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Declaration

To my beloved family for your unwavering support, encouragement and love that have been driving force behind my academic pursuits. Without your constant belief in me, I would not have made it to this point.

To all of my Friends who provided me with the ensile encouragement that kept me in line till this point

This thesis is dedicated to all as a token of gratitude for your unwavering loyalty and support.

Thank you for being an integral part of my life’s journey

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Abstract

The Barbary deer (*Cervus elaphus barbarus*) is the only representative species of the Cervidae family in North Africa, and is considered as a symbolic species in its habitat. According to the IUCN, the Barbary deer is listed as a vulnerable species by The IUCN Red List of Threatened Species because of human activity, habitat fragmentation and habitat degradation. However, studies on the ecology, behaviour, diet and distribution on the species are lacking. Our aim in this study is to shed light on the diet selection of the endangered Barbary deer. This study was conducted in Beni Salah 2200 ha natural reserve, North-east Algeria. We collected 11 faecal samples near possible resting or feeding points and 10 transects of vegetation were made based on possible footprints of the Barbary deer. Micro-histology method was applied to obtain faecal samples slide and epidermis references slide. Our results showed that *Quercus suber* and unknown herbs formed the bulk of the diet with (21.3 ± 7.8 %, 19.2 ± 8.3 %), respectively. Overall, trees and shrubs were the most positive selected class ($w_i = 1.111$, $\chi^2 = 18.62$, $p<0.045$), and herbs and grasses were classified as a negative selected class ($w_i = 0.732$, $\chi^2 = 44.94$, $p<0.001$). Our finding revealed that seven species from trees and shrubs were positively selected by the Barbary deer, with Erica arborea being the most positively selected species (4.45%) ($w_i = 3.402$, $\chi^2 = 368.94$, $p<0.001$). However, herbs and grasses were negatively selected by the deer, represented only one species *Ampelodesmos muritanicus* with (9.08%) ($w_i = 0.254$, $\chi^2 = 64.77$, $p<0.001$). Our results were in accordance with other studies in the Mediterranean region. In this preliminary study, further research on seasonal variation and habitat structure of the Barbary deer is essential for comprehensive determination of the Barbary deer Diet.

Key words: Cervidae, Barbary deer, Diet selection, Micro-histology, selectivity index, Beni Salah.

ملخص

الأيل البربري (*Cervus elaphus barbarus*) هو الممثل الوحيد لعائلة الغزلان في شمال أفريقيا، ويُعتبر نوعاً رمزا بيئة طبيعية. وفقاً الاتحاد الدولي للحفاظ على الطبيعة (IUCN)، تم إدراج الأيل البربري كنوع مهدد بالانقراض في قائمة الأنواع المهددة بالانقراض للاتحاد الدولي للحفاظ على الطبيعة بسبب النشاطات البشرية وتجزئة المواطن والتدهور البيئي. مع ذلك، يوجد فقر في الدراسات المتعلقة ببيئة الحيوان وسلوكه ونظامه الغذائي وتوزيعها. هدفنا في هذه الدراسة هو إلقاء الضوء على النظام الغذائي للأيل البربري المهدد بالانقراض. تمت هذه الدراسة في محمية بني صالح الطبيعية الممتدة على مساحة 2200 هكتار في شمال شرق الجزائر حيث تم جمع 11 عينة براز من نقاط محتملة للراحة أو التغذية، أُجريت 10 مسارات للنباتات استنادًا إلى آثار اقدام محتملة للأيل البربري، حيث تم تطبيق طريقة الميكروهستولوجي للحصول على شرائح عينات البراز وشرائح عينات الطبقات الخارجية للنبتة. أظهرت نتائجنا أن شجرة البلوط الكورك *Quercus suber* وأعشاب المجهولة تشكلان الجزء الأكبر من النظام الغذائي بنسبة (21.3 ± 7.8 %، 19.2 ± 8.3 %) على التوالي. بشكل عام، تعتبر الأشجار والشجيرات هي الفئة الإيجابية الأكثر بنسبة (wi = 1.111، χ^2 = 18.62، $p<0.045$)، في حين تم تصنيف الأعشاب والنباتات العشبية على أنها فئة محددة بشكل سلبي (wi = 0.732، χ^2 = 44.94، $p<0.001$). كشفت نتائجنا أن سبعة أنواع من الأشجار والشجيرات تم اختيارها بشكل إيجابي من قبل الأيل البربري، مع شجرة الإريكا الشائعة كأكثر الأنواع المحددة بشكل إيجابي (4.45%) (wi = 3.402، χ^2 = 368.94، $p<0.001$). ومع ذلك، تم تصنيف الأعشاب والنباتات العشبية بشكل سلبي من قبل الأيل، والتي تمثلت في نوع واحد فقط وهو أمبيلوديسموس موريتانيكوس بنسبة (9.08%) (wi = 0.254، χ^2 = 64.77، $p<0.001$).

كانت نتائجنا متطابقة مع الدراسات الأخرى في منطقة البحر الأبيض المتوسط. في هذه الدراسة الأولية، يعد إجراء مزيد من الأبحاث حول الاختلاف الموسمي وهيكل مواطن الغزلان البربرية أمرًا ضروريًا لتحديد حمية الغزلان البربرية بشكل شامل.

الكلمات المفتاحية: الغزلان البربرية، اختيار النظام الغذائي، علم الأنسجة الدقيقة، مؤشر الانتقائية، بني صالح

Résume

Le cerf de Barbarie (*Cervus elaphus barbarus*) est la seule espèce représentative de la famille des cervidés en Afrique du Nord et est considéré comme une espèce symbolique dans son habitat. Selon l'UICN, le cerf de Barbarie est répertorié comme une espèce vulnérable sur la Liste rouge de l'UICN des espèces menacées en raison de l'activité humaine, de la fragmentation de l'habitat et de la dégradation de l'habitat. Cependant, les études sur l'écologie, le comportement, l'alimentation et la répartition de l'espèce font défaut. Notre objectif dans cette étude est d'éclairer la sélection alimentaire du cerf de Barbarie en voie de disparition. Cette étude a été menée dans la réserve naturelle de Beni Salah, d'une superficie de 2200 hectares, dans le nord-est de l'Algérie. Nous avons collecté 11 échantillons fécaux près de points de repos ou d'alimentation potentiels, et 10 transects de végétation ont été réalisés en se basant sur les empreintes potentielles du cerf de Barbarie. La méthode de micro-histologie a été utilisée pour obtenir des échantillons de fèces et des échantillons de référence d'épiderme. Nos résultats ont montré que le chêne-liège et des herbes non identifiées constituaient l'essentiel du régime alimentaire avec des proportions de (21,3 ± 7,8 %, 19,2 ± 8,3 %) respectivement. Globalement, les arbres et les arbustes étaient la classe la plus positivement sélectionnée (wi = 1,111, χ^2 = 18,62, p < 0,045), tandis que les herbes et les graminées étaient classées comme une classe négativement sélectionnée (wi = 0,732, χ^2 = 44,94, p < 0,001). Nos résultats ont révélé que sept espèces d'arbres et d'arbustes étaient positivement sélectionnées par le cerf de Barbarie, l'Erica arborea étant l'espèce la plus positivement sélectionnée (4,45 %) (wi = 3,402, χ^2 = 368,94, p < 0,001). Cependant, les herbes et les graminées étaient négativement sélectionnées par le cerf et représentées par une seule espèce, *l'Ampelodesmos muritanicus* avec un taux de (9,08 %) (wi = 0,254, χ^2 = 64,77, p < 0,001). Nos résultats sont conformes à d'autres études menées dans la région méditerranéenne. Dans cette étude préliminaire, des recherches supplémentaires sur les variations saisonnières et la structure de l'habitat du cerf de Barbarie sont essentielles pour une détermination complète du régime alimentaire du cerf de Barbarie.

Mots clés: Cervidé, cerf de Barbarie, sélection alimentaire, micro-histologie, indice de sélectivité, Beni Salah.

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List of acronyms

IUCN: The International Union for Conservation of Nature.

CITES: The Conservation of International Trade in Endangered Species of Wild Fauna and Flora.

CCZ: The Cygenetic Center of Zeralda

DGF: general direction of forests.

INTRODUCTION

Large ungulates are an important group of herbivorous mammals that play a vital role in maintaining biodiversity and ecosystems functioning. These animals possess distinctive characteristics, such as their substantial size, hooved feet, and efficient digestive systems, enabling them to efficiently process nutrients from plant material. They inhabit various ecosystems worldwide, including grasslands, savannas, forests, and tundra. Unfortunately, numerous populations of large ungulates are currently facing significant threats, including habitat loss, fragmentation, poaching, and climate change (**Ceballos et al, 2017**), which can lead to population declines, alterations in ecosystem dynamics, and cascading effects on other species **(Ripple et al, 2014**). They act as important herbivores, shaping plant communities through their browsing and grazing activities **(Polak. Tanja et al, 2014**). Additionally, they serve as prey for various predators, including carnivorous mammals and birds of prey, while their carcasses provide a food source for scavengers and decomposers (**Ripple et al, 2014**). Furthermore, large ungulates play a significant role as vectors for long-distance seed dispersal in forests (**Pellerin, Maryline et al, 2016)**.

Ungulates can be classified into two main groups: Perissodactyls and Artiodactyls. Perissodactyls, such as horses, zebras, and rhinoceroses, possess an odd number of toes and are primarily adapted for grazing. They have historically played a crucial role in shaping grassland ecosystems and promoting biodiversity **(Prins and van Langevelde, 2008)**. On the other hand, Artiodactyls, comprise a diverse group including deer, antelopes, bovids (such as cattle and goats), and pigs. These animals possess a symmetrical count of digits on their feet and display diverse ecological adaptations, enabling them to thrive in different environments and utilize a broad spectrum of plant resources (**Geist, 1998**).

Large ungulates encompass several families with distinct morphological, behavioural, and evolutionary characteristics.

- **Equidae:** includes horses, zebras, and donkeys, having a long evolutionary history and historical wide range distribution across the world, but now, most of these species occurs in Africa and Asia (**MacFadden, 2005)**.
- **Giraffidae:** consists of giraffes and okapis, primarily found in savanna habitats, they are characterized by their long necks and special cardiovascular systems **(Mitchell and Skinner, 2003**).

- **Bovidae:** the largest family, comprises over 140 species of antelopes, sheep, goats, and cattle, exhibiting diverse adaptations (grazing and browsing) **(Geist, 1998),** and playing an important role in nutrient cycling and vegetation dynamics.
- **Cervidae:** which includes deer and elk, primarily inhabit forested habitats and exhibit browsing behaviour. Characterized by their antlers which are used for display, fighting, and dominance hierarchies (**Côté and Festa-Bianchet, 2001**). They are recognized as keystone species, influencing seed dispersal and forest regeneration dynamics.

In Africa Cervid and bovids populations, have developed a range of adaptations to thrive in different habitats, enabling them to engage in selective browsing and grazing activities **(Geist, 1998)**. Through their feeding behaviour, they have the capacity to shape the composition of plant communities by promoting the growth of specific plant species and influencing competitive dynamics. In the past, cervids have played an important role as a vital component of the mammalian fauna in North Africa. However, these populations have experienced substantial declines in recent decades, primarily due to human activities such as habitat loss and overhunting **(Romero-Muñoz. A et al, 2021)**. These pressures have even led to local extinctions of certain cervid species, including the Barbary deer (*Cervus elaphus barbarus*) **(IUCN).**

The Barbary deer or *Cervus elaphus barbarus* is a specie of red deer of North Africa. It is found in Algeria, Morocco, and Tunisia. Its populations are generally associated with dens forested habitats, including woodlands and scrublands. Its distribution differs between the three countries. In Algeria, it can be found in a limited patchy distribution, mainly in the northeast area of the country. While in Tunisia and Morocco, it can be found in two main places El Feija national park (Northern West of Tunisia) and Tazekka national park (Northern East of Morocco). The distribution of the barbary deer is determined by the quality and the availability of the habitat **(Berlioz. E, 2017).** However, hunting pressure, habitat degradation and fragmentation have resulted in a decline of the quality and availability of suitable habitat for the Barbary deer, leading to a serious decrease in their population and even the risk of extinction **(DGF, 2022).** In addition, the impact of climate change on that distribution and habitat requirements is an emerging concern for their conservation. The distribution of the Barbary deer may shift in response to changes in temperature and precipitation patterns.

Diet selection, refers to the active and adaptive process where herbivores choose specific plant species, parts, or individuals from the available vegetation in their habitat to meet their nutritional requirements and optimize their foraging efficiency within an ecosystem. However,

knowing the diet of the species can make a difference in the conservations of different ecosystems, and ensuring the future presence of that species **(Birnie-Gauvin et al, 2017).**

The diet selection of the red deer can be challenging to study due to different factors, like plant availability, nutritional requirements and browsing behaviour. Red deer are known to be generalist herbivores, consuming a wide range of plants, from grasses to woody species, all depending on their availability and their nutritional value. Then the species can be classified among the intermediate feeders with a mixed diet (**Gebert, C, & Verheyden-Tixier. H, (2001).** To reveal the diet variation of the barbary deer in north Africa a study has been conducted in Morocco, faecal samples were collected in 520ha reserve (Bab Khalti reserve) in the national park, from a population estimated to 66 individuals. and then were analysed, using "Microhistology" methods where faecal samples composition were compared to a reference epidermis catalogue of all existing plants in the study area **(Ismaili. B et al, (2018).** There is a considerable lack of studies on the barbary deer in Algeria, with only one paper published **(Burthey-Mandret, A. and F. Burthey 1997).** Thus, the aim of our study is to identify the seasonal diet of the last remaining Algerian Barbary deer population, with an estimated number of 45-50 individuals dispersed throughout Beni Saleh Natural reserve (North-east Algeria). The area of the natural reserve is estimated to be 4667 ha, and a fence with a length of 20 km **(DGF, 2022)**. During May, August and October 2022, we collected 11 faecal samples, and 10 transects were made for the study of plants availability. Our study was based on the microscopic identification of indigestible plant fragments, particularly the epidermal characteristics of various plant groups **(Metcalfe, 1990)**. Although alternative methods exist, but because of the species secretive nature, the direct observation are difficult and imprecise **(Ismaili. B, 2018).** Despite this study was multiply used for studying different diets of ungulates (**Chetri. M, 2007)**, it has one drawback which is the inability to accurately quantify the amount of forage consumed. However, it remains valuable for determining the feeding behaviour and habitat of endangered species. We studied the references slides by distinguishing histological features (e.g., cell wall structure, shape and size of cells, hairs and trichomes, shape and size of stomata and inter-stomatal cells, fiber structure and arrangement of veins) where, they were sketched to match with the faecal Plant fragments (**Chetri. M, 2007**).

The expected results of this study will allow us to characterize the dietary preferences of the species. By comparing them with the abundance of resources, we will be able to determine whether the environment in which this emblematic species evolves is conducive to a

positive population growth. Additionally, if necessary, we can propose concrete actions that could help to ensure the long-term viability of the populations and the ecosystems they inhabit.

CHAPTER I

LITERATURE REVIEW

Presentation Of the Barbary deer:

1 Classification:

The **Barbary deer** (*Cervus elaphus barbarus*), also known as Barbary stag, Atlas deer, or African elk, is a subspecies of the red deer that is native to North Africa, and it is the only living deer known to be native to Africa.

Table 1: Scientific classification of the barbary deer.

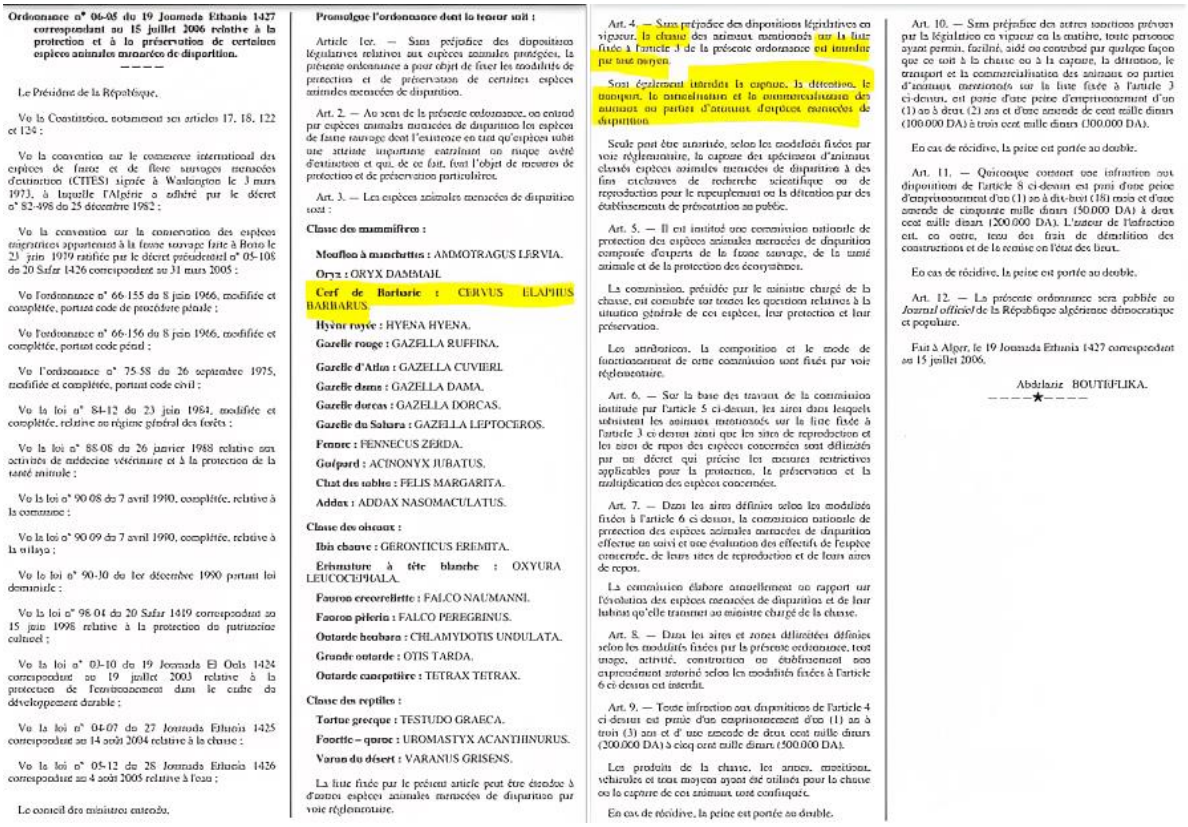
Taxonomic level	**Classification**
Kingdom	Animalia
Phylum	Chordata
Sub-phylum	Vertebrata
Class	Mammalia
Superorder	Ungulata
Order	Artiodactyla
Sub-order	Ruminantia
Family	Cervidae
Sub-family	Cervinae
Genus	Cervus
Species	*Cervus elaphus*
Sub-species	*Cervus elaphus barbarus* (Pitra et al., 2004)

2 Legal status of the Barbary Deer:

In Algeria, the French laws of December 16th 1929 and September 6th 1937 prohibited hunting the Barbary deer and destroying its habitat. However, these measures failed to stop the illegal hunting of the species.

The International Union for Conservation of Nature (IUCN) has not yet assessed the status of the Barbary deer's subspecies. Currently, the entire species and all recognised subspecies are listed under the "least concern" category by the IUCN. However, in response to a request from the Algerian government, the subspecies was listed under Appendix III of the International Convention for the Conservation of International Trade in Endangered Species of Wild Fauna and Flora **(CITES, 2015).**

Algeria granted the Barbary deer species complete protection in 1983 through Decree no. 83-509 on protected non-domestic animal species. This step was taken 20 years after Tunisia implemented similar measures. Subsequently, under Ordinance No. 06-05 of July 15th, 2006, the Barbary deer (*Cervus elaphus barbarus*) was categorised as a highly protected species in Algeria. This classification signifies the implementation of specific measures and regulations aimed at safeguarding the population and habitat of the Barbary deer, with the goal of preventing its extinction and promoting its conservation.



Ordonnance n° 06-05 du 19 Joumada Ethania 1427 correspondant au 15 juillet 2006 relative à la protection et à la préservation de certaines espèces animales menacées de disparition.

Le Président de la République,

Vu la Constitution, notamment ses articles 17, 18, 122 et 124 ;

Vu la convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction (CITES) signée à Washington le 3 mars 1973, à laquelle l'Algérie a adhéré par le décret n° 82-498 du 25 décembre 1982 ;

Vu la convention sur la conservation des espèces migratrices appartenant à la faune sauvage faite à Bonn le 23 juin 1979 ratifiée par le décret présidentiel n° 05-108 du 20 Safar 1426 correspondant au 31 mars 2005 ;

Vu l'ordonnance n° 66-155 du 8 juin 1966, modifiée et complétée, portant code de procédure pénale ;

Vu l'ordonnance n° 66-156 du 8 juin 1966, modifiée et complétée, portant code pénal ;

Vu l'ordonnance n° 75-58 du 26 septembre 1975, modifiée et complétée, portant code civil ;

Vu la loi n° 84-12 du 23 juin 1984, modifiée et complétée, relative au régime général des forêts ;

Vu la loi n° 88-08 du 26 janvier 1988 relative aux activités de médecine vétérinaire et à la protection de la santé animale ;

Vu la loi n° 90-08 du 7 avril 1990, complétée, relative à la commune ;

Vu la loi n° 90-09 du 7 avril 1990, complétée, relative à la wilaya ;

Vu la loi n° 90-30 du 1er décembre 1990 portant loi domaniale ;

Vu la loi n° 98-04 du 20 Safar 1419 correspondant au 15 juin 1998 relative à la protection du patrimoine culturel ;

Vu la loi n° 03-10 du 19 Joumada El Oula 1424 correspondant au 19 juillet 2003 relative à la protection de l'environnement dans le cadre du développement durable ;

Vu la loi n° 04-07 du 27 Joumada Ethania 1425 correspondant au 14 août 2004 relative à la chasse ;

Vu la loi n° 05-12 du 28 Joumada Ethania 1426 correspondant au 4 août 2005 relative à l'eau ;

Le conseil des ministres entendu,

Promulgue l'ordonnance dont la teneur suit :

Article 1er. — Sans préjudice des dispositions législatives relatives aux espèces animales protégées, la présente ordonnance a pour objet de fixer les modalités de protection et de préservation de certaines espèces animales menacées de disparition.

Art. 2. — Au sens de la présente ordonnance, on entend par espèces animales menacées de disparition les espèces de faune sauvage dont l'existence est en tant qu'espèces subit une atteinte importante entraînant un risque avéré d'extinction et qui, de ce fait, font l'objet de mesures de protection et de préservation particulières.

Art. 3. — Les espèces animales menacées de disparition sont :

Classe des mammifères :

Mouflon à manchettes : AMMOTRAGUS LERVIA.

Oryx : ORYX DAMMAH.

Cerf de Barbarie : CERVUS ELAPHUS BARBARUS.

Hyène rayée : HYENA HYENA.

Gazelle rouge : GAZELLA RUFFINA.

Gazelle d'Atlas : GAZELLA CUVIERI.

Gazelle dama : GAZELLA DAMA.

Gazelle dorcas : GAZELLA DORCAS.

Gazelle du Sahara : GAZELLA LEPTOCEROS.

Fennec : FENNECUS ZERDA.

Guépard : ACINONYX JUBATUS.

Chat des sables : FELIS MARGARITA.

Addax : ADDAX NASOMACULATUS.

Classe des oiseaux :

Ibis chauve : GERONTICUS EREMITA.

Erismature à tête blanche : OXYURA LEUCOCEPHALA.

Faucon crécerellette : FALCO NAUMANNI.

Faucon pèlerin : FALCO PEREGRINUS.

Outarde houbara : CHLAMYDOTIS UNDULATA.

Grande outarde : OTIS TARDA.

Outarde canepetière : TETRAX TETRAX.

Classe des reptiles :

Tortue grecque : TESTUDO GRAECA.

Fouette – queue : UROMASTYX ACANTHINURUS.

Varan du désert : VARANUS GRISEUS.

La liste fixée par le présent article peut être étendue à d'autres espèces animales menacées de disparition par voie réglementaire.

Art. 4. — Sans préjudice des dispositions législatives en vigueur, la chasse des animaux mentionnés sur la liste fixée à l'article 3 de la présente ordonnance est interdite par tout moyen.

Sont également interdits la capture, la détention, le transport, la naturalisation et la commercialisation des animaux ou parties d'animaux d'espèces menacées de disparition.

Seule peut être autorisée, selon les modalités fixées par voie réglementaire, la capture des spécimens d'animaux classés espèces animales menacées de disparition à des fins exclusives de recherche scientifique ou de reproduction pour le repeuplement ou la détention par des établissements de présentation au public.

Art. 5. — Il est institué une commission nationale de protection des espèces animales menacées de disparition composée d'experts de la faune sauvage, de la santé animale et de la protection des écosystèmes.

La commission, présidée par le ministre chargé de la chasse, est consultée sur toutes les questions relatives à la situation générale de ces espèces, leur protection et leur préservation.

Les attributions, la composition et le mode de fonctionnement de cette commission sont fixés par voie réglementaire.

Art. 6. — Sur la base des travaux de la commission instituée par l'article 5 ci-dessus, les aires dans lesquels subsistent les animaux mentionnés sur la liste fixée à l'article 3 ci-dessus ainsi que les sites de reproduction et les aires de repos des espèces concernées sont délimités par un décret qui précise les mesures restrictives applicables pour la protection, la préservation et la multiplication des espèces concernées.

Art. 7. — Dans les aires définies selon les modalités fixées à l'article 6 ci-dessus, la commission nationale de protection des espèces animales menacées de disparition effectue un suivi et une évaluation des effectifs de l'espèce concernée, de leurs sites de reproduction et de leurs aires de repos.

La commission élabore annuellement un rapport sur l'évolution des espèces menacées de disparition et de leur habitat qu'elle transmet au ministre chargé de la chasse.

Art. 8. — Dans les aires et zones délimitées définies selon les modalités fixées par la présente ordonnance, tout usage, activité, construction ou établissement non expressément autorisé selon les modalités fixées à l'article 6 ci-dessus est interdit.

Art. 9. — Toute infraction aux dispositions de l'article 4 ci-dessus est punie d'un emprisonnement d'un (1) an à trois (3) ans et d'une amende de deux cent mille dinars (200.000 DA) à cinq cent mille dinars (500.000 DA).

Les produits de la chasse, les armes, munitions, véhicules et tous moyens ayant été utilisés pour la chasse ou la capture de ces animaux sont confisqués.

En cas de récidive, la peine est portée au double.

Art. 10. — Sans préjudice des autres sanctions prévues par la législation en vigueur en la matière, toute personne ayant permis, facilité, aidé ou contribué par quelque façon que ce soit à la chasse ou à la capture, la détention, le transport et la commercialisation des animaux ou parties d'animaux mentionnés sur la liste fixée à l'article 3 ci-dessus, est punie d'une peine d'emprisonnement d'un (1) an à deux (2) ans et d'une amende de cent mille dinars (100.000 DA) à trois cent mille dinars (300.000 DA).

En cas de récidive, la peine est portée au double.

Art. 11. — Quiconque commet une infraction aux dispositions de l'article 8 ci-dessus est puni d'une peine d'emprisonnement d'un (1) an à dix-huit (18) mois et d'une amende de cinquante mille dinars (50.000 DA) à deux cent mille dinars (200.000 DA). L'auteur de l'infraction est, en outre, tenu des frais de démolition des constructions et de la remise en l'état des lieux.

En cas de récidive, la peine est portée au double.

Art. 12. — La présente ordonnance sera publiée au *Journal officiel* de la République algérienne démocratique et populaire.

Fait à Alger, le 19 Joumada Ethania 1427 correspondant au 15 juillet 2006.

Abdelaziz BOUTEFLIKA.

Figure 1: The Ordinance No. 06-05 of July 15, 2006 the protection and preservation of certain endangered animal species **(***cervus elaphus barbarous***)**

3 The history of the Barbary deer:

The Barbary Deer is an indigenous species to North Africa, and it first appeared in the region approximately 5 million years ago during the end of the Miocene period. It is believed that the Barbary deer originated through intercontinental exchanges. According to research by (**Zachos et al, 2010**), the Algerian deer shares similarities with the Corsican red deer (*Cervus elaphus corsicanus*). Fossil deposits of the Barbary deer have not been found west of Algeria, leading to the hypothesis that the Corsican subspecies was introduced to the African continent via the land bridge connecting Sicily to Tunisia. These introduced subspecies successfully established and persisted, resulting in the Barbary deer being considered a descendant of the European red deer.

Throughout the Quaternary period, the Barbary deer inhabited the entire Maghreb region, with its range extending as far as the borders of Morocco. However, due to a combination of climate variations and significant human activities, the distribution range of the Barbary deer has undergone a drastic reduction **(Khamann in 1959)**.

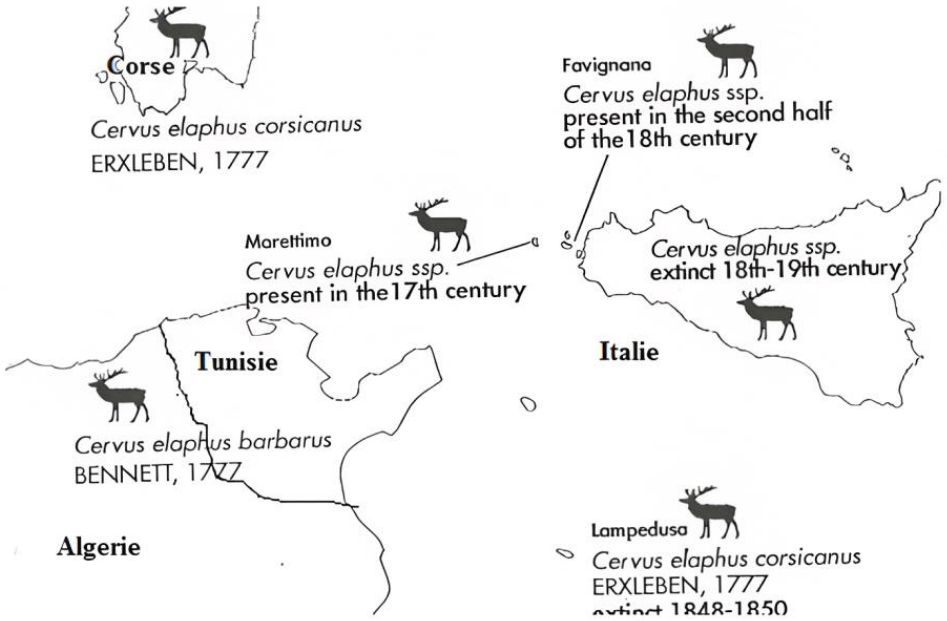


Figure 2: Distribution of *Cervus elaphus* in the Southern Mediterranean Basin

(**Masseti And Zava, 2002)**.

By the early 18th century, the distribution of the Barbary deer had become limited to specific areas. These included the western regions of Tunisia, the eastern area of Tébessa in the

Djbel Onk region, the surroundings of Skikda, the Edough forest in Annaba, and the region around Bejaia. However, the decline of the Barbary deer population continued to worsen over time, as noted by (**Burthey, 1991)**. In some instances, populations of the deer existed in the southern regions of the Sahara mountains when favourable rainfall conditions allowed. However, these populations were fragmented into small residual groups, which eventually disappeared over time.

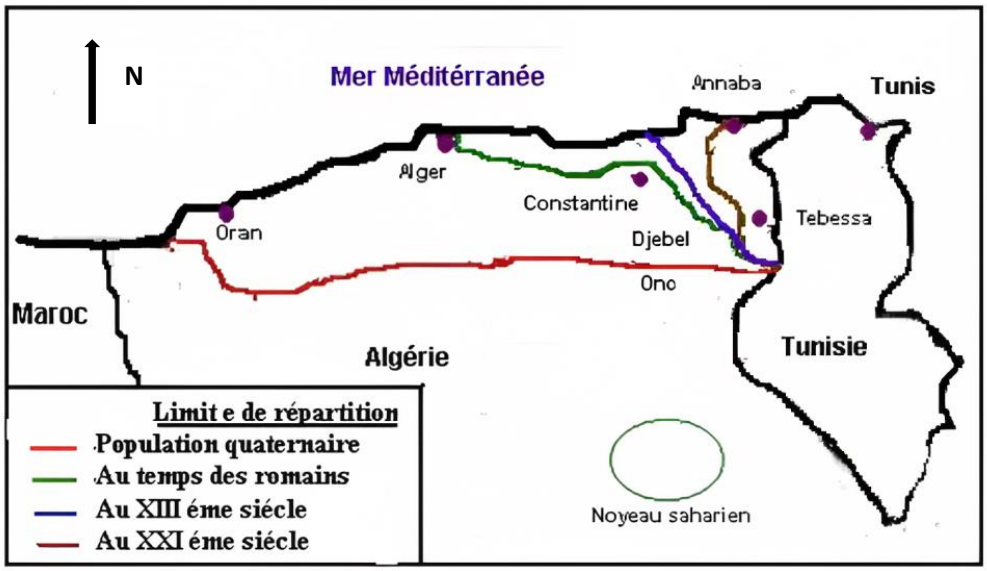


Figure 3: Historical distribution of the Barbary Deer **(Burthey, 1991)**

Presently, the Barbary deer can be found exclusively in certain forests along the northern border of Algeria and Tunisia. Since 2005, researchers from the Cynegetic Center of Zeralda (CCZ) have been involved in the reintroduction of the species. Reintroduction efforts have taken place in forests such as Akfadou, Collo. In Tunisia, the Barbary deer has been observed in the Ghardimaou and Tabarka regions, as documented by Amadou in 2002.

4 The eco-biology of the barbary deer:

4.1 Morphology:

The Barbary red deer is the largest wild ruminant mammal in North Africa. It is perfectly adapted to running with prominent withers, two pairs of legs of equal length with excellent musculature, a broad powerful neck to support the antlers, an elongated head with a coat that varies throughout the year, light brown with reddish tints in summer and dark brown with greyish tints in winter. Older deer are often darker, and fawns have a marked mottling all over their body, which remains in the adult. This clearly distinguishes the Barbary Red Deer from

the European Red Deer (**Burthey, 1991**). It has slender, muscular limbs, with well-developed ears lined with long, light-coloured hair (**Fichant, 2003**).

Sexual dimorphism is established during the development of the Barbary red deer, where only males have antlers. The body size differs between genders: the male can reach a height of 1.40 meters, while the female rarely exceeds 1 meter. The weight ranges between 150 and 205 kg for males and 100 to 150 kg for females.

The strongest antlers of an adult deer can reach a size 100 cm and weigh around 3.5 kg both. Usually, the antlers are cast between February and April and they immediately start growing the new antler. During that period, the antlers will be covered by a live tissue called velvet; this tissue contains neurons and blood vessels which hormonally control that growth.

After they complete the growth, the shedding start, cleaning the antlers of the dead velvet after cutting off the supply of nutrients at the burr **(Ceacero, 2023)**.

-A- -B-

Figure 4: A female barbary deer (hind) -A-, and barbary deer males -B- **(Dihia, C and Dehia. H S, 2016)**

Figure 5**:** Last two female Barbary deer in Europe at Tier Park, Berlin **(Taken by Mouadna. A, 2023).**

4.2 Age distinction criteria:

There are several methods to determine the age of a deer in general. Some are based on direct observation of the animal in its natural habitat, such as body size, antler size and the number of decorations for males or the colour of the coat for females.

Others use a different method, which involves examining the teeth of the animal's lower jaw.

A. From the antlers:

This method applies to male barbary deer, since the females don't grow antlers.

Males cast their antlers annually between February and April, depending on the individual's age. Their regrowth process takes about four months. During regrowth, the antlers are covered with a thin, slightly velvety skin called velvet, hence the expression "velvet antlers." This highly vascularised covering serves as a transporter for the necessary materials for antler reconstruction. As the deer ages, the antlers gradually lengthen, the number of tines (points) increases, and the main beam thickens.

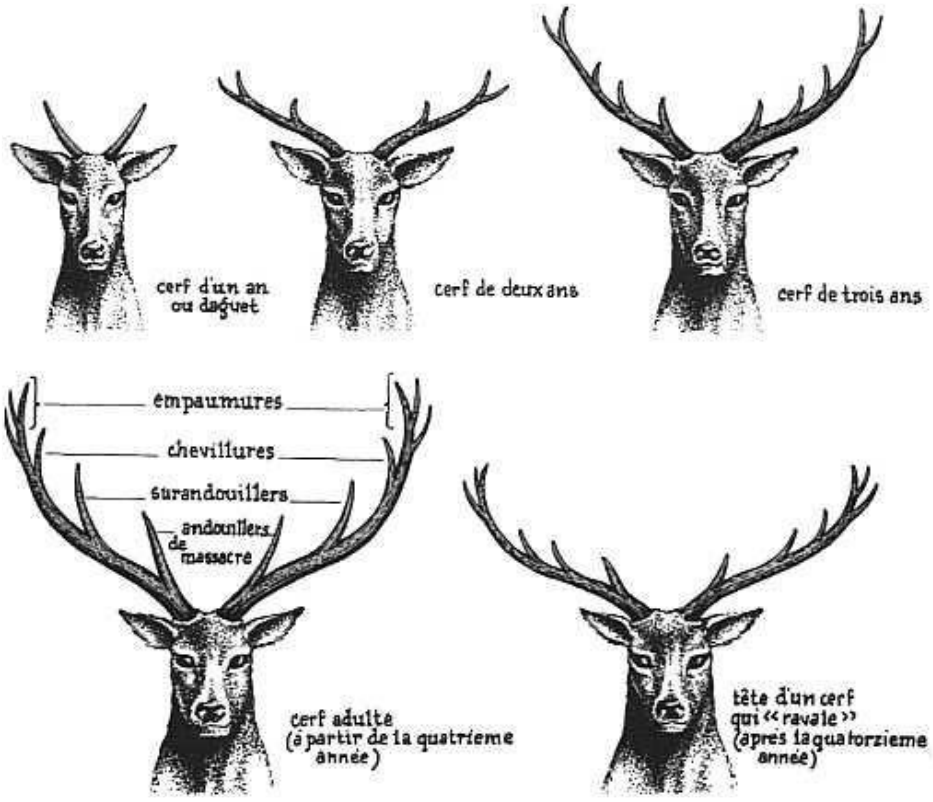


Figure 6**:** Different stages of deer antler development **(Amadou. O, 2002)**

B. From the teeth of the lower jaw:

This method applies to both sexes, and it is the most accurate because it is based on the number of molars in the jaw. At birth, fawns have their front teeth (incisors), and during the first month, the molars start to appear, the first three premolars come first, and are temporary (baby teeth) that fall out around six months. The other teeth are located behind them. Old stags are relatively easy to recognise because of their worn out and flat teeth (**Khammes. T, 2014).**

4.3 Behaviour:

The deer generally is a discreet animal with a rhythm of life that consists of sleeping during the day and eating at night (**Amadou. O, 2002**). But we can see some changes in that behaviour for reasons related to the habitat.

The Barbary deer is a creature that lives in groups known as herds. The herd's composition can be in different sizes (more or less large), depending on their access to food and other resources.

The adult males usually form smaller and less stable groups, with the older ones being solitary or accompanied by a young male (squire). By the end of July, their herds disperse or become looser until wintertime, when the rut season begins.

During that period, the males partake in ceremonial exhibitions of supremacy, engaging in antlers fights to secure the opportunity to mate with females. (**Brelurut et Al, 1990).**

The rut season occurs in large clearings and is triggered by the arrival of females in heat. Years with abundant food can induce early rutting (**Burthey, 1991**).

For its behaviour that relates directly to its physical characteristics, the male deer enjoys wallowing in mud, especially during the rut season. They also mark vegetation with the secretion from its tear glands (preorbital glands). It is a good runner; it trots, gallops when fleeing, jumps, and swims well. It regularly follows frequented routes. Its vision, hearing, and sense of smell are well developed (**Amadou. O, 2002**).

As for the females, they deliver a solitary calf annually during a single rut season. They carefully conceal it amidst thick foliage to shield it from potential threats posed by predators. Their social structure is matriarchal, so outside the specific rut period, females and young deer under three years old form herds away from males, and they are led by the older hind (female deer) called the "lead hind." The females are strongly attached to the territory where they were born. Concentrations of hinds and their offspring in these areas called "Population Cores" or "nurseries".

Figure 7**:** A hind herd outside the rutting season **(Dihia, C and Dehia. H S, 2016).**

Figure 8: A female Barbary deer. Tier Park, Berlin **(Taken by Mouadna. A 2023)**

4.4 Reproduction:

This is a fundamental act for ensuring the species' perpetuity. Under the influence of sexual maturity, males and females exhibit specific behaviour. In males, this is manifested by a movement towards females, visible stereotyped behaviour, and olfactory and vocal displays (roaring) that begin towards the end of August and continue until the end of October. Males enter the rut period first and fertilise the first female in heat, often the oldest.

Female deer typically reproduce from 3 to 13 years of age, while males do so from 6 to 12 years. The gestation period for female deer lasts an average of 8 months. Most births occur in April, but since mating for some can be late until December, isolated births can be observed until August or even September and early October (**Burthey, 1991**).

After birth, a fawn can start walking within a few hours and may weigh around 6.5 kg. In particularly favourable environments, their weight can double. While young females often stay with the maternal herd, young males leave the herd in the autumn of their second year of life **(Brelurut et al, 1990**).

4.5 The habitat:

The Barbary deer is specifically adapted to thrive in the maquis vegetation, forests dominated by cork and Zeen oak, and the accompanying plant communities. Adult males and females establish sedentary lifestyles within their respective home ranges, although their activity patterns vary. When moving within a forest, the herd follows a closed circuit, and the size of its territory changes over time in response to the availability of vegetation cover and the overall peacefulness of the environment **(Fichant, 2003).**

The dimension of a deer's home range is influenced by the characteristics of the individual deer and his potential of mobility, The individual itself and its mobility potential, the level of tranquillity and frequency of disturbances in the area, also factors that may restrict the expansion of the home range, such as highways, railways, and other human-made structures. The availability of food resources is vital, especially under hunting management practices within the territory (not the case for the barbary deer). And eventually, the habitat and the season during the rut period **(Fichant, 2003).**

The habitat of the barbary deer in North Africa predominantly occupies mountainous landscapes, specifically thriving amidst the dense woodlands and shrubby areas. This particular habitat poses challenges due to its rough topography, but the Barbary deer have evolved and possess robust legs that enable them to navigate steep inclines and rocky formations. It is

located northeast of Algeria (Akfadou to Beni Salah forests). It extends to the northwest of Tunisia, even though the most substantial concentration of Barbary deer can be found within the forests of Morocco's Atlas Mountains through different establishments of national parks and nature reserves.

4.6 The diet selection:

The deer is a ruminant whose feeding behaviour and digestive physiology closely resemble those of cattle, sheep, and goats. Like these animals, its production (foetal growth, milk production in females, body growth in young individuals, or antler growth in males) strongly depends on its diet **(Brelurt Et Al, 1990)**.

The deer primarily seeks its food at dawn and dusk. Additionally, its dietary choices follow the seasonal cycle of vegetation, as noted by (**Burthey, 1991)**, who studied the Barbary deer diet in the Beni Salah reserve, Guelma.

4.7 Presence indicators:

The deer is a timid and elusive animal that is not easily spotted. To determine its presence, looking for signs such as droppings, footprints, and bark stripping is important.

Observing this animal is not always easy, but some traces indicate their presence in a given habitat:

- **Trails**: These are natural paths, usually relatively straight, created by deer as they move in. Usually, they consistently use the same passages **(Bonnet and Klein, 1991)**.

- Footprints: They are well-defined in moist terrain and show only the two hooves **(Fig 8**). They measure between 40 and 80 mm in length and between 30 and 65 mm in width **(Bonnet and Klein, 1991)**.

- Odours: The scent of deer is characteristic of the species. It can be perceived throughout the year when deer stay for extended periods, but it is solid during the rutting season.

- Droppings or faeces: Analysing droppings information about using ecological niches throughout the year **(Fig. 10)**. The shape, consistency, colour, and dispersion of the droppings vary significantly during the annual cycle **(Fichant, 2003)**. Those of adult males are generally larger than those of females or young males. Droppings of weaned fawns are small, poorly formed, and uneven **(Bonnet and Klein, 1991)**.

- Rubbing and bark stripping: Male deer or bucks rub their antlers against the stems of young trees, more or less forcefully, depending on whether it is rutting or fraying. The bark is torn off, leaving the stem bare and sometimes even broken. The bark can be stripped all around the stem. This behaviour differs from bark stripping as the torn bark may remain attached to the stem **(Saint-Andrieux, 1994) (Fig. 7).**

- Resting areas or beds: These are the spots where deer rest and ruminate. They are often made on bedding material **(Fig. 8).**

Figure 9: A barbary deer footprint at Beni Salah reserve **(Taken by Mouadna. A, 2023).**

Figure 10: Droppings of a barbary deer in Beni Salah natural reserve **(Taken by Mouadna. A, 2022).**

CHAPTER II

MATERIAL AND METHODS

1 Study area:

The study was conducted in the Beni Salah reserve (2200 ha), part of the Beni Salah Natural Forest in Guelma province (northeast Algeria). The reserve belongs to Beni Salah National Forest, one of the most important and massive forests of the country's eastern region (**DGF, 2022)**. It straddles three provinces (Guelma, El Taref and Souk Ahras), for a total area of 35000 ha. The area under the authority of Guelma province is estimated at 12000 ha, of which 2200 ha was dedicated to the reserve. Lately it was extended by 2467 ha, for a total of 4667 ha, with a range of altitude between 490-909 masl. The reserve was created in 1972 to protect and conserve the Barbary deer **(DGF, 2022)**.

The study area is occupied exclusively by woodland, where the vegetation covers around 95% of the total area of the reserve, consisting mainly of pure stands of cork oak (*Quercus suber*), Atlas oak (*Quercus canariensis*) and mixed stands of cork oak and Atlas oak **(DGF, 2022)**. The landscape is also characterised by the presence of a significant understory, typical of Mediterranean forests. Species of shrubs such as juniper (*Juniperus sp*), mastic (*Pistacia lentiscus*), and strawberry tree (*Arbutus unedo*) are very abundant. The structure of these stands is heterogeneous and ideal for the conservation of biological diversity, because of the varied biotopes **(DGF, 2014).**

In the reserve, the barbary deer shares the habitat with different mammals represented by wild boars (*Sus scrofa*), horses, domestic livestock, the golden jackal *(Canis aureus algeriensis),* Stripped hyena *(Hyaena hyaena),* red fox *(Vulpes vulpes),* wild cat *(Félis silvestris),* common genet *(Genetta genetta),* mongoose (*Herpestes ichneumon),* weasel (*Mustela numidica*), hare (*Lepus capensis),* rabbit *(Oryctolagus cuniculus),* porcupine (*Hystrix cristata*).

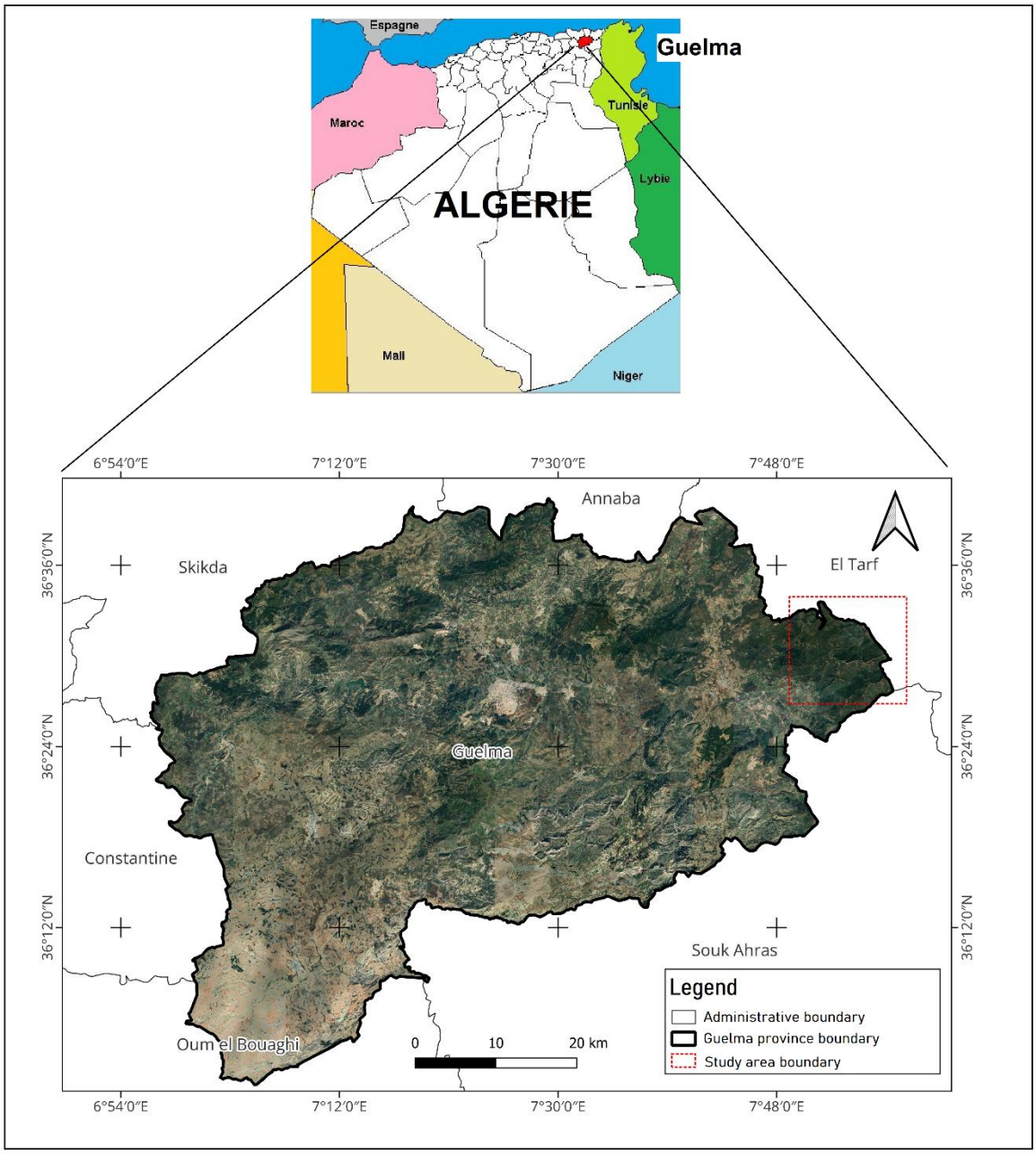


Figure 1 : Map of the study area.

2 Hydrography:

2.1 Water network:

The reserve is fenced along its borders and contains multiple water lines and networks, valleys and rivers are oriented from SW to NE (Soudan, Bounamoussa) **(DGF, 2022)**.

Oued Soudan is a branch of Oued Bounamoussa where they meet 16 km further east. Oued Soudan, which rises in the centre of the reserve and created by the convergence of chaabet

Guenater and chaabet Ain El Kasba, which joins with chaabet Ghambouz just before the reserve territory **(DGF, 2014).**

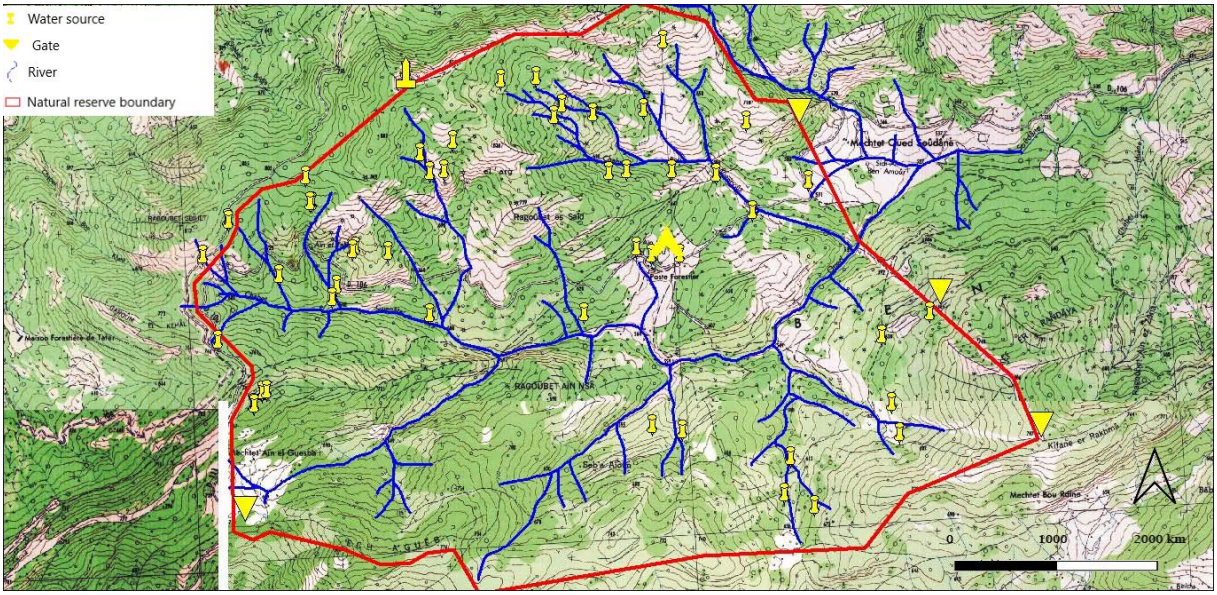


Figure 2: Map of the hydrographic network in Beni Saleh Reserve **(DGF, 2014).**

2.2 Water sources:

Beni Saleh reserve has multiple permanent water sources estimated at around 30 natural sources, with many other constructed ones **(DGF, 2022)**.

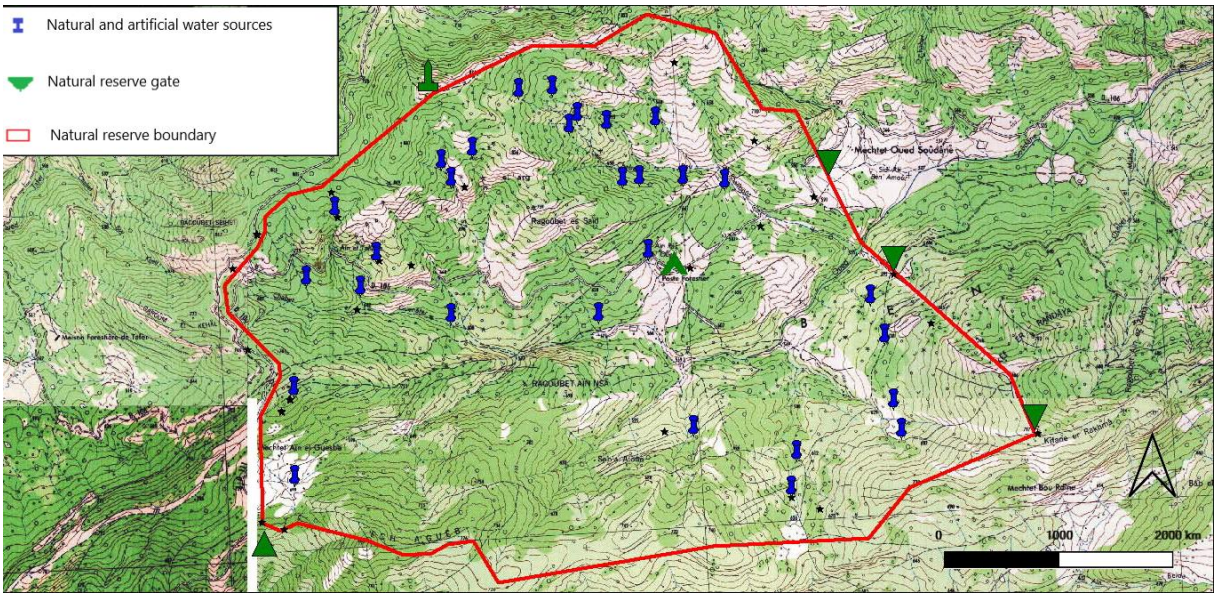


Figure 3: Map of both natural and artificial water sources in Beni Saleh Reserve **(DGF, *2014*).**

3 Geology:

The reserve lies almost entirely on a substratum of Numidian clays and sandstones, up to several hundred meters thick. Small-scale alpine movements have folded these exposed marine formations, giving them a large radius undulation **(DGF, 2014).**

Sandstones that form all the region's peaks often give rise to escarpments and cliffs of moderate amplitude **(Burthey, 1991).**

4 Climate:

The reserve is characterised with Subhumid climate and a precipitation varying between 600-800mm per year. The average temperature can reach 8°C in winter and 26°C in summer, with an annual temperature of around 18°C **(DGF, 2022)**.

5 Flora:

The study area contains a rich and diverse flora, with the presence of several rare plants, endemic or belonging to several phytogeographical domains. This goes back to the geomorphological conditions, climatic characteristics, nature and structure of the forest stands **(DGF, 2014).**

The flora exhibits interesting phytogeographical groups and numerous Phyto choric groups, with a significant presence of Mediterranean plant species. It encompasses several taxa with special status, listed as protected species according to Executive Decree 12-03 of January 4, 2012, which establishes the list of protected uncultivated plants **(DGF, 2014).**

6 In the Field:

6.1 Vegetation transects:

We applied this method to the study site at different times of the year to collect leaves and estimate the vegetation cover and density of specific points in the reserve.

A. Material and equipment

- Zip-bag for leaf samples.
- Waterproof pens for labelling the zip bags.
- 25 m long rope.
- Compass.
- Ruban meter.
- GPS.

B. Methodology:

We visited different sites in the reserve, and made 10 vegetation transects (N=10) following the footprints of the Barbary deer near water points. After selecting the sites, all of the ten transects were made in October. Using the compass, we placed the 25 m rope from south to north (start to endpoint). Above 40 cm from the ground, we calculated the density of the vegetation cover on both sides (1m on east and west) of the rope. The number of specimens for each species was calculated. Leaf samples were collected and stored in labelled zip bags and later left to dry.

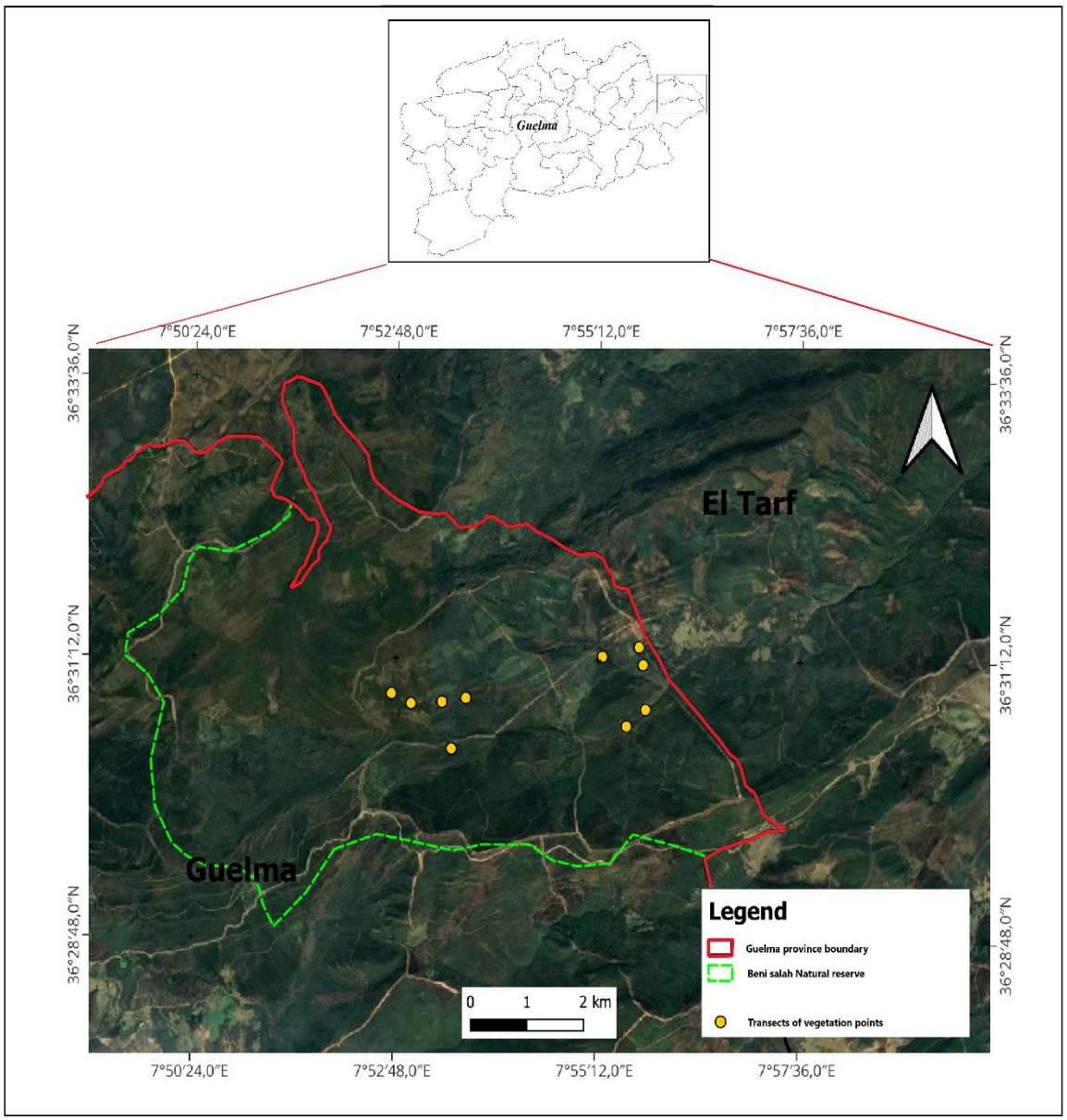


Figure 4 : Map of transects of vegetation points in Beni salah natural reserve.

6.2 Faecal samples Collection:

A. Material and equipment:

- Clean new plastic gloves for each sample.
- Mid-size zip bags.
- Waterproof pens for labelling the zip bags.
- GPS.

B. Methodology:

For the collection of faecal matter, we targeted the surrounding of each transect that had been made. We collected 11 faecal samples by following possible sites for resting or feeding **(Figure 15).** Four samples were collected in May, three samples in August and four samples were collected in October. Finally, faecal analysis were preformed to obtain faecal slides.

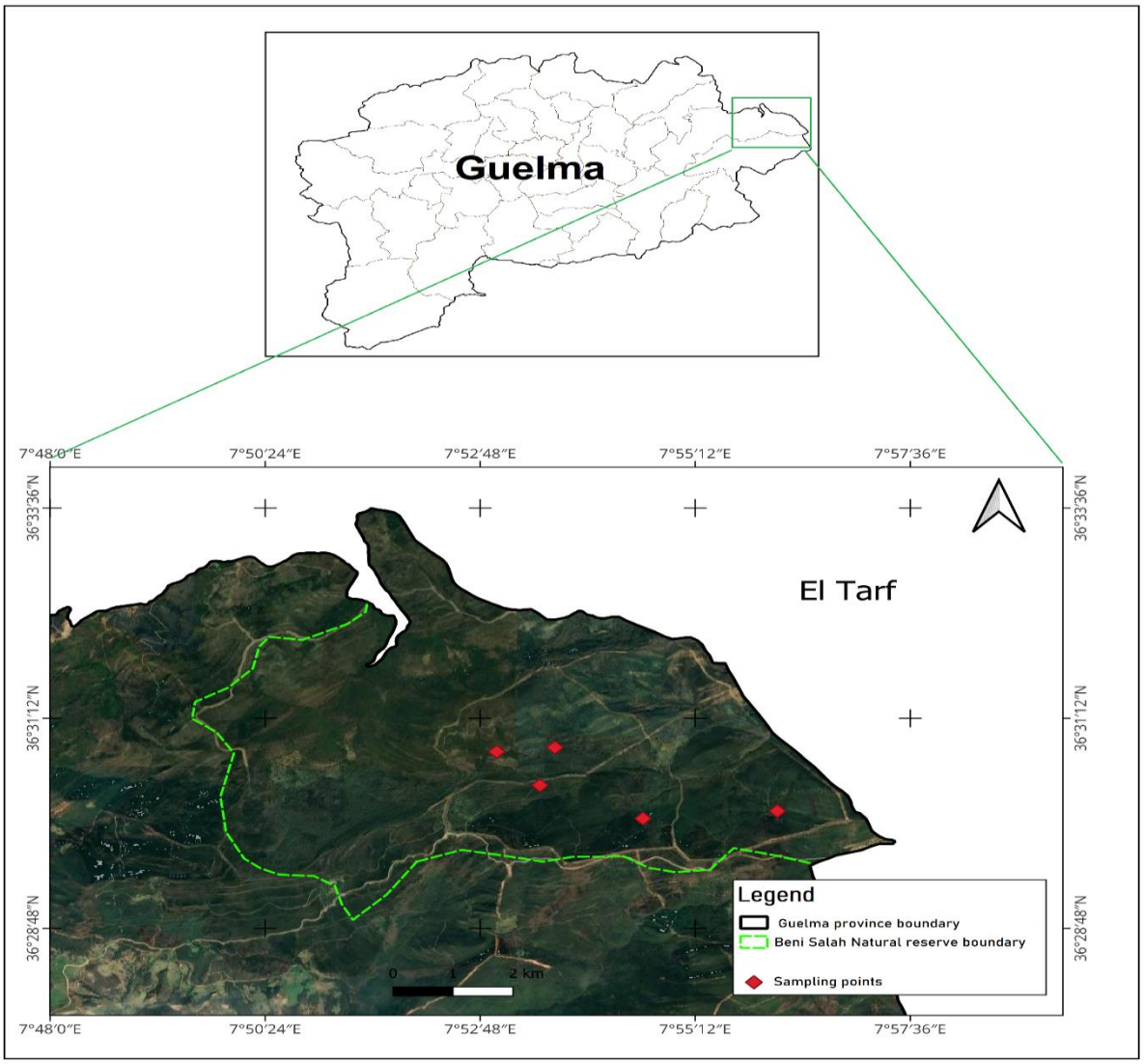


Figure 5: Map of faecal sampling points.

7 In the lab:

7.1 Epidermis references catalogue:

The leaf epidermis can be obtained using different methods, we adapted the method used by **Département de Ciència Animal i dels Aliments, UAB Barcelona, Spain.**

A. Material and equipment:

- Test tubes.
- Scalpel.
- Tweezers.
- 200 ml precipitation vessel.
- Test tube rack.
- Pipettes.
- Slides.
- Coverslips 24 x 60 mm.
- Tags.
- Glycerine at 50%.
- DPX.
- Glass rod.
- NaClO.

B. Procedure:

In the sampling process, also called scraping, we applied the following steps, where, the leaf is moistened and placed on the slide, where we can observe the abaxial side, then using a scalpel, we scrape the leaf gently to remove the mesophyll tissue, during this process we can add 30% NaClO to lighten the epidermal tissue when it becomes transparent, we place it using a tweezer in petri dish filled with water to wash it, the same process to be repeated for the adaxial face of the leaf **(Figure 16)**.

We prepared the slides by labelling them, then applied four drops of glycerine on each slide and spread. With a tweezer we transfer the epidermis tissue from the petri dish to the corresponding slide, where we place it carefully to avoid any folding of the tissue; after that, we apply the sealing resin (DPX) on the edges of the slide and cover it with a coverslip (24 x 60 mm). After drying (5 minutes), we obtain the leaf epidermis slide **(Figure 16)**.

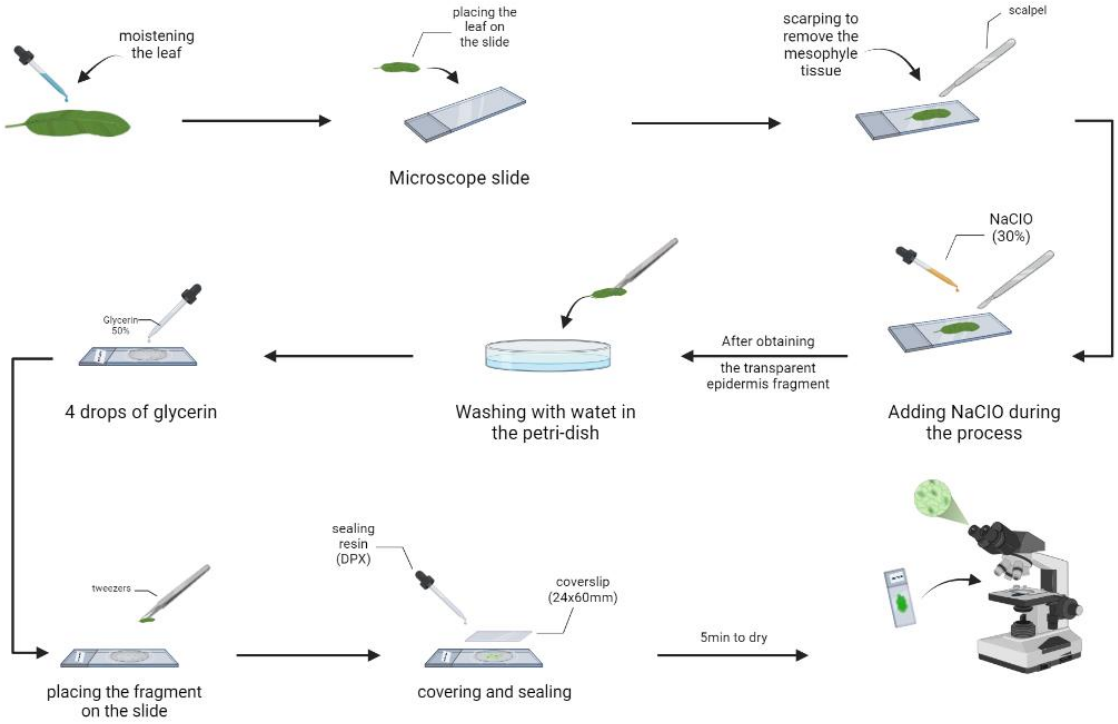


Figure 6: Steps of Epidermis reference slide.

7.2 Faeces processing and analyses:

The sampling analysis required collecting and preparing faecal samples. We adapted the method used by **the Département de Ciència Animal i dels Aliments, UAB Barcelona, Spain.**

A. Material and equipment:

- Mortar.
- Test tubes.
- Scalpel.
- Tweezers.
- 200 ml precipitation vessels.
- Test tube rack.
- Sieves 0.125, 0.5 and 1mm mesh.
- Pipettes.
- Slides.
- Coverslips 24 x 60 mm.
- Funnel.

- Tags.
- Glycerine at 50%.
- DPX.
- Thermostatic bath.
- Glass rod.
- HNO_3.
- NaClO.

B. Procedure:

All the collected samples were analysed at the Animal science lab of the Faculty of Tropical Agriscience, Czech University Life Science, Prague **(Figure 21)**. Most of the collected samples were dry already; non-dry ones were freeze-dried separately for a minimum of 72 hours **(Figure 17, 18).**

They were grounded separately by a coffee grinder and placed in new labelled zip bags. Using a spoon, we placed approximately 0.5 g of each ground sample in a labelled test tube, and 3 ml of nitric acid was added to each tube with a pipette until the sample is covered. Introducing the rack tube to the thermostatic bath at 80°C for 2min; after placing a 200ml of distilled water in a labelled beaker, we empty the tube content into the corresponding beaker to clarify the sample; after that, using two sieves (0.125 and 1.0 mm or 0125 and 0.5 mm, depending on the particle size) we filtered the content of the beaker by placing the larger pore sieve on top, the collected material on the 0.125 mm sieve was placed in a test tube with the help of a tweezer, and added 3 ml of NaClO for 30 min in the test tube (blanching)**(Figure 19).**

After blanching we emptied the content of the test tubes into a 200 ml distilled water beaker and sieved it again with a 0.125 mm sieve. After preparing the labelled slides, four drops of 50% glycerine are added and spread, then with a tweezer, a little of the sieved sample is placed and spread over the slide, and sealing resin (DPX) is placed on the edge of the slide and covered with a coverslip (24 x 60 mm). After drying (5min), we obtain the faecal sample slide **(Figure 20).**

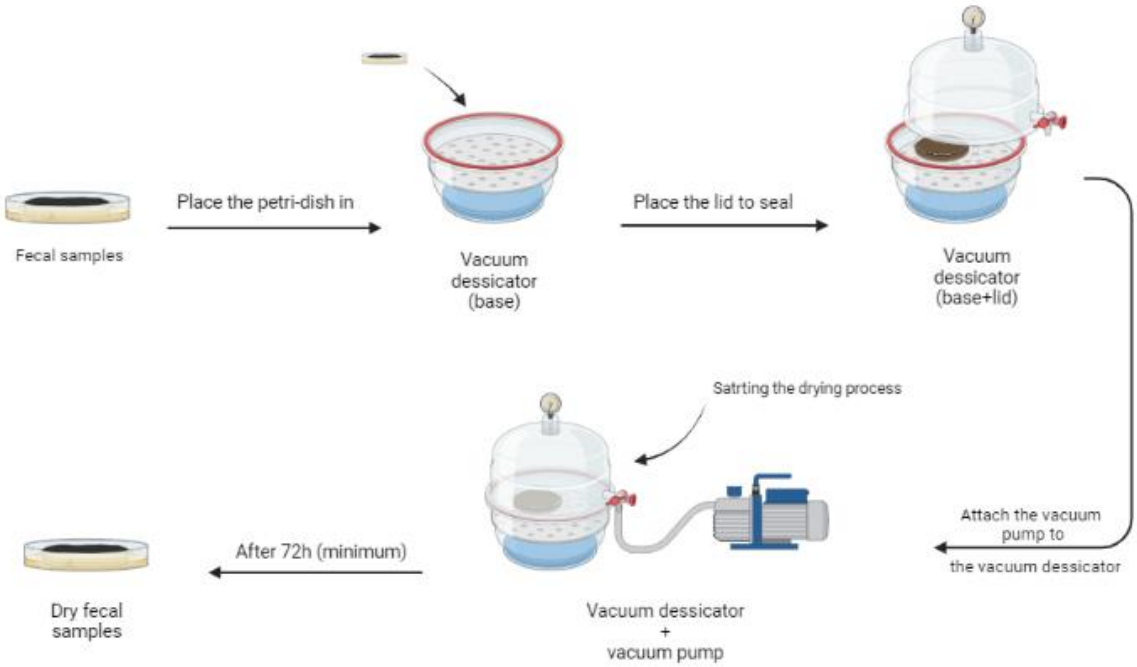


Figure 7 : drying method **(Vacuum desiccator + vacuum pump).**

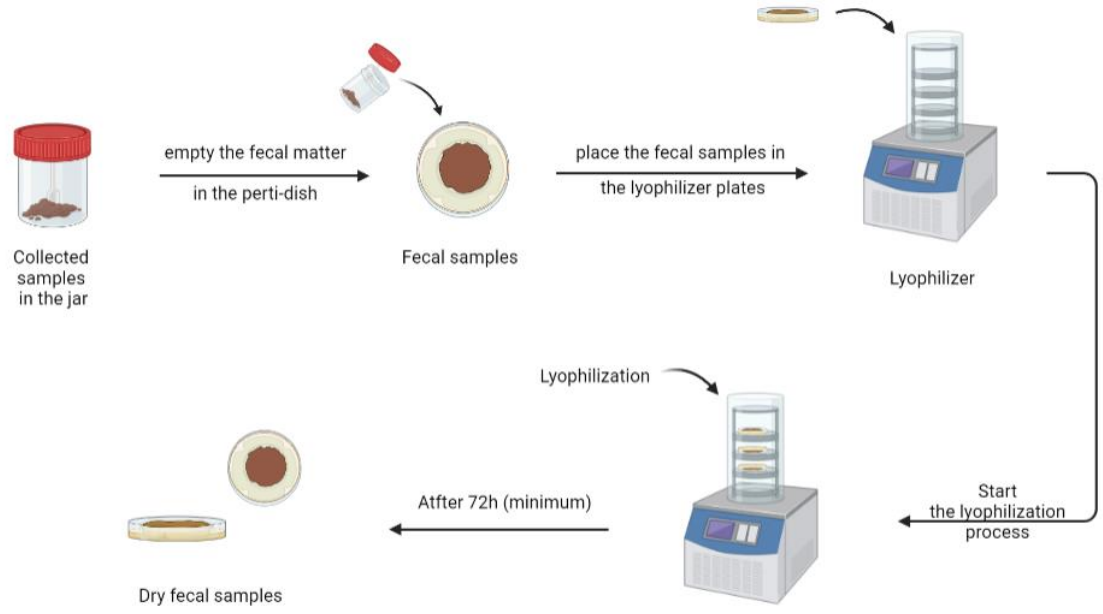


Figure 8: Freeze-drying faecal sample using a lyophiliser **(lyophilisation).**

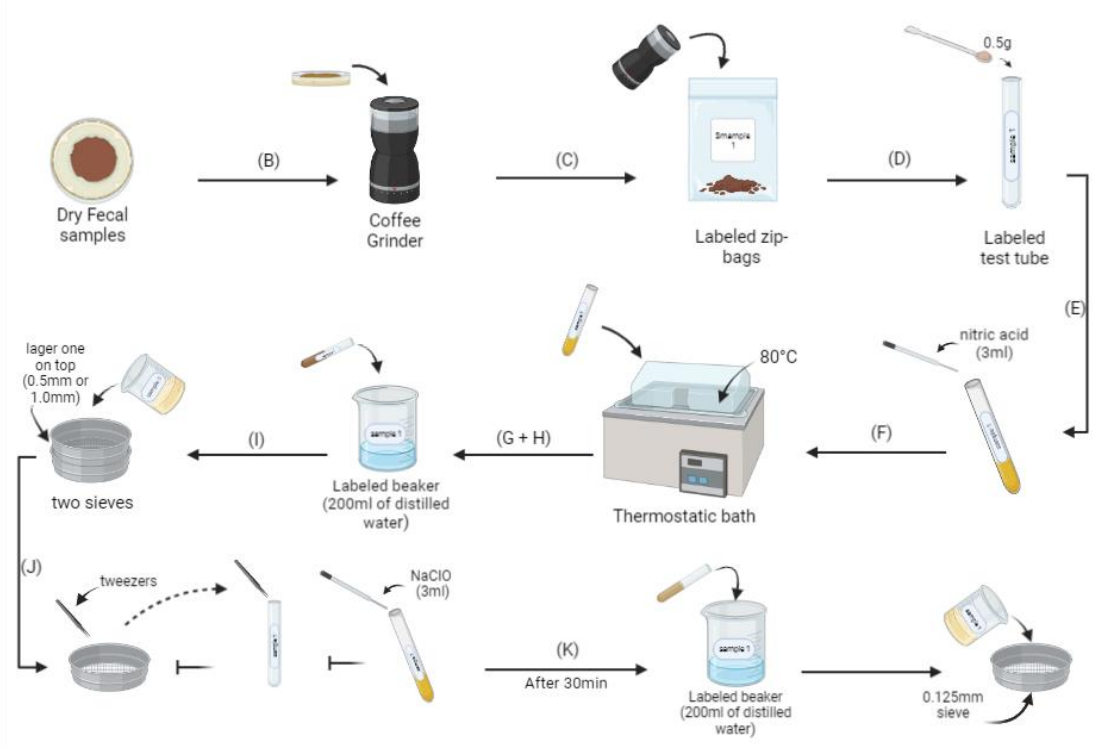


Figure 9 : Process and preparation of the faecal samples.

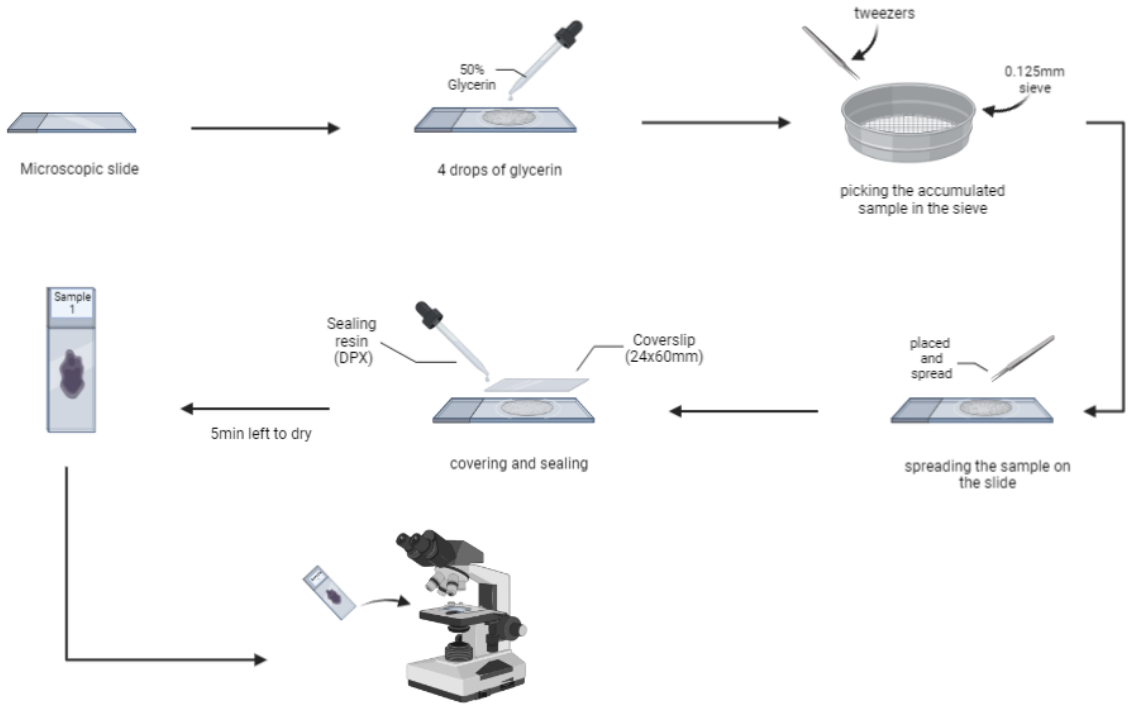


Figure 20: Final steps of the faecal sample's slides.

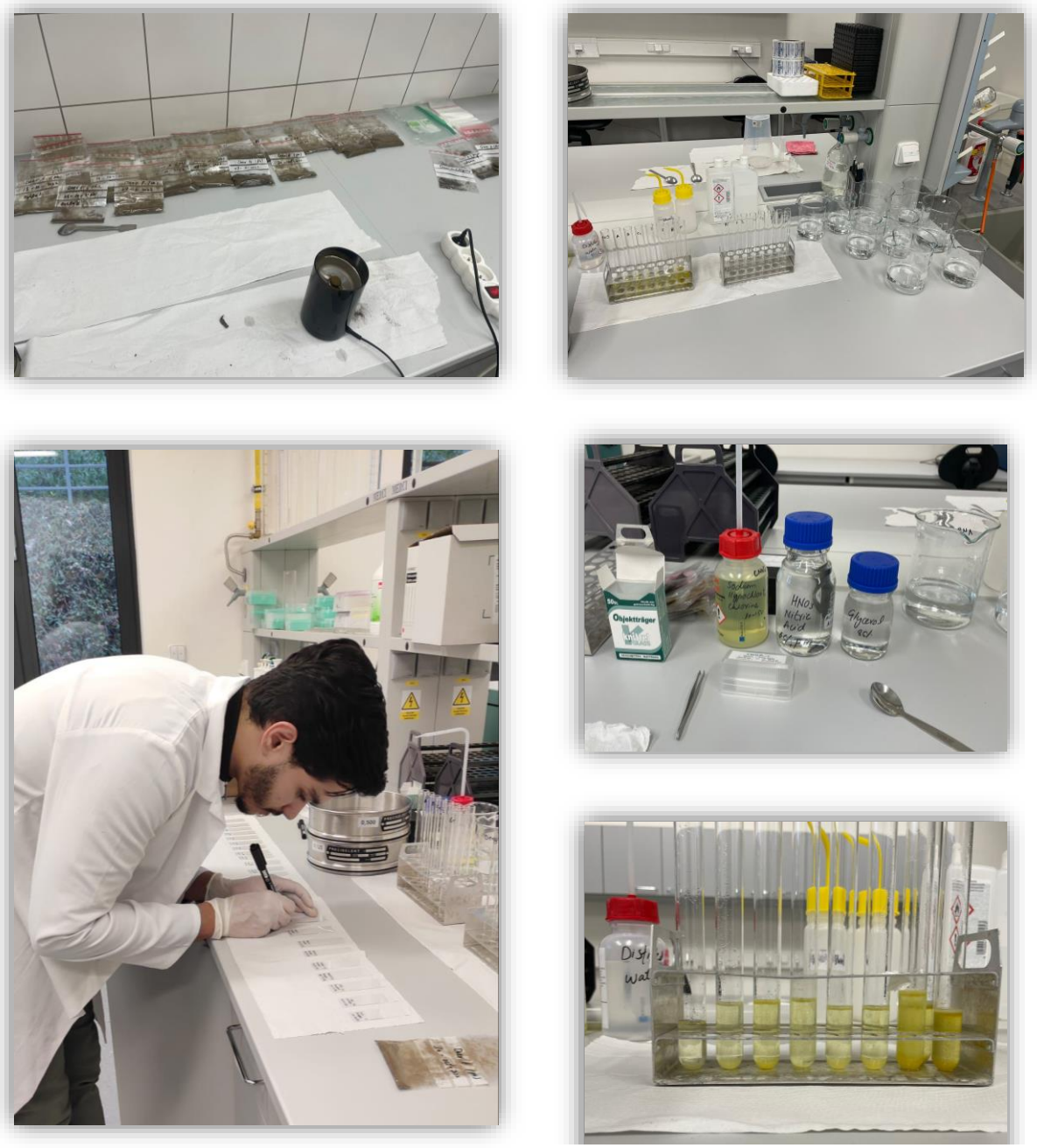


Figure 10: Faeces analyses at the Animal science lab, Faculty of Tropical Agriscience. CZU Prague. **(By Mouadna. A 2023).**

CHAPTER III

RESULTS AND DISCUSSION

1 Results:

1.1 Plants availability:

In our study, we found that the plant availability in the field was represented mainly by two classes, trees and shrubs with 70.7% (first class) and Herbs and grasses with 29.3% (second class). We found nine families belonging to trees and shrubs and four families belonging to herbs and grasses. A total of nine families and fourteen species of trees and shrubs were found including one species from *Cistaceae (Cistus creticus*), one species from *Lamiaceae* (*Salvia fruticose*), two species from *Fabaceae* (*Cytisus villosus*, *Calicotome spinosa*), three species from *Ericaceae* (*Erica arborea, Erica scoparia, Arbutus unedo*), two species from *Fagaceae* (*Quercus suber, Quercus canariensis*), five families (*Oleaceae, Myrtaceae, Rosaceae, Thymelaeaceae, Asparagaceae*) were represented only by one species each (*Phillyrea latifolia, Myrtus communis, Crataegus azarolus, Daphne gnidium, Asparagus acutifolius*), respectively.

During the whole period of study and according to the first class, we found *Cistus criticus* was the dominant species with 31.7%, followed by *Salvia fruticose (*14.1%), *Erica scoparia* (7.8%), *Cytisus villosus* (7.4%), *Erica arborea* (4.5%), *Calicotome spinosa* (1.8%), *Phillyrea latifolia* (0.8%), *Myrtus communis* (0.6%), *Crataegus azarolus* (0.5%), *Arbutus unedo* (0.5%), *Quercus suber* (0.5%), *Daphne gnidium* (0.4%), *Asparagus acutifolius* (0.3%), *Quercus canariensis* (0.1%). At the same time, the second class was dominated by *Asphodelus ramosus* with 10.4%, followed by *Ampelodesmos muritanicus* (9.1%), *Polypogon monspeliensis* (4.7%), *Eryngium campestre* (2.2%), *Daucus carota* (2.2%), *Drimia maritima* (0.8%).

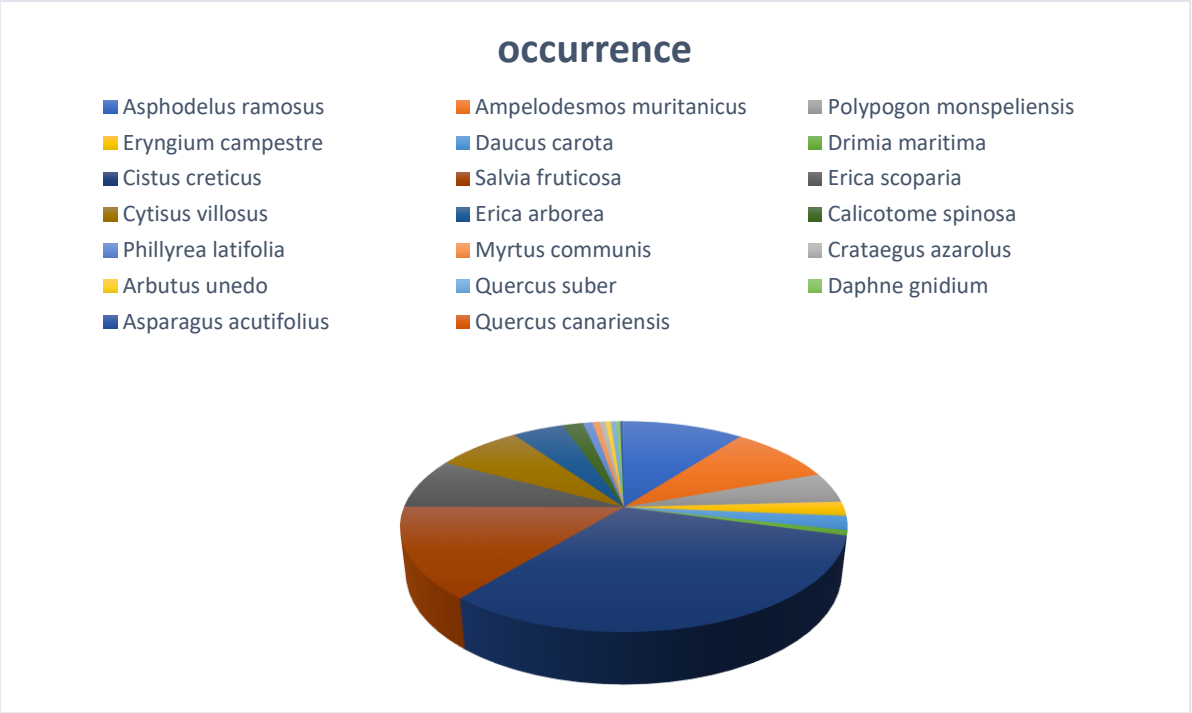


Figure 11: Plant availability in Beni Salah natural reserve

1.2 Diet of the barbary deer:

Table 2 shows the main plant species (with maximum and minimum) that have been observed to be consumed by the deer during the study period (Spring, Summer and Autumn). Trees and shrubs characterised the diet composition with a mean of 78.5 ± 8 %, while herbs and grasses appeared with a mean of 21.5 ± 8 % **(Figure 23)**.

***Table 2*:** Maximum and minimum consumption of the plants consumed by the Barbary deer during the study period in Beni Salah natural reserve **(Northeast Algeria).**

Family	Consumed species	Minimum	Maximum
Fagaceae	*Quercus suber*	14.0%	40.0%
Ericaceae	*Erica arborea*	5.3%	27.3%
Ericaceae	*Arbutus unedo*	4.0%	22.7%
Myrtaceae	*Myrtus sp*	5.3%	16.0%
Myrtaceae	*Myrtus communis*	0.0%	11.3%
Thymelaeaceae	*Daphne gnidum*	0.0%	13.3%
Oleaceae	*Phillyrea latifolia*	0.0%	8.7%
Liliaceae	*Smilax aspera*	0.0%	2.7%
Poaceae	*Ampelodesmos muritanicus*	0.0%	7.3%
Unknown	Unidentified herbs	2.7%	32.0%

The *Fagaceae* family with only one species (*Quercus suber*) represented the largest proportion, averaging 21.3 ± 7.8 %. An average of 19.2 ± 8.3 % was recorded with unknown herbs species. In the second place *Erica arborea* with 15.2 ± 6.2 %, *Arbutus unedo* 14.2 ± 5.9 %, *Myrtus sp* 10.5 ± 3.9 %. The rest of the species (*Myrtus communis, Daphne gnidum, Phillyrea latifolia, Smilax aspera, Ampelodesmos muritanicus*) presented a low proportion with (6.5 ± 4.2 %, 5.8 ± 4.3 %, 3.7 ± 3.3 %, 1 ± 1.2 %, 2.3 ± 2.9 %), respectively.

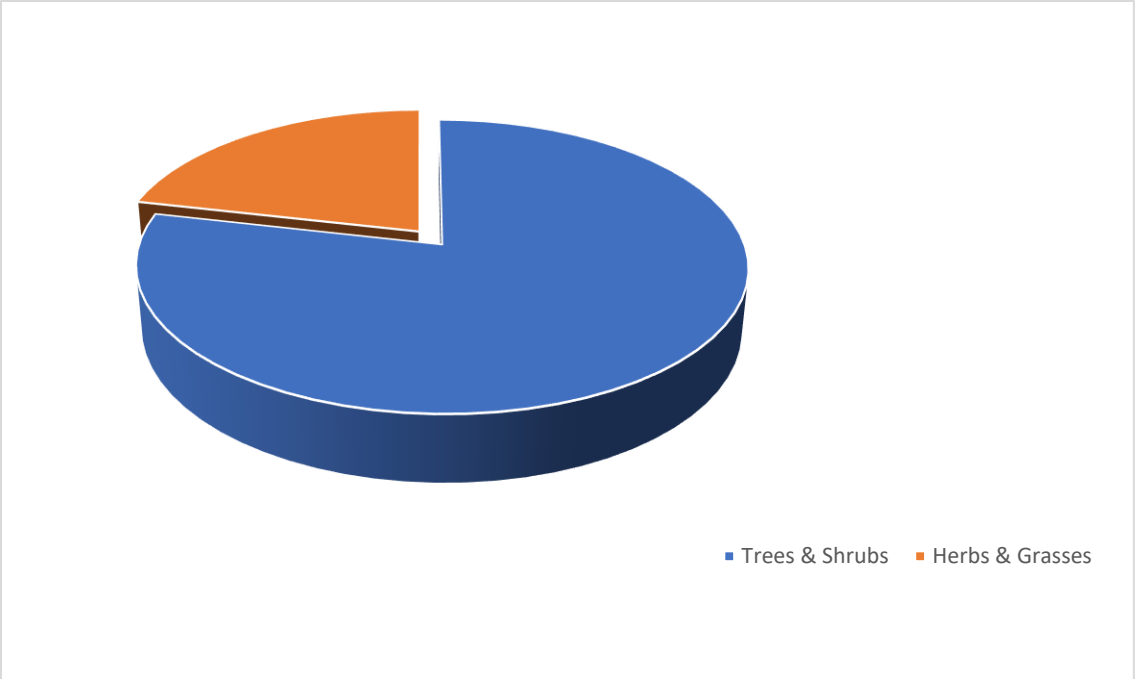


Figure 12: Diet composition of the Barbary deer in Beni Salah natural reserve

1.3 Selectivity indices:

Based on the Manly's selectivity index, trees and shrubs were the most positively selected class ($w_i = 1.111$, $\chi^2 = 18.62$, $p<0.045$). On contrary, herbs and grasses were classified as a negatively selected class ($w_i = 0.732$, $\chi^2 = 44.94$, $p<0.001$). Our study revealed that six species of trees and shrubs were positively selected by the deer during the study period including (*Quercus suber, Daphne gnidium, Phillyrea latifolia, Arbutus unedo, Erica arborea, Myrtus sp*) ($P < 0.001$), respectively (table 3). Only one species of herbs and grasses was negatively selected by the deer (*Ampelodesmos muritanicus*) ($P<0.001$).

Among the plant categories observed, *Erica arborea* was the most positively selected species with (4.45%) ($w_i = 3.402$, $\chi^2 = 368.94$, $p<0.001$), followed by *Phillyrea latifolia* and *Myrtus sp* with (0.84, 0.60%) ($w_i = 4.388$, $\chi^2 = 235.48$, $p<0.001$) ($w_i = 28.466$, $\chi^2 = 2063.44$, $p<0.001$), respectively. The lowest value positively selected by the deer was *Daphne gnidium* with (0.36%) ($w_i = 16.297$, $\chi^2 = 1447.04$, $p<0.001$). The only negatively selected species was *Ampelodesmos muritanicus* with (9.08%) ($w_i = 0.254$, $\chi^2 = 64.77$, $p<0.001$) (Table 3).

***Table 3*:** Positive and negative selected plant species by the Barbary deer

Plant species	Occurrence	Availability	w_i	χ^2	p-value	Selection
Quercus suber	0.52%	21.33%	40.750	10255.74	<0.001	+
Daphne gnidium	0.36%	5.82%	16.297	1447.04	<0.001	+
Phillyrea latifolia	0.84%	3.70%	4.388	235.48	<0.001	+
Arbutus unedo	0.47%	14.48%	30.780	5321.86	<0.001	+
Erica arborea	4.45%	15.15%	3.402	368.94	<0.001	+
Myrtus sp	0.60%	17.09%	28.466	2063.44	<0.001	+
Ampelodesmos muritanicus	9.08%	2.30%	0.254	64.77	<0.001	-

2 Discussion:

In this study, we conducted research on the threatened Barbary deer Diet in Northeast Algeria.

Our results showed a similarity with others studies conducted on the species in the North African region. These studies noted that the strawberry tree *Arbutus unedo (Ericaceae*) was at the top of the consumed trees and shrubs in the diet composition of the deer, during the whole year (**Burthey, 1991)**, **(Oumani, 2002)**. Although, in the Northern part of Morocco **Brahim, I et al. (2018**) found that *U. boivini* and *C. triflorus* were the most consumed species from trees and shrubs class during all of the four seasons. However, in our study during the three months (Spring, Summer and Autumn), *Quercus suber* and unidentified herbs species presented the most consumed species with highest selectivity. However, *Quercus suber* was the only species that exhibited a positive selectivity by the deer.

In South of Europe, researches on the deer diet across the Mediterranean basin also showed signs of aligns with our results. A study on the roe deer diet in Spain **(Bartolomé, J et al. 2002)**, showed that *hedera helix* (shrubs) and *Rubus sp* (trees) formed the bulk of the annual diet composition, followed by *Quercus sp* (trees). In another study by **Bugalho, M.N., & Milne, J.A. (2003)**, red deer in southern Portugal consumed more browse species such as Cork oak during summer season in dry years rather than wet years.

Within the San Rossore reserve, Pisa, Italy. **Bruno, E, and Apollonio, M. (1991)** noted that the most important plants for the fallow deer were trees and shrubs in both overall and seasonal diets. In contrast, during our study period of three seasons, our results shows that the Barbary deer exhibited a browse trait with a positive selectivity towards trees and shrubs, dominating the diet composition of the deer with 78.5 %. However, herbs and grasses showed a negative selectivity from the deer with a diet composition of 21.5 %.

The vast consumption of trees and shrubs by the deer during almost all seasons, may be due to the availability and the deer need of crude protein and nutrient, considering the dry years that occurred in all of the Mediterranean area

In general, the deer diet in some areas of the Mediterranean basin showed signs of similarity in the diet composition and the preferred plants. This similarity most likely related to the climate, and the availability of the vegetation cover considering the geographic resemblance of the region. Although, our study may be missing the seasonal variation of the deer diet, we couldn't compare its seasonal variation of the Barbary deer diet in Algeria with other areas. Significantly, the Barbary deer in Northeast Algeria appear to share a similarity in the diet composition with other deer across the Mediterranean basin.

Conclusion

In conclusion, the diet selection of the barbary deer appears to be influenced by number of factors, including the availability of food resources. However, our results showed a slight difference in the diet as well as the preferred plant species of the Barbary deer in Algeria compared to other population in the North African region. This may be explained by the difference in the vegetation cover, heterogeneity of landscape and season in these different areas. Although, the Barbary deer also exhibited a major difference in the diet compared to most of the deer species in Southern Europe. Our results can be used as bassline for future studies to reveal the diet and other factors that could be contributed to the variation of this latter such as habitat vegetation cover, range of elevation, human activities, natural disasters, climate change. On account of outcome of this research we recommend, that further studies focused on the seasonal variation of the hole food web and habitat selection of the Barbary should be made for more comprehensive determination of the Barbary deer diet.

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