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IMPLEMENTATION OF A PHYTOECOLOGICAL DATABASE FOR NORTHERN ALGERIAN SPECIES

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Abstract.

The Algerian Northern area is very biodiverse. It is one of the richest Mediterranean hotspot countries in terms of species, most of which are considered rare to extremely rare. It totals nearly half of Algerian flora threatened with disappearance and presents many endemics. Unfortunately, the continental natural ecosystems face various threats. Studies involving assessing biodiversity through inventories and systematic surveys to better understand these natural environments still need improvement. Because of its interest as a synthetic tool to store and manage data, an ecological Northern Algerian flora database was conceived using access, a relational database management system. Built around four tables, it allows for several queries about the floristic and ecological characteristics of about 1699 Phyto-ecological surveys. Each species is identified by a code and is characterised by several qualitative traits relating to abundance, plant formation, climatic and bioclimatic conditions, topography, and biogeographical distribution. For better exploitation of the database, "MapInfo" software, which is a Geographic Information System (GIS), has been used to map the results of queries. The produced maps reveal significant changes in the distribution of biogeographical ranges of species.

KEY WORDS

Relational databases; Database Management System; GIS; Chorology; Endemic species; **Character's database; Data a**nalysis.

Introduction

The flora of Algeria is characterised by a remarkable diversity of species. According to the General Directorate of Forests (DGF, 2021) [1], there are an estimated 3,139 species, of which 1,611 are considered rare or extremely rare, and almost 51% of Algerian flora is threatened with extinction. The majority of these species are found in all of Algeria's 40 key areas for Mediterranean biodiversity, according to [2] and the report written by Derneği (2010) [3]. Regrettably, these natural habitats are under constant threat, rapidly degrading due to uncontrolled land use. Compounding this issue is the dwindling number of naturalists qualified in systematics and the decline in initiation to the study of flora [4], [5].
To this end, the preservation and organisation of floristic data respond to the urgent concerns about this degradation.
There is a pressing need to consolidate existing information into a comprehensive phyto-ecological database. This database is essential for effective environmental management, informed analysis of ecological issues, and the development of corresponding solutions. The concept of developing the database originated from the research conducted by main authors such as [6], [7], [8], [9], [10], who gathered edaphic data for Northern Algeria. As the original database was precarious and not optimised for queries and lacked comprehensive information, it was transformed into a relational phyto--ecological database centred on the relationships between the different floristic and ecological parameters supplied. Data is gathered from many different sources, different dates, and different ecosystems (from woodlands and steppes that cover northern Algerian territory) in order to study the chorology of these species, particularly the rare and the endemic ones. The on-field ecological and edaphic variables are insufficient to explain the distribution of the vegetal species by themselves. They are hence completed for the climatic part by meteorological and meso-climatic data. The efficiency of this new database lies in its ability to store and manage field survey data, further enhanced by the list of taxa and their interrelationships with environmental factors. In addition to extracting information from raw data, the database enables the construction of more intricate surveys. The potential range of inquiries expands with the diversity of sampled environments and encountered taxa. As the database's information pool grows, it becomes possible to establish stronger statistical correlations between traits themselves as well as between traits and environmental characteristics. This article aims to introduce the database by detailing its structure, functions (data storage, data management), and key components (surveys, species).

Materiel and Methods

1. Available data:

Data have been gathered from a large number of academic studies all over Northern Algeria. The attribute-based data available represent 1699 surveys and 1351 species, which equals 43,03% of the total number of species that exist all over the Algerian soil. Each data source, with utmost precision, presents a comprehensive set of floristic surveys for every studied ecosystem coming from woodlands and steppes that cover Northern Algerian territory. These surveys classify each species based on its degree of abundance, provide a detailed description of the ecological conditions, and include chemical analyses conducted from at least the A horizon (from the surface) of the soil. The data is complete by meteorological and spatialized meso-climatic data.

The graphical data employed in this study are derived from five sources: The North African topographic map [11], the pluviometry maps of Northern Algeria produced by Chaumont and Paquin (1971) map [12], the National Agency of Hydraulic Resources (ANRH, 2005) [13] and the bioclimatic map Lebane et Zidane (1995) [14]. All the maps are scaled up to 1:500,000. Additionally, the map illustrating the principal biogeographical divisions of Algerian soil, as established by Quezel and Santa (1962-1963) [15], was utilised. These documents were digitised in order to permit the extraction of information through the superposition of layers. This vectorisation permitted the addition of phytogeographical data, the filling of gaps in climatic data, and the exportation of all output information as table files.

2. Structure of the geographical relational database:

The database was developed under Microsoft Access (version 2010), which is a relational database management system. This type of database has advantages in terms of organizational capacity, flexibility, and user-friendliness. When information is changed or updated, only the tables relating to that information are modified, maintaining a high degree of flexibility in accessing the information stored.

The database's structure organises the information from the surveys by creating tables containing the different variables entered. Four tables are made up of horizontal rows and vertical columns (Figure 1). Rows and columns are referred to respectively as records and fields.

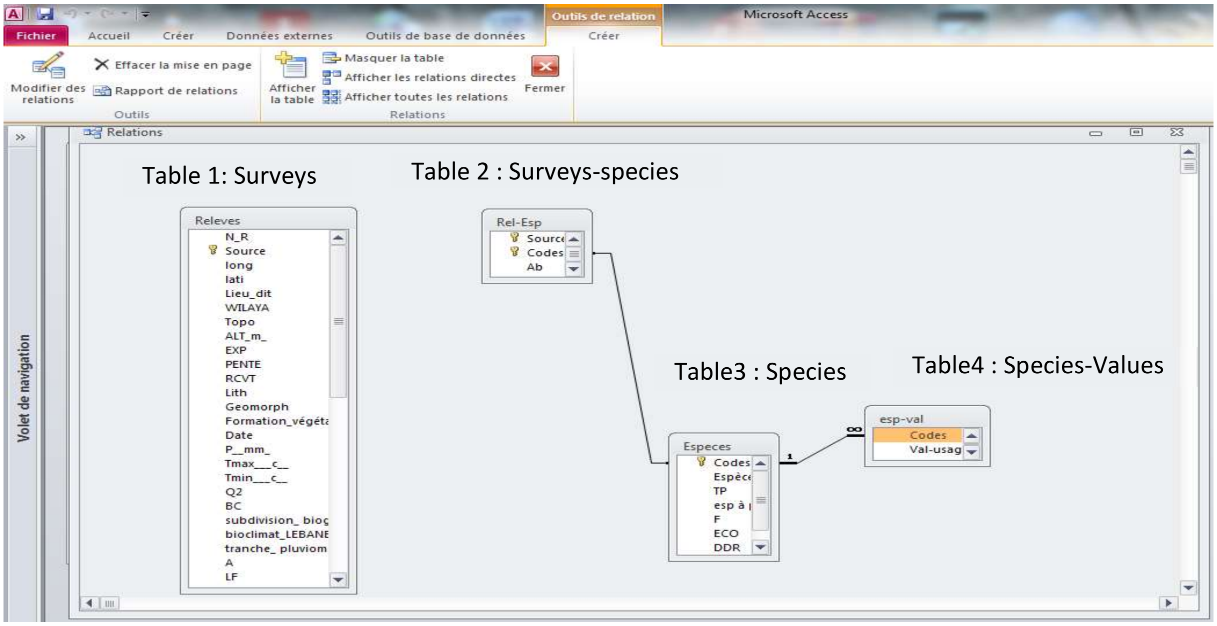


Fig.1 Relational Phyto-ecological Database. Table 1 is named "Surveys". It is a numeric and alphanumeric table. Table 2 is named "Surveys-species", Table 3 is named "species" and Table 4 'species-values'. all of these three tables are alphanumeric

A field is a way of organising information by type. Each table's columns are defined according to the nature and size of the type of data stored. These tables have the faculty to eliminate redundant information or surveys in which place names would not have been specified, to homogenise the information; and to codify their limited values.

3. Simplified representation of the tables and fields of the phyto-ecological database:

The data are organized as follows within the table:

- The field provides the source of the given datum with indications on the Survey ID number and the author's name’s first letter.
- The geographical localization is stored in the longitude-latitude system with coordinates that have been converted from grades and degrees, minutes and seconds to decimal degrees in order to use Mapinfo. This allowed us to easily calculate the position of the different surveys on the maps that we have digitalized; and which was instrumental in our dynamic study.
- The crossing of localized surveys at every point of the territory has also allowed the deduction of new data (meteorological or altimetric information, topographical data for example).
- The realization date of the surveys; which is a crucial factor, is important to detect any potential bias that could be linked to the realization period of the floristic surveys or to study the dynamic of floristic or pedological phenomena over several years.

The fields used to analyse the chorology of species are informed by a range of attributes, including ecological, floristic, the degree of plant cover, biological types of species, bioclimatic data, the Latin names of species and species families.

In addition to this information, the database has been updated with the following contributions:

- The use values and vernacular names of the species required the consultation of many other works such as [16],[17], [18],
- The Auto-ecology of species, their phytogeographical type, and their family were completed by] and the floras of QUEZEL and SANTA (1963). [15] and OZENDA (1977) [19],
- The degree of rarity of the species has been extracted from the red list of the UICN.
- Some Phyto-ecologic information are updating and completing by a numerous research as [20], [21], [22], [23], [24], [25], [26]

Only the most pertinent parameters were kept for analyses aiming to explain the dynamic of species. The stocked climatic variables corresponding to the macroclimate (temperatures, average annual rainfalls, bioclimate, hydric deficit), the topo-climate slope (exposition), and the microclimate (recovery of the tree and shrub strata) could help us explain the development of the species.

Hence, we have kept the pedological variables which allowed us to estimate soil textures, the rate of organic matter, the groundwater alimentation (useful water reserve), the mineral nutrition exchangeable cations (calcium, magnesium and potassium), the nitrogen and phosphorus nutrition, and finally the toxicity phenomena due to an excess of aluminium or calcium.

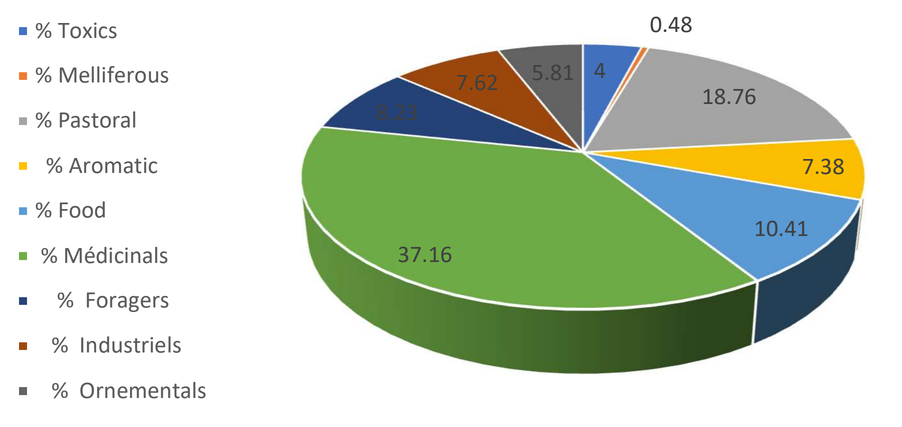
Results

Once the data has been stored in accordance with the specifications set forth in the relevant tables, it will be subject to dynamic checking. For example, the database will return the attribute to the predefined list for a given character or will require that dates all be entered in the same format.

After processing the database, a several interesting results emerged, shown in figure 2 below as:

For a total of 61.13% of the terrestrial vascular species listed are known to be of interest (Figure 2).

Fig.2 Terrestrial vascular species listed of known interest



The main result obtained from the queries on the geographic database is a list of endemic species that have displayed, once analyzed, a dynamic aspect and exhibited three main groups of species. One of them the endemic species showing a progressive dynamic. Example: After overlaying the multi-dated recordings corresponding to geographical positions and phytogeographical subdivisions, *Fumana fontanesii* (Pomel.) which is an Algerian-Moroccan endemic species showed a fabulous extension. A comparison is made between the information found in the flora of QUEZEL and SANTA (1963), who found it only in the Algiers region, a sub-region of the Tellian Atlas, and the data from the various sources in the database (Figure 3).

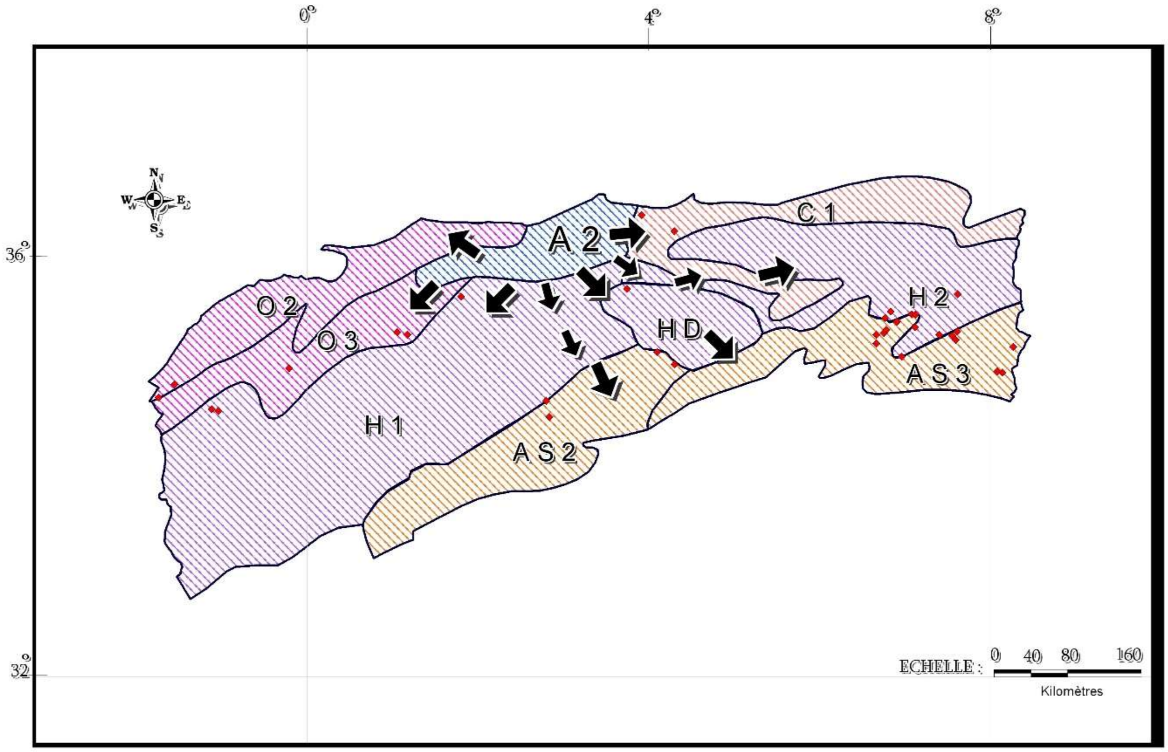


Fig. 3: Illustration of the biogeographical range extension of *Fumana fantanesii* Pomel

Legends:
The different biogeographic fields illustrated in the maps are the followings: A 2: The Algiers region, sub-region of the Tellian Atlas **(Flore source),** A 1: The Algiers region, sub-region coastal; K 1: Kabylian region and Numidian, sub-region of the Great Kabylia; K 2: Kabylian region and Numidian, sub-region of the Lesser Kabylia; C 1: Constantine Hills region; O 1: Oran region, sub-region of the coastal Sahels; O 2: Oran region, sub-region of the coastal plains; O 3: Oran region, sub-region of the coastal plains of the Tellian Atlas; H 1: Region of the high Hills, sub-region of Algiers and Oran's High Hills; H 2: Region of the high Hills, sub-region of Constantine's High Hills; AS 1: Region of the Saharian Atlas, sub-region of Oran's Saharian Atlas; AS 2: Region of the Saharian Atlas, sub-region of Algiers' Saharian Atlas; AS 3: Region of the Saharian Atlas, sub-region of Cosntantine's Saharian Atlas; Hd: Region of the Northern Sahara, sub-region of the Hodna **(multidata sources).**
Extensions are represented by arrows

Discussion:

A characterisation of the species according to their utilisation has revealed the socio-economic interest of the specific resources inventoried.

The comparative study of the distribution areas of some endemic species exhibited phenomena of dynamism distributed over fifty-eight years. This period distinguished the separation between the works of the flora of QUEZEL and SANTE (1963) as well as those of our sources (1978-2024). This study considered the intrinsic potential of the species, including its genetic makeup, ecological range and evolutionary capacities in response to external environmental factors.

Conclusion:

The database contains a substantial corpus of information, facilitating a multitude of avenues for observation and analysis of natural ecosystems. It can be employed to augment data pertaining to the influence of environmental factors on the evolution and decline of flora. Additionally, it offers insights into shifts in floristic composition and the underlying causes thereof.

The results may also be analysed in spatial terms to define, at a regional scale, the areas of poor, average, or high fertility. We could even extract the ecosystems that would be sensitive to global changes.

This work has made it possible to acquire detailed knowledge of a large number of data relating to the biodiversity, dynamics, and conservation of vegetation in the Northern part of Algeria.

This phytoecological database, a testament to our long-term commitment, contains information on samples collected over the past 58 years in Algeria. Our goal is to continue building on this legacy, creating a robust and adaptable database that can incorporate palaeoecological data with a focus on seed characteristics. This will provide an excellent tool for understanding and modelling the ecology of communities in Mediterranean ecosystems.

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