Changes in wildlife diversity along pastoral improvement techniques in arid rangelands of Morocco

AZEDDINE HACHMI[1, *], ASMAE ZBIRI[1], FATIMA EZZAHRAE EL ALAOUI-FARIS[1]

[1]Department of Biology
Mohammed V University, Faculty of Science
MOROCCO

Abstract: - Ethological research has focused on areas rich in animal species. Nevertheless, arid rangelands have been little studied by naturalists and still have gaps in scientific and technical knowledge. The environment studied in this work occupies the eastern part of the highlands region of Morocco. It is characterized by an arid bio-climate. The main purpose of this study is to make a wildlife inventory of five sites characterized by different plant species. Four sites are equipped by pastoral improvement techniques and one fifth in a free grazing. The samplings are carried out from April 2015 to May 2016, divided into 45 statements. The qualitative and quantitative study of animal species revealed a total of 87 species. The majority of species collected belong to the class of insects with 65, 51% of the total species against 16% for the rate of spiders; 6, 89% for Birds; 4, 59% for reptiles; 2, 29% for mammals and gastropods; and 1, 14% for Chilopodes and amphibians.

Key-Words: - Rangelands, arid, pastoral improvement, wildlife.

1 Introduction

From a geographical, climatic and ecological point of view, Morocco is one of the most original countries on the African continent; it is the second most biologically diversified country in the Mediterranean basin after Turkey. The combination of these factors has resulted in a physiognomic diversity of plant formations; ecological diversity of habitats and a landscape diversity of environments that translates into a biological diversity of biotopes. Thus, Moroccan biodiversity is of particular ecological importance, with more than 24,000 animal species and 7,000 plant species with an overall endemism rate of 11% for fauna, and more than 20% for vascular plants, a rate almost unequalled in the entire Mediterranean basin (Semee, 2009) [1].

In recent decades, the natural pathways of the highlands have been marked by intense degradation affecting plant productivity, biodiversity and soil fertility. The most noticeable changes are those affecting the dominant perennial plants that provide the physiognomy and protection of these rangelands from ecological stressors. This is the case of *Stipa tenacissima* and *Artemisia herba-alba*, which play a fundamental role in maintaining pastoral activities in steppe regions. Sheep and goat grazing (random and without a management plan) is likely to have dramatic consequences on the ecological balance of all natural formations and consequently the disappearance of fauna dependent on these fragile ecosystems.

In fact, the fauna of these ecosystems is an extremely well-adapted group of animals that is qualified to make many contributions to the functioning of rangeland soils. Also, some species participate in the decomposition of litter that leads to the recycling of nutrients, others participate in the pollination of Asteraceae and some others contribute to the process of seed dispersal (zoochory). Invertebrates also provide an important food source for many amphibians and reptiles, birds and some mammals (Tingle, 2002) [2].

Similarly, the study of biodiversity leads to an understanding of the complex links between modified and natural systems and the application of this knowledge to promote sustainable development (UNEP, 1994) [3]. Hebert (1999) pointed out that biodiversity issues are associated with species recognized as vulnerable, threatened or endangered belonging to vertebrates or plants [4]. However, the question that arises is how can we talk about biodiversity by ignoring nearly 2/3 of the animal beings belonging to insects and other arthropods? The inventory of these animals in this work provides information on current levels and trends in biodiversity (UNEP, 1994) and is therefore a valuable tool for studying ecosystems and assessing their health status [3].

Few ethological studies have been carried out in arid areas of Morocco. In this context, the objective of the study proposed in this article is to conduct a fairly comprehensive inventory of dry land faunal populations in order to expand and enrich our knowledge of pastoral ecosystems. This study compares the composition and structure of rangeland settlement in five different sites in the eastern highlands.

2 Materials and methods

2.1 Study area

The study area is a natural course called *Khoui Lamchach*, with an area of 5000 ha. It is located in the high plateaus in the east of Morocco, at altitudes between 1010 and 1073 m, longitudes between 1.57° and 1.50° East, and latitudes between 34.00° and 34.04° North (Figure 1).

This area is characterized by low and irregular annual rainfall in the order of 194 mm with a minimum of 77 mm and a maximum of 299 mm recorded during 1998 and 2009 respectively.

The average temperature is 15.5°C, August is the hottest month of the year and January is the coldest. The potential evapotranspiration is about 1153 mm/year. The soils in the study area are silt to clayey-silt, poorly developed, poorly permeable, of variable depth (20 to 50 cm), low in organic matter, and highly vulnerable to water and wind erosion (Ruellan, 1966 [5]; Bechchari et al., 2014 [6]).

These natural routes are composed of much degraded steppe plant formations. It mainly contains *Stipa tenacissima*, *Artemisia herba-alba*, *Peganum harmala*, *Atractylis serratuloides* and *Noaea mucranata*. The latter three species occupy increasingly large areas subject to open grazing. Different biotopes from almost the entire study area were sampled at a set of representative localities. The choice of sites was based on the type of environment (resting, resting + CES, resting + plantation, natural formation based on *Stipa tenacissima*, and grazing land) and geographical distribution (altitude, latitude and longitude). Five sites were selected (Figure 2).

- The site (S1) is mainly dominated by *Artemisia herba-alba,* this site has been put in rest since 2010 (area=370 ha).

- The site (S2) is a mixed facies and characterized by two co-dominant species: *Stipa tenacissima* and *Artemisia herba-alba.* This site was put in rest in 1991 and then planted with *Atriplex nummularia* in 2010 with a density of 1000 plants/ha (area=1730 ha).

- The site (S3) was put on standby in 1991, then improved by the water and soil conservation technique (CES) in 2010 (area=400 ha).

- For the comparison between the sites, a fourth site (S4) was chosen in a natural steppe formation not grazed, this site is mainly dominated by *Stipa tenacissima*.

- The free grazing site (PL), dominated by *Atractylis serratuloides, Peganum harmala* and *Noaea mucronata*. This site was chosen in an open rangeland where the animal load can reach 4.13 head per hectare.

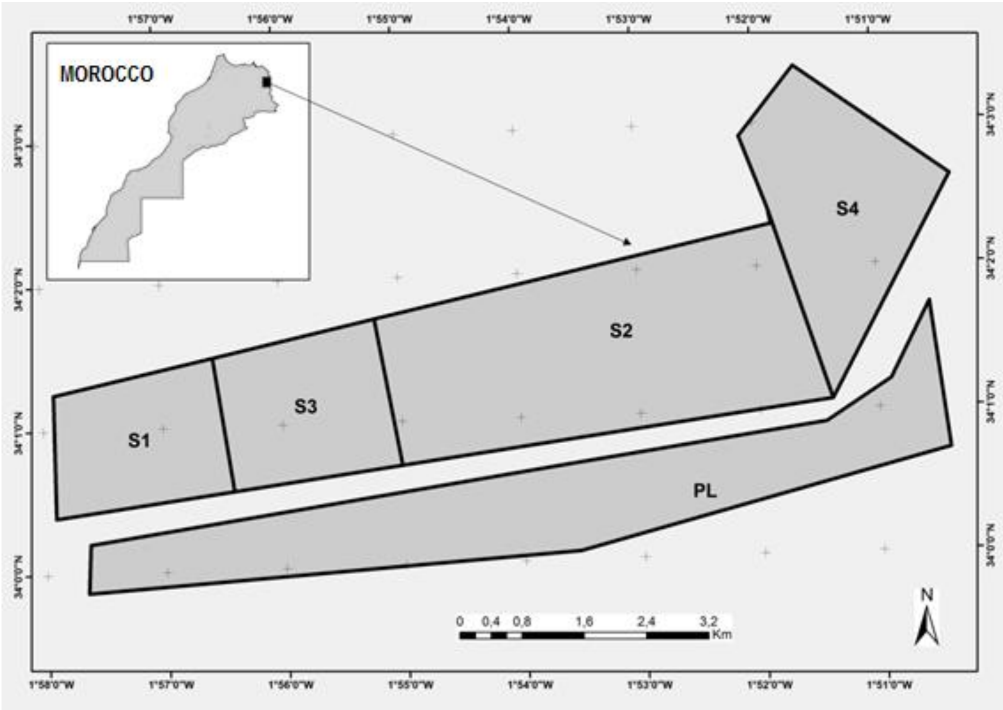

Fig 1. Location of the study area. S1: fencing site dominated by *Artemisia herba-alba*; S2: fencing with *Atriplex nummularia* plantation; S3: fencing with CES technique; S4: site not grazed and dominated by *Stipa tenacissima*. PL: free grazing site.

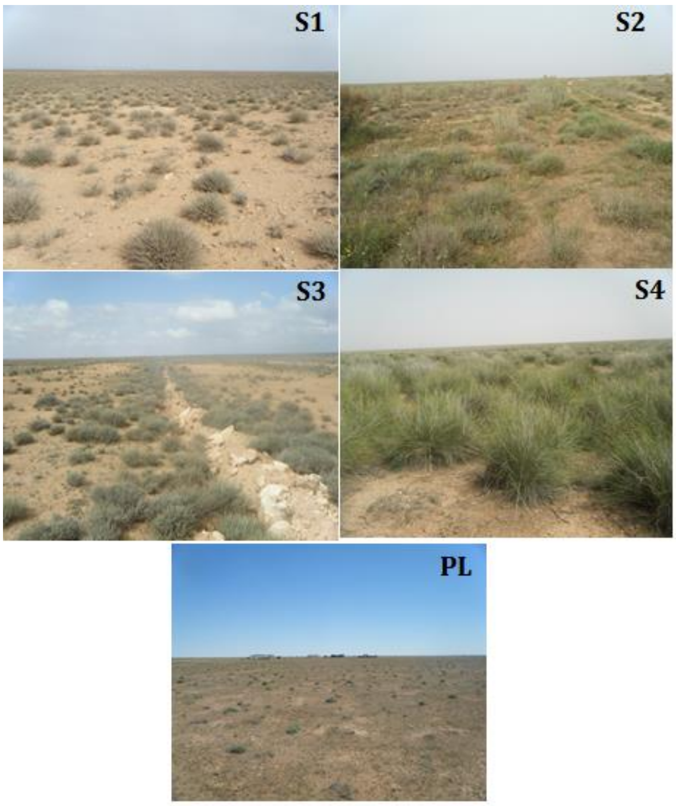

Fig 2. Photos of the 5 sites studied. S1: fencing site dominated by *Artemisia herba-alba*; S2: fencing with *Atriplex nummularia* plantation; S3: fencing with CES technique; S4: site not grazed and dominated by *Stipa tenacissima*. PL: free grazing site.

2.2 Sampling method

The choice of sampling method used was based on the various harvesting methods described by the authors, taking into account several criteria, the purpose of the study under consideration, the types of environment and density (Lecoq, 1978 [7]; Voisin, 1986 [8]). For each site, the distribution of stands was studied using the band method. These bands were randomly defined but representative within each site. This method is widely used (Duranton et al., 1982) [9], as it allows us to approach reality on species density and to have an idea on stand phenology.

The number of species is counted separately at sight in a strip 10 meters long by 10 meters wide (Duranton et al, 1982) [9] (Figure 3). Sampling was carried out by direct sight hunting or under stones and in faces. Catches shall be taken either by means of a net or by direct manual sampling. For specimen collection, we used cardboard boxes where we put the individuals (Figure 3). In addition, baited traps were placed at the entrance of rodent burrows. Each specimen essentially includes the number or name of the locality and the date of capture.

Fig 3. Band of 10 meters long by 10 meters wide and cardboard box where we put the individuals.

2.3 Determination of specimens

For the determination, we used a binocular magnifying glass. This allows the species to be examined precisely and the necessary criteria to be observed. Determinations were made using identification keys, established by Chopard (1922; 1951) [10,11]; Jeannel (1941;1942) [12]; Dajoz (1996; 2000 and 2002) [13, 14 and 15]; Kocher and Raymond (1954) [16]; and Hochkirch and Husemann, (2008) [17]. The nomenclature adopted and the order followed for insects take into account the classifications of Roth (1980) and Platnick (2012) [18] and [19].

3 Results and Discussion

3.1 Wildlife inventory

The Chelicerate subbranch is represented by the Arachnid class. Among the 2 orders in this class, we note that the order of Aranaeides is the most diversified (12 species). The Mandibulates subbranch includes only one class of Insects.

These insects are represented in 7 orders: Beetles, Hymenoptera, Diptera, Orthoptera, Hemiptera, Lepidoptera and Dermaptera. Concerning the vertebrate subbranch, it is represented by four classes: amphibians, birds, mammals and reptiles. We also note the presence of Eumusques and hexapod sub-branches (Table 1). The taxonomic composition of the wildlife population at the study sites is arranged into classes as follows:

In the first rank, the insect class dominates with 57 species followed by the spider class with 14 species, the bird class (Aves) with 6 species, reptiles with 4 species, mammals and gastropods with 2 species. We also have 1 species in each of the classes of Chilopods and amphibians (Table 1). The first remark to be made is that the majority of species belong to the insect class, i.e. 66% of the total against 16% for the spider rate; 7% for birds; 5% for reptiles; 2% for mammals and gastropods; and 1% for Chilopods and amphibians.

Table 1: List of collected species with their classifications in each site.

Espèces	S1	S2	S3	S4	PL	Famille	Ordre	Classe	S. Emb	Emb
Sclerophrys mauritanica (Schlegel, 1841)	-	-	+	-	-	*Bufonidae*	*Anura*	*Amphibia*	*Vertebrata*	*Chordata*
Alopecosa kuntzi (Denis, 1953)	-	+	-	-	-	*Lycosidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Anelosimus vittatus (Cl Koch, 1836)	+	-	-	-	-	*Theridiidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Buthus occitanus (Amoreux, 1789)	-	-	-	+	-	*Buthidae*	*Scorpionida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Haplodrassus dalmatensis (CL. Koch, 1866)	-	+	-	-	-	*Gnaphosidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Latrodectus tredecimguttatus (ROSSI, 1790)	-	+	-	-	-	*Theridiidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Salticus scenicus (Clerck, 1757)	-	-	-	+	-	*Salticidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Xysticus cribratus (Simon, 1885)	-	-	-	+	-	*Thomisidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Xysticus cristatus (Clerck, 1757)	-	+	+	-	-	*Thomisidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Androctonus australis (Linnaeus, 1758)	-	+	-	-	-	*Buthidae*	*Scorpionida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Eratigena atrica (C. L. Koch, 1843)	+	-	-	-	-	*Agelenidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Lycosa narbonensis (Walckenaer, 1806)	-	+	-	-	-	*Lycosidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Mesiotelus tenuissimus (L. Koch, 1866)	+	-	-	-	-	*Liocranidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Pholcus phalangioides (Fuesslin, 1775)	+	-	-	-	-	*Pholcidae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Pisaura mirabilis (Clerck, 1757)	+	-	-	-	-	*Pisauridae*	*Araneida*	*Arachnida*	*Chelicerata*	*Arthropoda*
Chlamydotis undulata	-	+	-	-	-	*Otididae*	*Otidiformes*	*Aves*	*Vertebrata*	*Chordata*

(Jacquin, 1784)										
Cursorius cursor (Latham, 1787)	-	+	-	-	-	*Glareolidae*	*Charadriiformes*	*Aves*	*Vertebrata*	*Chordata*
Fringilla coelebs (Linnaeus, 1758)	-	-	-	+	-	*Fringillidae*	*Passeriformes*	*Aves*	*Vertebrata*	*Chordata*
Galerida cristata (Linnaeus, 1758)	+	-	-	-	-	*Alaudidae*	*Passeriformes*	*Aves*	*Vertebrata*	*Chordata*
Pterocles alchata (Linnaeus, 1766)	-	+	+	-	-	*Pteroclidae*	*Pterocliformes*	*Aves*	*Vertebrata*	*Chordata*
Ramphocoris clotbey (Bonaparte, 1850)	-	-	-	+	-	*Alaudidae*	*Passeriformes*	*Aves*	*Vertebrata*	*Chordata*
Scolopendra cingulata (Latreille, 1829)	-	+	+	-	-	*Scolopendridae*	*Scolopendromorpha*	*Chilopoda*	*Myriapoda*	*Arthropoda*
Otala depageana (Pallary 1923)	-	-	+	-	-	*Helicidae*	*Stylommatophora*	*gastéropoda*	*Eumollusca*	*mollusca*
Otala tigris (Gervais)	-	+	-	+	-	*Helicidae*	*Stylommatophora*	*gastéropoda*	*Eumollusca*	*mollusca*
Adesmia metallica (Klug, 1830)	-	+	-	-	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Amara lunicollis (Schiodte, 1837)	-	-	-	+	-	*Carabidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Apis mellifera (Linnaeus 1758)	+	-	+	+	-	*Apidae*	*Hymenoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Asilus barbarus (Linnaeus, 1758)	-	+	-	-	-	*Asilidae*	*Diptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Beduinus bodilus (Reitter 1892)	-	+	-	-	-	*Aphodiidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Berberomeloe majalis (Linnaeus, 1758)	-	-	+	-	-	*Meloidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Brachycerus callosus (Gyllenhal, 1833)	-	-	-	+	-	*Curculionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Calliptamus barbarus (Costa, 1836)	-	-	-	+	-	*Acrididae*	*Orthoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Carabus coriaceus (Linnaeus, 1758)	-	-	-	-	+	*Carabidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Carabus glabratus (Paykull, 1790)	-	+	-	+	-	*Carabidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Carabus problematicus (Herbst, 1786)	-	-	-	-	+	*Carabidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Certallum ebulinum (Linnaeus, 1767)	-	-	-	+	-	*Cerambycidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Chorthippus albomarginatus (DE Geer, 1773)	-	-	-	+	-	*Acrididae*	*Orthoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Cicada orni (Linnaeus, 1758)	-	+	-	-	-	*Cicadidae*	*Hemiptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Coccinella septempunctata (Linnaeus, 1758)	-	-	-	-	+	*Coccinellidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*

Colias croceus (Fourcroy, 1785)	-	-	-	+	-	*Pieridae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Coniocleonus excoriatus (Gyllenhal, 1834)	-	-	+	-	-	*Curculionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Corizus hyoscyami (Linnaeus, 1758)	-	-	-	+	-	*Rhopalidae*	*Hemiptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Crematogaster auberti (Emery, 1869)	-	-	-	+	-	*Formicidae*	*Hymenoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Cryptocephalus sericeus (Linnaeus, 1758)	+	-	-	-	-	*Chrysomelidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Cucullia tanaceti (Denis & Schiffermüller, 1775)	-	+	-	-	-	*Noctuidae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Dailognatha quadricollis (Eschscholtz, 1829)	+	-	-	-	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Dociostaurus maroccanus (Thunberg, 1815)	+	-	+	-	-	*Acrididae*	*Orthoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Eupelix cuspidata (Fabricius, 1775)	-	-	-	+	-	*Cicadellidae*	*Hemiptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Forficula auricularia (Linnaeus, 1758)	-	-	-	+	-	*Forficulidae*	*Dermaptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Galeruca tanaceti (Linnaeus, 1758)	-	-	-	+	-	*Chrysomelidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Geotrogus araneipes (Fairmaire, 1860)	-	-	+	+	+	*Scarabaeidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Geotrupes stercorarius (Linnaeus, 1758)	-	-	-	-	+	*Geotrupidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Gryllomorpha dalmatina (Ocskay, 1832)	-	-	+	+	-	*Acrididae*	*Orthoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Hybomitra micans (Meigenn, 1804)	-	-	-	+	-	*Tabanidae*	*Diptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Julodis aequinoctialis deserticola (Fairmaire, 1859)	-	+	+	-	-	*Buprestidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Lycaena phlaeas (Linnaeus, 1761)	+	-	-	+	-	*Lycaenidae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Melanargia ines (Hoffmannsegg, 1804)	+	-	-	-	-	*Nymphalidae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Messor capitatus (Latreille, 1798)	-	+	+	-	-	*Formicidae*	*Hymenoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Micipsa mulsanti (Levrat, 1853)	-	-	-	+	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Musca domestica (Linnaeus, 1758)	-	+	-	-	-	*Muscidae*	*Diptera*	*Insecta*	*Mandibulata*	*Arthropoda*

Mylabris quadripunctata (Linnaeus, 1767)	+	+	+	+	-	*Meloidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Oedipoda germanica (Latreille, 1804)	+	+	+	-	-	*Acrididae*	*Orthoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Oniscus asellus (Linnaeus, 1758)	-	-	-	-	+	*Formicidae*	*Hymenoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Onthophagus nuchicornis (Linnaeus, 1758)	-	-	+	-	-	*Scarabaeidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Philonicus albiceps (Meigen, 1820)	-	-	+	-	-	*Brachycera*	*Diptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Pimelia angusticollis (Solier, 1836)	-	-	+	-	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Pimelia bipunctata (Fabricius, 1781)	+	-	+	-	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Plutella xylostella (linnaeus, 1758)	-	-	-	+	-	*Plutellidae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Polistes gallicus (Linnaeus, 1767)	-	+	+	-	-	*Vespidae*	*Hymenoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Pontia edusa (Fabricius, 1777)	-	-	-	+	-	*Pieridae*	*Lepidoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Prionotropis rhodanica (Uvarov, 1923)	-	-	-	+	-	*Pamphagidae*	*Orthoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Pyrgomorpha cognata (Krauss, 1877)	-	-	+	+	-	*Pyrgomorphidae*	*Orthoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Sarcophaga carnaria (Linnaeus, 1758)	-	+	-	+	-	*Sarcophagidae*	*Diptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Sciaphilus asperatus (Bonsdorff, 1785)	-	-	-	+	-	*Curculionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Sepidium aliferum (Erichson, 1841)	-	+	-	-	-	*Tenebrionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Sphingonotus caerulans (Linnaeus, 1767)	-	-	-	+	-	*Acrididae*	*Orthoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Sphodrus leucophthalmus (Linnaeus, 1758)	+	-	+	+	-	*Carabidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Spilostethus pandurus (Scopoli, 1763)	-	-	-	+	-	*Lygaeidae*	*Hemiptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Timarcha punctella (Marseul, 1870)	+	+	+	-	-	*Chrysomelidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*
Timarcha tenebricosa (Fabricius, 1775)	-	-	-	-	+	*Chrysomelidae*	*Coleoptera*	*Insecta*	*Hexapoda*	*Arthropoda*
Tychius aureolus (Kiesenwetter, 1851)	-	-	-	+	-	*Curculionidae*	*Coleoptera*	*Insecta*	*Mandibulata*	*Arthropoda*

Atelerix algirus (Lereboullet, 1842)	-	+	-	-	-	*Erinaceidae*	*Erinaceomorpha*	*Mammalia*	*Vertebrata*	*Chordata*
Jaculus jaculus (Linné, 1758)	-	-	-	+	-	*Dipodidae*	*Rodentia*	*Mammalia*	*Vertebrata*	*Chordata*
Agama impalearis (Boettger, 1874)	+	-	-	+	-	*Agamidae*	*Squamata*	*Reptilia*	*Vertebrata*	*Chordata*
Chamaeleo chamaeleon (Linnaeus, 1758)	-	+	-	-	-	*Chamaeleonidae*	*Squamata*	*Reptilia*	*Vertebrata*	*Chordata*
Psammodromus hispanicus (Fitzinger, 1826)	+	-	+	-	+	*Lacertidae*	*Squamata*	*Reptilia*	*Vertebrata*	*Chordata*
Testudo graeca (Linnaeus, 1758)	-	-	-	+	-	*Testudinidae*	*Testudines*	*Reptilia*	*Vertebrata*	*Chordata*

3.2 Distribution of animal groups according to the 5 sites

The total number of species inventoried in the five sites (S1, S2, S3, S3, S4 and PL) is around 87. This number belonging to 56 families includes 19 (16 families), 28 (26 families), 24 (19 families), 38 (30 families) and 7 (7 families) species respectively in sites S1, S2, S3, S4 and PL (Figure 4). The comparison in terms of fauna richness indicates that there is a significant difference between the five sites (S1, S2, S3, S4 and PL).

Indeed, figure 5 shows that the dominant families are Acrididae (6 species), Tenebrionidae (6 species), Carabidae (5 species), Curculionidae (4 species) and Formicidae (3 species). These families account 33% of the total wildlife in the five sites. The remaining 65% of the species belong to 51 families of high ecological importance and wildlife richness (Alaudidae, Buthidae, Helicidae, Lycosids, Meloids, Piedidae, Scarabaeidae, Theriaidae, Thomisidae...). Insects are better represented (57 species) in the developed sites and S4. PL is marked by a decrease of 50 species.

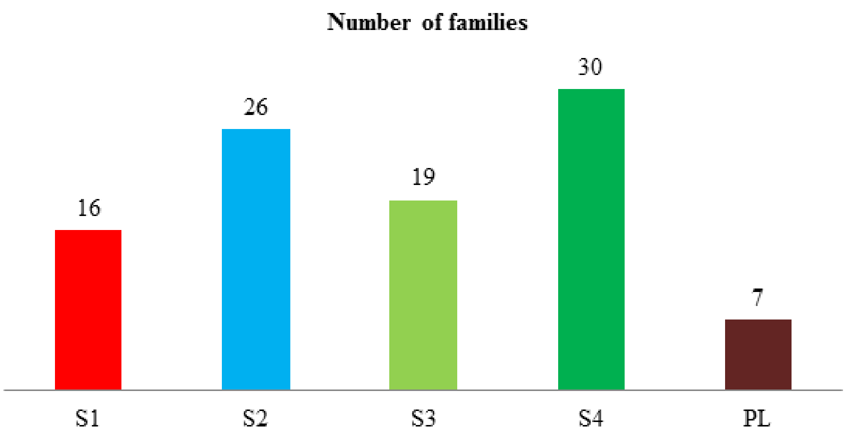

Fig 4. Distribution of the number of animal species families collected at each site**.**

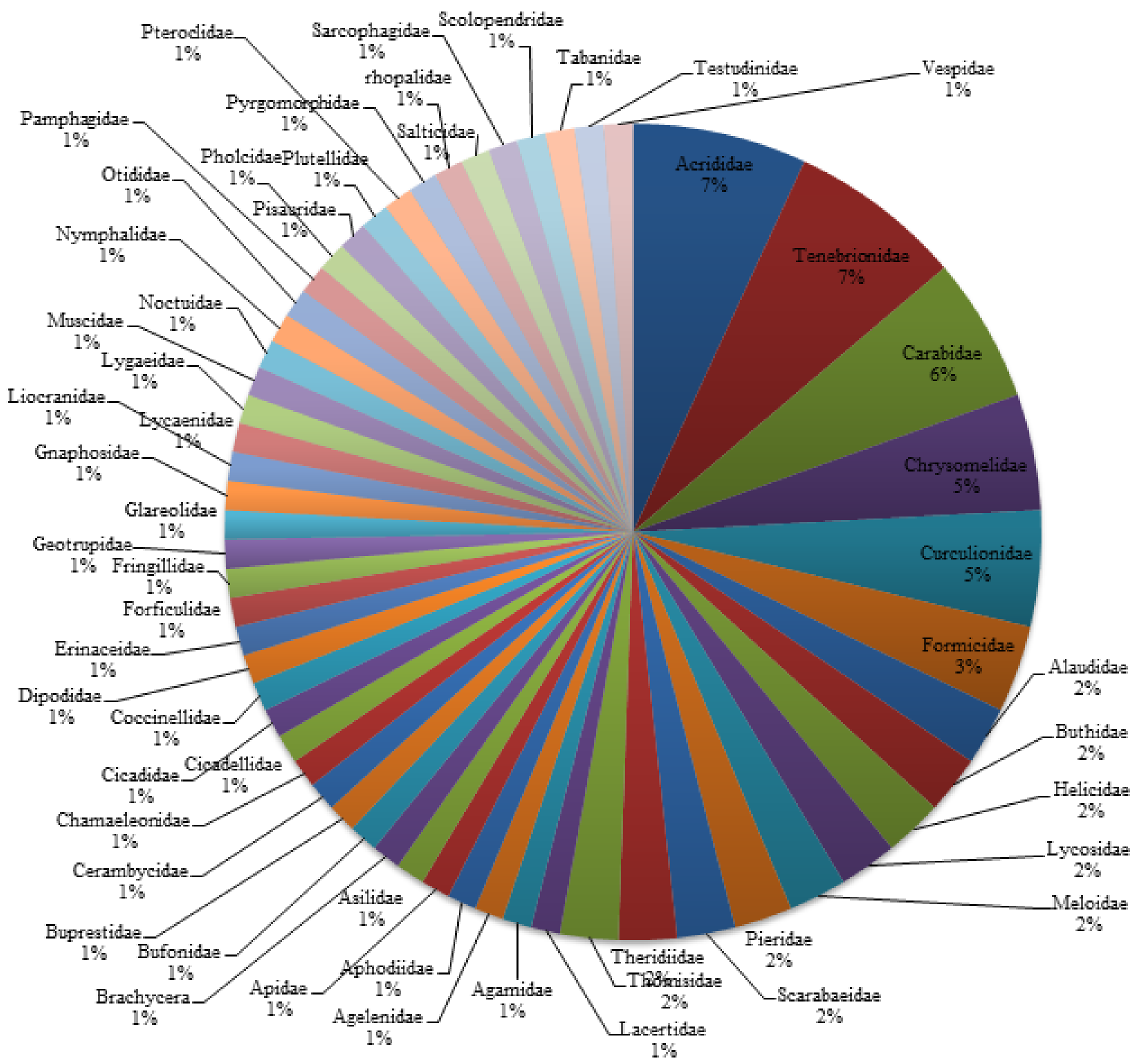

Fig 5. Proportions (%) of animal species families collected at the five sites.

Insects dominate because they climb on plants and represent a multitude of predation and adaptation strategies. In fact, detritus feeders play an important role in the decomposition of organic matter (Faucheux, 2009) [20]. They are more abundant in the site S4 (30 species), which explains the increase in organic matter levels at this site.

The Tenebrionidae is the richest family with 6 species. Carabids are more diversified with the presence of 5 species and are found in the five sites (S1, S2, S3, S3, S4 and PL) because they react differently to biotic and abiotic conditions in the environment (Lambeets et al., 2008) [21]. Quezel & Verdier (1953) showed that Carabids characterize plant associations [22]. Acridids are represented by 6 species which are *Calliptamus barbarus*, *Chorthippus albomarginatus*, *Gryllomorpha dalmatina*, *Sphingonotus caerulans*, *Dociostaurus maroccanus* and *Oedipoda germanica*. Acridids are absent in the PL site and present with 2; 1; 3 and 4 species in sites S1, S2, S3 and S4 respectively. Scarabeidae generally live on dry and sandy soils, many of which are floricultural (Colas, 1966) [23].

Curculionids are represented by 4 species collected only from S3 and S4, with only one species (*Coniocleonus excoriatus*) in S3 and three species in S4 (*Brachycerus callosus*, *Sciaphilus asperatus* and *Tychius aureolus*).

The Forficulidae family is represented by *Forficula auricularia* in S4. The European earwig, *Forficula auricularia L.*, originates from Europe, West Asia and the northern fringe of Africa (Lamb and Wellington, 1975) [24]. It is distributed in temperate regions of the world (Zack et al., 2010) [25].

Earwigs are mainly nocturnal and take refuge in a wide variety of hiding places during the day (Zack et al., 2010) [25]. This behavior makes the insect an excellent candidate for dispersal by human activities (Zack et al., 2010) [25].

The Scolopendridae family is represented by *Scolopendra cingulata* in S2 and S3. Iorio observed two cases of predation on scorpions *Euscorpius (Tetratrichobothrius) flavicaudis* (De Geer, 1778) [26] (Scorpiones, Euscorpiidae) by *Scolopendra cingulata* (Scolopendromorpha, Scolopendridae) in the forests of the Bouches-du-Rhône (Iorio, 2006) [27].

Asilidae in S2 are a homogeneous group of predators and are able to consume wasps or butterflies, whereas smaller species in this family feed on small flies or aphids (Lavigne et al., 2000) [28]. *Xysticus cristatus* is an ambush hunter, spending a lot of time sitting motionless, with its front legs spread apart, using the foliage of *Atriplex nummularia* to hunt its prey (Figure 6).

Fig 6. *Xysticus cristatus* uses *Atriplex nummularia* foliage to hunt insects.

Chrysomelids are represented by *Timarcha punctella* in sites S1, S2 and S3. *Cryptocephalus sericeus* occurs only in site S1, *Galeruca tanaceti* in S4 and *Timarcha tenebricosa* in the free grazing site (PL).

The soil surface in S2, S3 and S4 is a very popular environment for many soil species because it represents suitable sites for hunting. Indeed, *Crematogaster auberti*, *Messor capitatus* are often found in the bottom of plant species that offer them some protection against trampling in S2, S3 and S4 (Figure 7).

Fig 7. *Messor capitatus* often found at the foot of plant species.

The soft nature of steppe soils makes it easier for the nests of these Hymenoptera to settle. In general, ants are soil species that reflect the nature of the environment in which they are found (Cagniant, 1965) [29], they play a very important role in the composition of the plant cover (Plaisance and Cailleut, 1958) [30]. These ants can more easily maintain environmental homeostasis, regulating temperature and humidity in the nest and making it less stressful (Holway et al., 2010) [31]. They are responsible for the fragmentation of accumulated litter from vegetation and other resources available in the environment (Bull and Hawkswor, 2006) [32]. Luc and Serge (2005) showed that the Crematogaster plants their nests and makes hanging gardens by incorporating epiphyte seeds into the walls of their nests made of fibres or chewed wood pulp [33].

The planting site of Atriplex (S2) records a maximum of spiders (6 species) and birds (3 species) against only 1 species in site S3 respectively for spiders and birds. *Latrodectus tredecimguttatus* found in S2 is an araneomorphic species that takes advantage of the stubble-protected area to install its irregular asymmetric mesh canvas (Williams et al., 1994) [34] characteristic of Theridae (Foelix, 1996) [35]. *Latrodectus tredecimguttatus* always builds its trap close to the ground and captures invertebrates living mainly on the ground (Duma, 2006) [36].

In S4, *Salticus scenicus* (Zebra jumping spider) uses *Stipa tenacissima* foliage to hunt its prey; this foliage represents a hostile environment for their food. The high recovery rate at this site generally affects the physiognomy of the *S. tenacissima* and defines the hunting strategy for other Spiders (*Xysticus cribratus*) to a certain extent. The closer tufts of *S. tenacissima* allowed insects (*Amara lunicollis, Calliptamus barbarus, chorthippus albomarginatus*...) to move easily between the tufts. However, spiders prepare their web in a web attached to the leaves of *S. tenacissima* and *Atriplex nummularia* to chase away small insects.

On the other hand, in the PL site (low coverage), the plants are further away, leaving the soil to appear for the survival of some beetles such as *Timarcha tenebricosa, Carabus coriaceus, Carabus problematicus* and manure geotrupe (*Geotrupes stercorarius*).

In degraded rangelands, the absence of shelters threatens the survival of animals, forcing animal species to develop their adaptation mechanisms. For example, this PL site is characterized by the presence of *Coccinella septempunctata* which secretes hemolymph (autohumorrhoea) loaded with slightly toxic alkaloids, the purpose of which is to give them a repellent taste for their predators (Figure 8). In addition, the Blood Spittle (*Timarcha tenebricosa*) is an apterous insect and has the particularity of secreting haemolymph through its mouth (reflex Bleeding phenomenon) and then through its joints, this orange-red liquid has a very bad taste for predators.

Buthidae are represented by two species, *Buthus occitanus* in S4 and *Androctonus australis* in S2. *Buthus occitanus* is found all over the Mediterranean coast of France, also in Spain, southern Italy and Greece (Emerit, 1995) [37]. In the southern Mediterranean, it is found in Egypt, throughout North Africa and also in West Africa (Emerit, 1995) [37]. *Buthus occitantus* is the only scorpion in France that is poisonous, although it is much less so than North African representatives of the same genus (Emerit, 1995) [37]. However, *Androctonus australis* is one of the most widespread species in the Buthidae family. It occurs in northeastern Morocco, Algeria, Tunisia, Libya, Niger, Chad, Sudan and Egypt (Geniez, 2009) [38].

In reptiles, mimicry is a very frequent adaptation of protection against their enemies. *Psammodromus hispanicus* is a very telling example of protection and predation. With a brown appearance, *P. hispanicus* is difficult to distinguish from the soil (Figure 8).

Fig 8. Coccinella septempunctata and the mimicry of Psammodromus hispanicus used for protection against their enemies and for predation of prey.

The encroachment of vegetation into the PL site through the creation of new trails has not only reduced the carrying capacity of livestock pastures, it has also resulted in habitat loss and fragmentation for natural plant and animal populations (Blaum and Wichmann, 2007) [39].

These changes lead to the fragmentation of natural formations and generate the direct extinction of species (Garay and Dias, 2001) [40]. These changes may have different impacts on local species, including soil fauna.

An important aspect of the impact of livestock on rangelands through habitat fragmentation can affect the genetic structure of populations (Gibbs, 2001) and can also increase genetic diversity by improving the adaptive evolution of spatially distinct populations (Grum, 1994 and Fahrig, 2003) [41, 42].

On the other hand, good herbivore behavior promotes seed dispersal (Marriott et al., 2004) by

epizoochory when seeds are transported in the animal's fleece (Fischer & Stöcklin, 1997) [43] and by endozoochory when seeds, after passing through the animal's digestive tract, are found in its faeces (Malo and Suarez, 1995) [44]. These feces present daily meals for several beetles by peeling the seeds of plant species. These processes can maintain the spread of plant species and the genetic diversification of Moroccan rangelands. The creation of heterogeneity (Sebastià et al., 2008) and the control of competitive species (Amiaud et al., 2008) are among the factors frequently mentioned to explain the impact of grazing on the floristic composition and diversity of plant communities [45, 46].

Pollinating insects are under the direct influence of certain legumes whose flowers have a high amount of pollen or nectar (Backowski and Borón, 2005; Goulson et al., 2005) [47]; [48]. In addition, several phytophagous beetles are dependent on the presence of legumes (Gibson et al., 1992) [49]. These legumes are highly selected by ruminants (Dumont et al., 2007) [50].

The relevance of a taxonomic group to indicate vegetation changes induced by land use varies among ecosystems (McGeogh et al., 2002) [51]. Diachronic evaluation of appropriate groups may therefore be necessary in each pastoral ecosystem in Morocco. In this sense, ants have been identified as good indicators of succession and disturbance in the dwarf shrublands of the Karoo (Dean and Milton, 1995) and in the semi-arid ranges of Australia (Hoffmann, 2000) [52,53]. Spiders were appropriate indicators in the savannah of northern Australia (Churchill and Ludwig, 2004) and agricultural landscapes (Duelli et al., 1999), while butterflies were very useful in tropical forests (Spitzer et al., 1997).

4 Conclusion

The qualitative and quantitative study of animal species associated with five sites studied during the period between 2014 and 2017, revealed a total of 87 species. The majority of the species collected belong to the insect class, i.e. 66% of the total, compared to 16% for the spider rate; 7% for birds;

6% for reptiles; 2% for mammals and gastropods; and 1% for Chilopods and amphibians. The order of Coleoptera is the richest in species with 28 species, followed by Orthoptera with 8 species and Lepidoptera with 6 species. Among the Hymenoptera, we recorded the dominance of Formicids with 3 species. While for the spider class, all the families encountered are mono specific (Liocranidae, Pholcidae, Pisauridae, Thomisidae, Agelenidae, Lycosidae, Lycosidae, Theridiidae, Gnaphosidae, Salticidae).

Examining diversity according to the three pastoral improvement actions reveals a better organization and sharing of resources in S3 and S2 sites. These pathways, as natural points of biodiversity, also represent a bank of genetic resources that can be used in the cosmetic or agronomic field. Some Heteropterans are predators present in these lands could be used in biological pest control (*Xysticus cristatus* has been observed as prey for wasps).

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