds disseminated by birds in the jujube tree find a favorable habitat to germinate (nurse effect). In addition, the soil where the leaves of the *Ziziphus lotus* fall would become acidic and would facilitate the germination of the seeds of the Atlas pistachio tree. This natural phenomenon constitutes the primordial natural element for the reconstitution of the Pistachio stands of the Atlas.

The growth of the atlas pistachio tree is to the detriment of the jujube tree. The jujube tree will be eliminated over time and gives way to the pistachio tree.

Figure 4. Atlas pistachio tree regeneration

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3.4. Architectural dynamics of *Pistacia atlantica*

The ARCHI diagnostic method is a key element for detecting the resilience mechanism of trees. As far as we are concerned, the ARCHI types visualized in the « Gaaloul » region are illustrated in Figure 5.

Healthy trees (Ht) constitute the fairly important part of the population of *P. atlantica* with a rate of 65,10%. Resilient trees (Rt) is represented the second proportion with 23,20%. These two ARCH types represent 88,30% of the trees diagnosed.

29 trees show signs of stress (stressed type St), i.e. a rate of 7,9% and 9 trees are in a state of crown descent (TDC), i.e. a ratio of 2,4%.

On the whole stand studied, there are only 5 dead trees (Dt), which represents only 1,4% of the whole. It should be noted that trees in irreversible decline (TID) are totally absent.

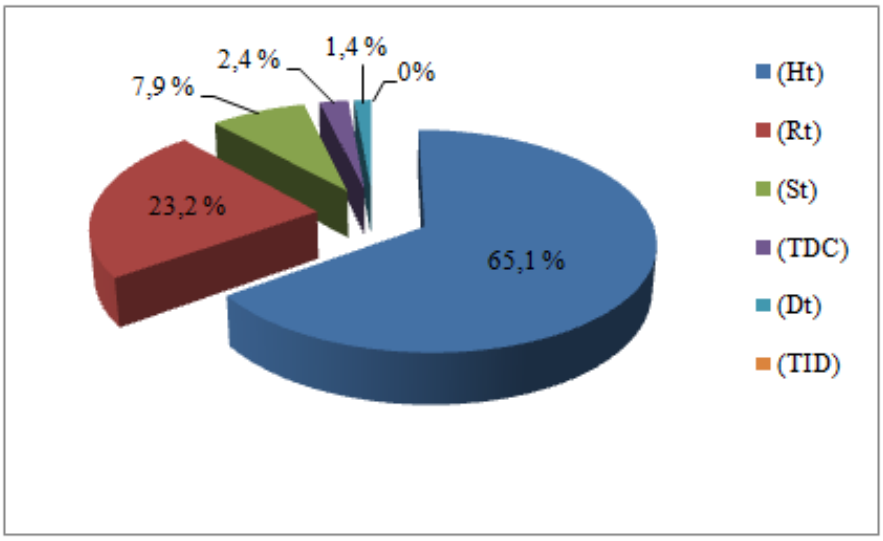

Figure 5. ARCHI type of Pistacia atlantica

3.5. Floristic diversity and vegetation strata

21 species belonging to 20 genera and 13 botanical families have been identified in the studied dayas. The most represented families are: Poaceae (5 species, 23,80%), Asteraceae (4 species, 19,05%), Amaranthaceae (2 species, 9,52%) (Fig. 6). The other families are represented by only one species (4,76%).

The dominance of species of the Poaceae and Asteraceae families in arid and semi-arid Mediterranean zones is reported by Ozenda (2004); Kazi-Tani et al. (2010); Guérine and Hadjadj (2019); Hadjaj et al. (2020); Hadjaj et al. (2021).

The identified species are divided into the following strata:

- tree strata: *Pistacia atlantica*

- shrub strata: *Pistacia atlantica, Ziziphus lotus*

- herb strata: *Aristida pungens, Peganum harmala, Salsola vermiculata, Adonis dentata, Hordeum murinum, Herniaria fontanesii, Cutandia divaricata, Astragalus tenuifolius, Malva lavatera, Marrubium deserti, Micropus bombycinus, Onopordum acaulon, Atractylis humilis, Atractylis serratuloides, Thymelaea microphylla, Stipa tenacissima, Lygeum spartum, Citrullus colocynthis, Noaea mucronata.*

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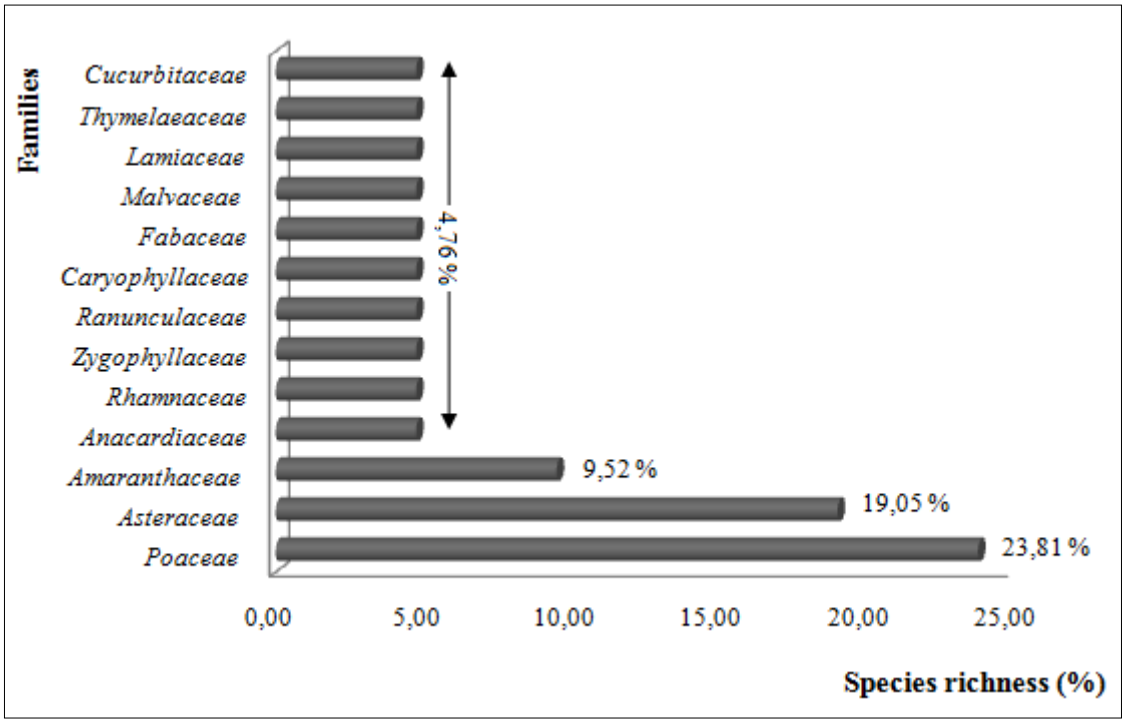

Figure 6. Richness of botanical families in species (%)

The anarchic and irrational grazing is the main cause of this low richness of the dayas studied, although the Atlas pistachio tree is one of the uncultivated and protected species in Algeria by the executive decree number 12-03 of January 4, 2012.

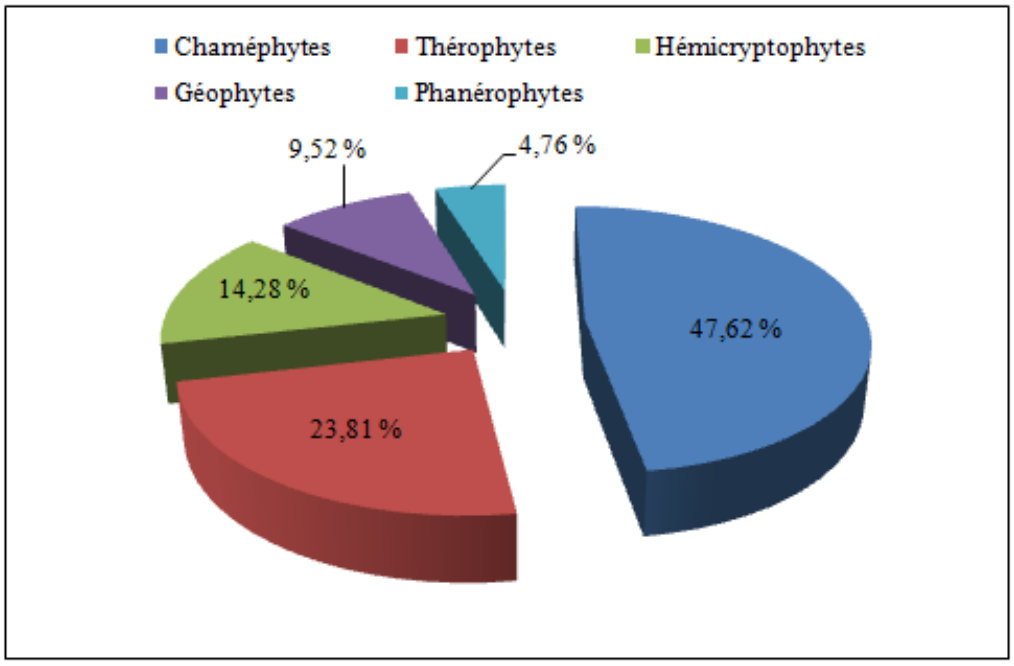

Figure 7. Biological types in the study region

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We note the presence of so-called psamophyte species such as: *Pistacia atlantica, Aristida pungens, Lygeum spartum, Malva aegyptia, Marrubium deserti* and *Thymelaea microphylla.*
Other species indicating advanced degradation are present, these are: *Noaea mucronata, Thymelaea microphylla, Peganum harmala, Astragalus tenuifolius, Atractylis humilis, Atractylis serratuloides*. The proliferation of these taxa is favored by their lack of palatability.

3.6. Biological types

The diagram of the biological types of the inventoried species is (Fig. 7): Chamephytes > Therophytes > Hemicryptophytes > Geophytes > Phanerophytes.
Chamaephytic species are dominant with 47.62%. They are followed by therophytes which represent 23.81%. This finding tells us about the extent of anthropogenic pressure and the climatic xericity that the region is undergoing.
Several studies have focused on the dominance of therophytes, chamephytes in arid and semi-arid Mediterranean areas: Ozenda (2004); Amghar and Kadi – Hanifi (2008); Ghafoul et al., (2019), Hadjadj et al., (2021). Indeed, therophytia is a strategy of adaptation to unfavorable conditions.

4. CONCLUSIONS

The Atlas pistachio tree (*Pistacia atlantica* Desf.), which is a species protected by Algerian law according to executive decree n°12-03 of January 04, 2012 establishing the list of protected uncultivated species, must deserve more importance in matter of rehabilitation and extension in biodiversity conservation programs in Algeria, because of its interest both from an ecological point of view (plasticity, resistance to drought, soil conservation etc.), and economic (production of essential oils, wood, beekeeping, recreation etc.).
In conclusion, this study has allowed us to collect information relating to the structural, architectural and ecological dynamics of the Atlas pistachio stands in the Naâma region (South West Algeria). These results constitute a basic inventory for rehabilitation actions.

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