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# THE ECOLOGICAL IMPORTANCE OF *CHAMAEROPS HUMILIS* STEPPE FOR ANIMAL BIODIVERSITY IN NORTHWEST AFRICA (MOROCCO)

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**Abstract.** Analysis of biological diversity in woody habitats is crucial for the implementation of suitable conservation policies. We carried out monthly field visits using the point count method for avian species and walked-transect surveys for mammals and reptiles from January 2018 to December 2021 in Fez, El Hajeb and Sefrou, central Morocco. The studied sites were steppes dominated by *Chamaerops humilis*. A total of 90 bird, 12 mammal and 8 reptile species were documented. Furthermore, two species of conservation concern, i.e., the vulnerable European turtle dove *Streptopelia turtur*, and the endangered Egyptian vulture *Neophron percnopterus* were recorded. The documented species use *Chamaerops humilis* for breeding (support for nesting birds), foraging (via fruits) and wintering purposes. These findings are the first results related to animal biodiversity in *Chamaerops humilis* shrublands in Morocco. However, other aspects, including the nutritive quality of *Chamaerops humilis* fruits for wintering animals, need further studying. Likewise, the threatening factors that might negatively influence North African forests require urgent studying.

## INTRODUCTION

*Chamaerops humilis* L., also called the Mediterranean dwarf palm, is an essential floristic component of the western Mediterranean zone because it is the only palm species naturally distributed in both Africa and Europe (Guzmán et al. 2017). It is widely known for hosting animal species including insects and other small invertebrates (Dembilio et al. 2009), which is of great interest for biodiversity. As such, the analysis of the importance of *Chamaerops humilis* within ecosystems can clarify its ecological role.

Plants are commonly used for breeding, foraging and sheltering by many animal species (Mansouri et al. 2019). Trees are used as nesting supports for birds, including migratory and resident species (César et al. 2018; Mansouri et al. 2021a, b, c), while leaves and stems serve as materials to build nests (Mansouri et al. 2021c). Similarly, fruits, seeds and other plant parts serve as foraging resources for animal species, principally during wintering periods when resources become scarce (Gosper et al. 2005; Mokotjomela et al. 2013). Therefore, the study of animal biodiversity in *C. humilis* will clarify the importance of this plant for a variety of bird, mammal and reptile species. Furthermore, *C. humilis* produces nutritious fruits and roots that can serve as foraging resources (Cadi et al. 2021).

In Morocco, *C. humilis* is widely distributed from the Mediterranean sea coasts (North) to the Agadir (in the South), and from the Atlantic coasts in the West to Alge-

rian borders in the east (Lachkar et al. 2020; Cadi et al. 2021). The species is found in steppes of high and low altitude zones, such as Mountains of Taza, Middle Atlas and at coastlines (Lachkar et al. 2020). Equally, the species is widely studied in terms of bio-ecology and chemical composition (Gaamoussi et al. 2010; Benmehdi et al. 2012). Fruits were investigated for chemical composition and therapeutic roles mainly against microorganisms (Cadi et al. 2021). Currently, the bioactive properties of leaves (Nekhla et al. 2021), seeds, pulp, and bark are being investigated for medicinal value (Gonçalves et al. 2018). On the contrary, the ecological roles of this widespread plant have not been fully explored yet.

Our main objective was the species identification of birds, mammals and reptiles using this biotope for breeding activities and foraging purposes, as well as the documentation of factors threatening this plant and its ecological services. The animal diversity in *C. humilis* was documented during field studies at three Moroccan sites, i.e., Fez, El Hajeb, and Sefrou provinces. Likewise, the evaluation of its ecological role will help propose conservation measures based on the diversity and conservation status of the encountered species. Moreover, this study will serve as a model for future comparative research concerning *C. humilis* and biodiversity in Morocco, entire North Africa, and Mediterranean basin.

## MATERIALS AND METHODS

### *Study area*

The study was conducted in the Middle Atlas, in central Morocco. Generally, this zone is a mountainous chain situated between the Rif and the High Atlas. It stretches for 350 km, from the Southwest to the Northeast of Morocco, covering a total area of 2.3 million hectares, or 18% of the mountains of the kingdom (El Jazouli et al. 2017). The area is characterized by a very high rainfall, giving the Middle Atlas the character of a "water tower", both from a hydrogeological and a hydrographic point of view (Adallal et al. 2019). Three geographical sites were selected for our study, namely Sefrou, Fez, and El Hajeb provinces (Figure 1). The climatic conditions and topographical features of the study sites are summarized in Table 1. Sefrou and El Hajeb provinces are characterized by forests dominated by Holm oak (*Quercus*

Table 1. Summary of temperature, rainfall, and altitude at the study sites.

| Site | Temperature min (°C) | Temperature max (°C) | Annual Rainfall (mm) | Altitude (m) |
|---|---|---|---|---|
| Fez | 9 (January) | 42 (August) | 549 | 400–600 |
| Sefrou | 6.5 | 33 | 660 | 847 |
| El Hajeb | 4 | 35 | 650 | 1 000 |

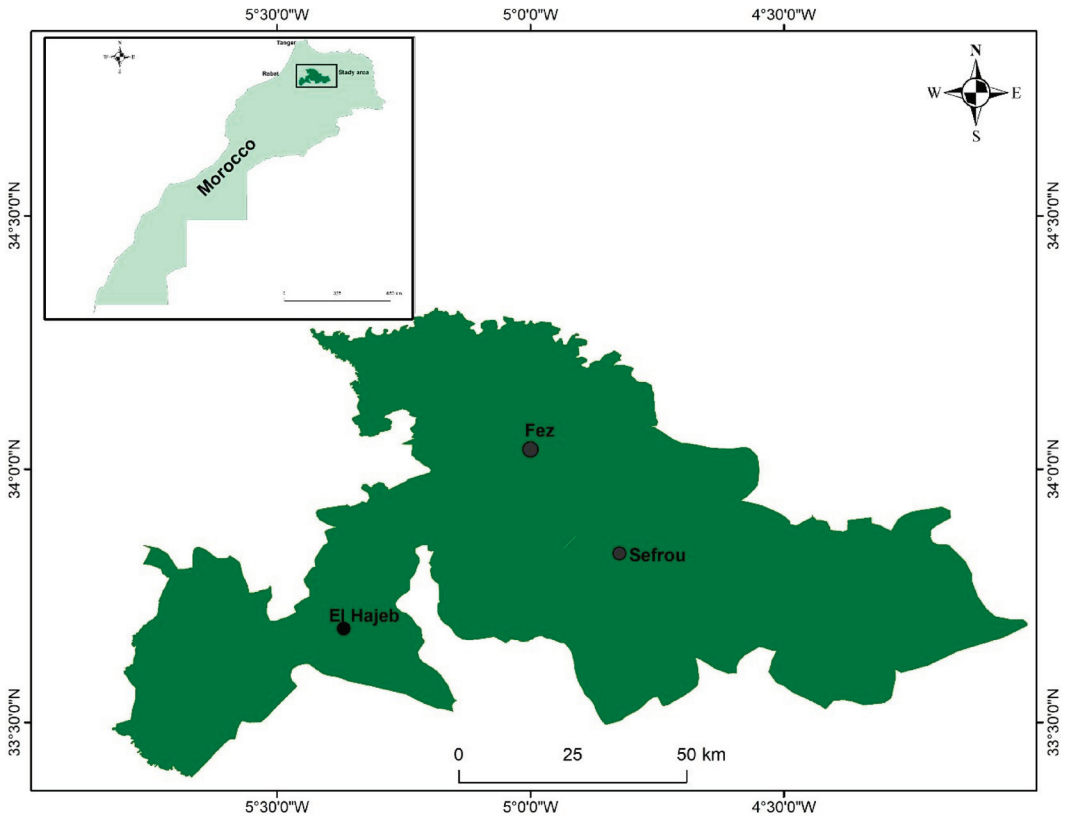


Figure 1. Prospected sites from 2018 to 2021.

*rotundifolia*), Aleppo pine (*Pinus halepensis*), Lentisk pistachio (*Pistacia lentiscus*), and false palm (*Chamaerops humilis* L.). Fez is dominated by agricultural fields of cereals, olives, and other fruit trees.

Animal diversity was investigated only in the areas dominated by *C. humilis*. Sampling was done monthly, in the morning (9–11 h) and in the evening (15–18 h), when species were active (to encounter the maximum number of species), during 2018–2021.

### *Bird sampling*

We documented bird species at each site from January 2018 to December 2021. Generally, birds were surveyed and recorded using the point-count method with unlimited distance (we did not limit the distance of transects because the habitats were open steppes) because the area explored was large. This method is widely used ((Bani et al. 2006; Blondel et al. 1970; Blondel 1975; Mansouri et al. 2021b), because it documents extensive areas and the neighbouring scenery (Blondel et al. 1970; Reynolds et al. 1980; Mansouri et al. 2022). Moreover, this technique allows collecting a wide variety of ecological data (mainly breeding and foraging activities) in a cost-effective way (Selmi and Boulinier 2003; Mansouri et al. 2022). During each 5 hour-long transect walk, the numbers of birds, seen and/or heard (mainly during the breeding phase), were recorded.

Identification of bird species was made using ornithological guidebooks (Guide de terrain des oiseaux d'eau au Maroc by Rhimou and Rihane, (2019) and Les Oiseaux du Maroc: Guide d'identification by Franchimont et al. (2010)), binoculars (BRAUN 10 × 50 Multi-coated optics 99M/1000M), and a telescope (Nikon waterproof D = 82 p).

### *Sampling of mammals and reptiles*

Species were recorded while walking along 7–10 km-long transects in open areas (each transect was divided into 150 m-long observation segments because reptiles are small animals with limited ranges) (Carvajal-Cogollo and Urbina-Cardona 2015). Further, we searched for animal species, mainly for reptiles, in cavities and under rocks. Aquatic species were searched for in the rivers and streams crossing the study sites. Species identification was based on 'Les grands mammiferes du maroc meridional (Haut Atlas, Anti Atlas et Sahara): Distribution, écologie et conservation' thesis (Cuzin 2003), and 'Inventaire commenté des amphibiens et reptiles du Maroc'. (Mellado and Dakki 1988)

### *Menacing factors*

We recorded the most impacting factors on the vegetation cover and animal diversity in the field (observations). The data concerning the farmlands, forest fires, urbanisation, and cattle were recorded in the regional directorate of water and forestry, watershed of Sebou agency, and service of Agriculture. Further, location of threatened species was documented using mobile GPS software (Geotraker), and then the map was generated using an Open-Source GIS (Qgis 3.14).

### *Statistics and protection status*

The recorded species were classified following the phenological status in Morocco and the one indicated on the IUCN Red List (IUCN 2021). Similarly, activities of these species were documented inside the habitats dominated by *C. humilis*. Animal species as variables (from 2018 to 2021) were tested for normality with the Kolmogorov–Smirnov test and compared via ANOVA. Menacing factors were compared between provinces with one-way ANOVA. All analyses were performed using SPSS 18.

## RESULTS

### *Bird species*

Table 2 shows avian species diversity in the habitats prospected. A total of 90 avian species were documented, including passerines, water birds, and raptors. These birds belong to 16 orders (mainly Passeriformes and Accipitriformes) and 33 families. The most dominant families were Muscicapidae (9 species), and Alaudidae (6 species), while Alcedinidae, Upupidae, and Coraciidae were represented only by one species each. Diversity of birds was found to be greater than that of mammals or reptiles ($N = 12$, $df = 2$ $f = 159.53$, $p < 0.05$).

In terms of phenological status, we recorded 76 breeding, 22 migrant and 10 wintering species. In parallel, two species, i.e., the vulnerable European turtle dove and the endangered Egyptian vulture, were identified as species of conservation concern in accordance with the IUCN Red list of threatened species. The other birds (88 species) were species of least concern.

### *Mammals*

The documented species are summarized in Table 3. There were twelve mammals belonging to six orders and ten families, including Suidae, Erinaceidae, Canidae, Viverridae, Leporidae, Sciuridae, Macroscelididae, Hystricidae, Muridae, and Dipodidae, recorded at the study sites. All the recorded species use *C. humilis* for breeding and feeding needs. On the other hand, all species were resident and breeding species. Equally, all the species were of least concern in terms of conservation status.

Table 2. Avian species, phenological status (b: breeding, m: migration, w: wintering) and IUCN conservation status (E: Endangered, LC: Least Concern, VU: Vulnerable), and status in *C. humilis* (B: Breeding, F: Feeding) between 2018 and 2021.

| Order | Family | Species | Status | Conservation Status | Status in *C. humilis* | No. of observations |
|---|---|---|---|---|---|---|
| Accipitriformes | Accipitridae | *Buteo rufinus cirtensis* | r, b | LC | B, F | 25–30 |
| | | *Pernis apivorus* | m, w | LC | M | 77–90 |
| | | *Circaetus gallicus* | m, w | LC | F | 12–17 |
| | | *Circus aeruginosus* | r, b | LC | B, F | 34–47 |
| | | *Accipiter nisus* | r, b | LC | B, F | 8–12 |
| | | *Milvus migrans* | b, m | LC | B, F | 450–550 |
| | | *Hieraaetus pennatus* | r, b | LC | B, F | 12–18 |
| | | *Aquila fasciata* | r, b | LC | | 18–26 |
| | | *Aquila chrysaetos* | r, b | LC | | 1–3 |
| | | *Elanus caeruleus* | r, b | LC | B, F | 32–36 |
| | | *Gyps fulvus* | m, w | LC | F | 26–34 |
| | | *Neophron percnopterus* | r, b, m | E | B, F | 54–64 |
| Anseriformes | Anatidae | *Anas platyrhynchos* | b, r | LC | B, F | 35–53 |
| Apodiformes | Apodidae | *Apus apus* | m, b | LC | F | 760–858 |
| Bucerotiformes | Upupidae | *Upupa epops* | r, b | LC | B, F | 18–23 |
| Caprimulgiformes | Caprimulgidae | *Caprimulgus europaeus* | r, b | LC | B, F | 4–6 |
| Charadriiforme | Glareolidae | *Cursorius cursor* | r, b | LC | B, F | 6–8 |
| | Burhinidae | *Burhinus oedicnemus* | r, b | LC | B, F | 6–8 |
| Ciconiiformes | Ciconiidae | *Ciconia ciconia* | r, b | LC | B, F | 112–134 |
| Columbiformes | Columbidae | *Streptopelia turtur* | m, b | VU | B, F | 180–350 |
| | | *Streptopelia decaocto* | r, b | LC | B, F | 223–306 |
| | | *Columba palumbus* | r, b | LC | F | 67–89 |
| | | *Columba livia* | r, b | LC | F | 1298–1567 |
| Coraciiformes | Meropidae | *Merops apiaster* | m, b | LC | B, F | 79–168 |
| | Coraciidae | *Coracias garrulus* | m, w | LC | B, F | 16–18 |
| | Alcedinidae | *Alcedo atthis* | m, w | LC | B | 3–8 |
| Falconiformes | Falconidae | *Falco tinnunculus* | r, b | LC | B, F | 56–78 |
| | | *Falco naumanni* | r, b | LC | B, F | 48–54 |
| | | *Falco peregrinus* | r, b | LC | B, F | 11–16 |
| Galliformes | Phasianidae | *Coturnix coturnix* | m, b | LC | B, F | 22–31 |
| Passeriformes | Passeridae | *Passer domesticus* | r, b | LC | B, F | 1408–1678 |
| | | *Passer hispaniolensis* | r, b | LC | B, F | 450–469 |
| | Corvidae | *Corvus corax* | r, b | LC | B, F | 123–168 |
| | Sturnidae | *Sturnus unicolor* | r, b | LC | B, F | 1780–1880 |
| | Turdidae | *Turdus merula* | r, b | LC | B, F | 670–764 |
| | | *Turdus viscivorus* | m, w | LC | | 123–145 |
| | Fringillidae | *Serinus serinus* | r, b | LC | B, F | 1380–1980 |
| | | *Fringilla coelebs* | r, b | LC | B, F | 890–1237 |
| | | *Linaria cannabina* | r, b | LC | B, F | 470–541 |
| | | *Carduelis carduelis* | r, b | LC | B, F | 260–340 |
| | | *Chloris chloris* | r, b | LC | B, F | 169–342 |
| | Hirundinidae | *Hirundo rustica* | m, b | LC | F | 470–761 |
| | | *Delichon urbicum* | r, b | LC | F | 445–451 |
| | | *Cecropis daurica* | m | LC | F | 130–160 |

| Order | Family | Species | Status | Conservation Status | Status in *C. humilis* | No. of observations |
|---|---|---|---|---|---|---|
| | Sylviidae | *Sylvia melanocephala* | r, b | LC | B, F | 120–150 |
| | | *Sylvia undata* | r, b | LC | B, F | 149–167 |
| | | *Sylvia atricapilla* | r, b | LC | B, F | 36–65 |
| | Phylloscopidae | *Phylloscopus bonelli* | r, b | LC | F | 120–160 |
| | | *Phylloscopus sibilatrix* | r, b | LC | | 150–160 |
| | | *Phylloscopus collybita* | m, w | LC | | 44–46 |
| | | *Phylloscopus trochilus* | r, b | LC | | 34–35 |
| | Paridae | *Cyanistes teneriffae ultramarinus* | r, b | LC | B, F | 150–160 |
| | | *Periparus ater* | m, w | LC | | 45–63 |
| | | *Parus major* | r, b | LC | B, F | 54–65 |
| | Muscicapidae | *Luscinia megarhynchos* | r, b | LC | | 43–44 |
| | | *Erithacus rubecula* | r, b | LC | | 26–49 |
| | | *Muscicapa striata* | m, b | LC | F | 45–21 |
| | | *Ficedula hypoleuca* | m, b | LC | F | 58–61 |
| | | *Phoenicurus moussieri* | r, b | LC | B, F | 38–49 |
| | | *Oenanthe leucura* | r,b | LC | B, F | 22–34 |
| | | *Oenanthe hispanica* | r, b | LC | B, F | 23–45 |
| | | *Oenanthe oenanthe* | r, b | LC | B, F | 34–44 |
| | | *Oenanthe deserti* | r, b | LC | B, F | 18–22 |
| | Alaudidae | *Eremophila alpestris* | m, w | LC | F | 34 |
| | | *Eremophila bilopha* | r, b | LC | B, F | 44 |
| | | *Calandrella brachydactyla* | r, b | LC | B, F | 48–62 |
| | | *Galerida cristata* | r, b | LC | B, F | 170–190 |
| | | *Melanocorypha calandra* | r, b | LC | B, F | 48 |
| | Laniidae | *Lanius senator* | r, b | LC | B, F | 56–66 |
| | | *Lanius excubitor* | r, b | LC | B, F | 46–62 |
| | Motacillidae | *Motacilla alba* | r, b | LC | B, F | 112–160 |
| | | *Motacilla cinerea* | r, b | LC | B, F | 44 |
| | | *Motacilla flava* | r, b | LC | B, F | 22 |
| | | *Anthus pratensis* | m, w | LC | B, F | 45 |
| | | *Anthus spinoletta* | m, w | LC | B, F | 14 |
| | | *Anthus campestris* | m, w | LC | B, F | 37–38 |
| | Emberizidae | *Emberiza calandra* | r, b | LC | B, F | 43 |
| | | *Emberiza cia* | r, b | LC | B, F | 22 |
| | | *Emberiza cirlus* | r, b | LC | B, F | 46 |
| | | *Emberiza sahari* | r, b | LC | B, F | 44 |
| | Prunellidae | *Prunella collaris* | m, w | LC | B, F | 16 |
| | Troglodytidae | *Troglodytes troglodytes* | r, b | LC | B, F | 66–68 |
| | Oriolidae | *Oriolus oriolus* | m, w | LC | B, F | 4 |
| Pelecaniformes | Ardeidae | *Bulbucus ibis* | b, r | LC | B, F | 380–440 |
| Piciformes | Picidae | *Dendrocopos major* | r, b | LC | | 14–18 |
| | | *Picus vaillantii* | r, b | LC | F | 12–17 |
| Pterocliformes | Pteroclidae | *Alectoris barbara* | r, b | LC | B, F | 32–44 |
| | | *Pterocles orientalis* | r, b | LC | B, F | 23 |
| Strigiformes | Strigidae | *Bubo bubo* | r, b | LC | | 2 |
| | | *Athene noctua* | r,b | LC | B, F | 16 |

Table 3. Mammalian species recorded in *C. humilis*, phenological status (b: breeding, r: resident), IUCN conservation status (LC: Least Concern), and status in *C. humilis* (B: Breeding, F: Feeding) between 2018 and 2021.

| Order | Family | Species | Status | Conservation Status | Status in *C. humilis* | No. of observations |
|---|---|---|---|---|---|---|
| Artiodactyla | Suidae | *Sus scrofa* | r, b | LC | B, F | 50–80 |
| Erinaceomorpha | Erinaceidae | *Atelerix algirus* | r, b | LC | B, F | 70–100 |
| Carnivora | Canidae | *Vulpes vulpes* | r, b | LC | B, F | 15–25 |
| Carnivora | Canidae | *Canis lupus lupaster* | r, b | LC | B, F | 7–8 |
| Carnivora | Viverridae | *Genetta genetta* | r, b | LC | B, F | 25–30 |
| Lagomorpha | Leporidae | *Lepus capensis* | r, b | LC | B, F | 50–60 |
| Lagomorpha | Leporidae | *Oryctolagus cuniculus* | r, b | LC | B, F | 100–120 |
| Rodentia | Sciuridae | *Atlantoxerus getulus* | r, b | LC | B, F | 20–30 |
| Macroscelidea | Macroscelididae | *Elephantulus rozeti* | r, b | LC | B, F | 30–40 |
| Rodentia | Hystricidae | *Hystrix cristata* | r, b | LC | B, F | 1–3 |
| Rodentia | Muridae | *Mus spretus* | r, b | LC | B, F | 115–120 |
| Rodentia | Dipodidae | *Jaculus orientalis* | r, b | LC | B, F | 20–25 |

Table 4. Reptile species recorded in *Ch. humilis,* phenological status (b: breeding, r: resident), IUCN conservation status (LC: Least Concern, VU: Vulnerable), and status in *Chamaerops humilis* (B: Breeding, F: Feeding) between 2019 and 2021.

| Order | Family | Species | Status | Conservation Status | Status in *C. humilis* | No. of observations |
|---|---|---|---|---|---|---|
| Testudines | Testudinidae | *Testudo graeca marokkensis* | r, b | VU | B, F | 65–70 |
| Testudines | Geoemydidae | *Mauremys leprosa* | r, b | LC | B, F | 100–150 |
| Squamata | Agamidae | *Agama impalearis* | r, b | LC | B, F | 38–45 |
| Squamata | Chamaeleonidae | *Chamaeleo chamaeleon* | r, b | LC | B, F | 60–78 |
| Squamata | Lacertidae | *Scelarcis perspicillata* | r, b | LC | B, F | 85–115 |
| Squamata | Lacertidae | *Psammodromus algirus* | r, b | LC | B, F | 56–66 |
| Squamata | Colubridae | *Hemorrhois hippocrepis* | r, b | LC | B, F | 200–250 |
| Squamata | Colubridae | *Malpolon monspessulanus* | r, b | LC | B, F | 166–200 |

### *Reptiles*

In total, eight species, including two species of testudines and four species of Squamata were documented at the studied sites (Table 4). The recorded species belong to six families, namely: Testudinidae, Geoemydidae, Agamidae, Chamaeleonidae, Lacertidae, and Colubridae. All reptiles use *C. humilis* for foraging and breeding activities. Similarly, all species were resident in the prospected areas and only *Testudo graeca* was vulnerable.

### *Distribution of threatened species*

Distribution of the globally threatened species is presented in Figure 2. The Endangered Egyptian vulture was limited to riparian habitats where cliffs were abundant. On the contrary, the vulnerable Moorish tortoise *Testudo graeca* was distributed in all the described habitats where *C. humilis* steppe was abundant. The locally vulnerable European goldfinch *Carduelis carduelis* was distributed in the habitats close to water and where *Onopordum acanthium* was mixed with *Chamaerops humilis* steppe. The European turtle dove was recorded mostly in farmlands.

### *Menacing factors*

The *C. humilis* steppe is threatened by different factors as shown in Table 5. *C. humilis* habitats have been negatively impacted by the expansion of farmlands (71000 ha in Fez, 97200 ha in Sefrou, and 150000 ha in El Hajeb). This ecosystem, mainly in Fez and Sefrou, was also affected by urbanization while in El Hajeb, this impact was reduced (49.2%). Equally, *C. humilis* habitats in Fez and Sefrou are exposed to fires, with 51 and 193 fire events recorded in each of them, accordingly. In the area studied, drought was a common phenomenon, causing death to these plants in huge areas. The studied areas were utilized for intense pasturage, with nearly 760500 cattle being documented in Fez, 433400 in Sefrou, and 283500 in El Hajeb. This mass of domestic animals mainly feed within the *C. humilis* shrublands and forest covers. Moreover, *C. humilis* leaves were used for animal feeding and for artisanal purposes.

## DISCUSSION

Our results showed the presence of the considerable animal diversity in the habitats dominated by *Chamaerops humilis*. A total of 90 bird species, including migrant and resident, were documented at the studied sites, which represent nearly 1/6 of the total birds recorded in Morocco (Bergier et al. 2022). We also recorded 8 reptiles and 12 mammal species (all resident). This important

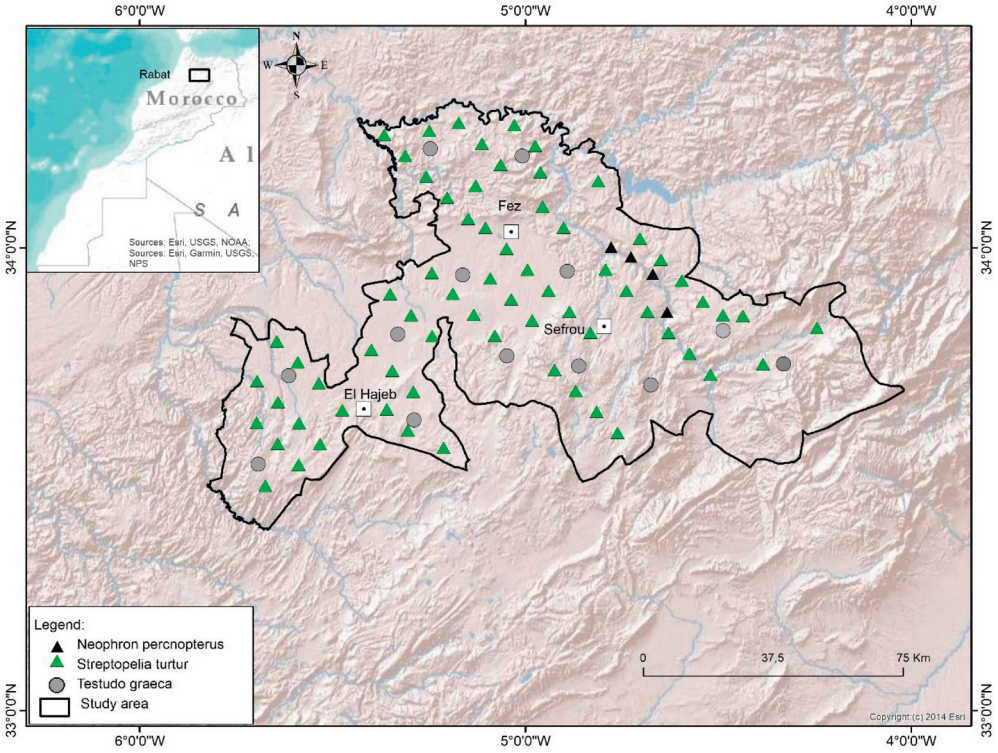


Figure 2. Distribution of the globally threatened Egyptian vulture, Turtle dove and the Maghreb Moorish Tortoise in the studied area.

Table 5. Recorded factors impacting on the *Chamaerops humilis* and natural ecosystems.

| | Fez | Sefrou | El Hajeb | F | *p*-value |
|---|---|---|---|---|---|
| Farmlands (ha) | 71000 | 97200 | 150000 | – | – |
| Urbanisation | 98.2% | 54.2% | 49.2% | 1.65 | <0.001 |
| Cattle | 760500 | 433400 | 283500 | 1.03 | 0.394 |
| Forest fires events | 51 | 193 | 0 | 15.33 | <0.001 |
| Burned areas (ha) | 72.2056 | 1638.7878 | 0 | 1.30 | <0.001 |

diversity confirms the importance of *C. humilis* for maintaining the ecological balance of the ecosystems, mainly with climate change and intensification of human impact during recent decades (Giovino et al. 2014; Siles et al. 2015). Similar results were reported for Moroccan forest habitats and, particularly, for the Middle Atlas woody ecosystems where avian species were widely documented (Marañón et al. 1999; Mansouri et al. 2021b, c). Moreover, in Fes and in the surrounding area, an important breeding population of the Red-knobbed coot *Fulica cristata*, which is a threatened species in Europe (Es Salai et al. 2021), and the Common coot *Fulica atra* (Squalli et al. 2020) were observed, and these facts confirm the ecological role of both studied sites and the *C. humilis* steppe. Equally, the study region shelters 2 of the 6 species endemic to North Africa, including *Alectoris barbara* and *Phoenicurus moussieri*, further confirming its biological and ecological importance.

Among the recorded species, were the Common tortoise (*Testudo graeca*), the Turtle dove (*Streptopelia turtur*), and the Egyptian vulture (*Neophron percnopterus)*, which have a critical conservation status according to the IUCN red list (Hanane 2009; Chergui et al. 2019). Therefore, it is assumed that the conservation of the habitats dominated by *C. humilis* will ensure the protection of the associated animal communities (Phalan et al. 2019), mainly of the long distance migrant Turtle doves that are using these ecosystems for reproductive purposes (Mansouri et al. 2020). Besides breeding resources, *C. humilis* provides highly nutritious fruit and roots (Cadi et al. 2021), which are used by different species for foraging. In our case, fruits were consumed principally by the European Blackbird *Turdus merula* and the wintering Horned lark *Eremophila alpestris*, while nutritive roots were consumed mainly by the wild boar. These resources are of great interest, principally during winter when foraging resources are less abundant (Naoe et al. 2018). On the other hand, small invertebrates such as arthropods living in or around *C. humilis* steppes serve as prey for reptiles and other insectivorous species.

Despite the importance of *C. humilis* as a breeding

habitat and a foraging resource for avian, mammal and reptile species, human and natural factors are threatening a wide area of the steppes where this plant grows. Rural populations use *C. s. humilis* as a traditional medicine and forage for the livestock, which affect large areas of Moroccan vulnerable forests. Equally, in many regions, including Rif in North and Middle Atlas in central Morocco, forest fires have destroyed more than 10.000 ha of forests including the *C. humilis* cover (unpublished data) between 2010 and 2021. All these threatening factors limit the distribution of *C. humilis* in Morocco and other North African countries. Forest areas in these countries (Ait Lamqadem et al. 2018; Besser and Hamed 2021) are also declining due to desertification and climate change.

## CONCLUSION

This is the first research providing insights into the ecological importance of *Chamaerops humilis* for animal species. We have shown that avian, mammal, and reptile species are using the habitats dominated by *C. humilis* for breeding and foraging activities. However, all these aspects, including the nutritive quality of *C. humilis* fruits for wintering species, need further studying to fully understand these complex ecological relationships. Similarly, the risk factors to North African forests need urgent studies. Finally, this study will open a new avenue for comparative investigations and adoption of adequate conservation measures. In our case, it is proposed that *C. humilis* steppes should be classified as a site of biological and ecological interest (one of the used conservation statuses to protect biodiversity in Morocco), which is expected to provide protection against anthropogenic impacts such as agricultural activities and pasturage that reduce the areas of natural ecosystems. Likewise, we suggest annexing the area to the national park of Ifrane, located only 70 km away. This will ensure more protection and sustainable use of ecosystem services.

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The authors declare they have no competing interests.

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### *Data Availability*

The data used to support the findings of this study are included within the article.

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