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Research report

Assessment of human-canid conflict and suggested mitigation strategies in the central High Atlas Mountains, Morocco

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Abstract

The opinion of local people plays a vital role in the conservation of wild canids. In the central High Atlas Mountains, Morocco, the effect of humans on wild canids is among the major problems responsible for the decline of the populations of these carnivores. The objective of this study was to assess the human-canid conflict in the central High Atlas Mountains and to find possible solutions for the protection of canids and the coexistence between humans and these carnivores. Surveys were carried out by conducting questionnaires among the villages around forests in the study area. Interview results showed that natural habitats have been destroyed over the last 20 years and that there is a conflict between local people and wild canids. The predation of livestock is the main cause of local people-canid conflict and negative attitudes toward these carnivores. The main domestic animals attacked by *Canis* spp. are goats and sheep, whereas foxes (*Vulpes vulpes*) attacked mainly poultry and rabbits. The extinction and decline of carnivore species have negative impacts on ecosystems and the economic activities of local people. These animals are crucial in regulating and maintaining ecosystems and their decline can have cascading effects throughout the food web. Based on this study, we recommend several measures to reduce the likelihood of these canid species becoming extinct in the study area. In addition, we recommend techniques to protect livestock from carnivores.

Introduction

Wild canid species are very adaptable carnivores, and they are capable of living in human-dominated landscapes (Holly 2015). In many regions of the world, there is increasing conflict between humans and wild canids, particularly in the context of the predation of domestic animals (Torres et al. 2018). To protect their livestock, local people hunt and kill carnivores, and these killings are the primary threat to many carnivore species. Today, human-canid conflict is a global problem, occurring in different forms all over the world (Torres et al. 2018). Torres et al. (2018) also reported that the predation of domestic animals is the greatest source of conflict between humans and wild canids. Local people generally have negative attitudes toward the larger canid species and many factors can influence people's perceptions and attitudes toward these carnivores (Sillero-Zubiri and Switzer 2004, Mitchell et al. 2019). But, in recent years, the role of carnivores in their ecosystem's health has been more widely appreciated. The removal of carnivores can have major cascading impacts on ecological communities, destabilizing ecosystems, and their food webs (Ripple et al. 2014, Newsome et al. 2017, LeFlore et al. 2019).

The Moroccan central High Atlas Mountains have a great diversity of habitats, plants, and animal species (El Alami et al. 2013, El Alami 2016, El Alami and El Alami 2018). This area is home to a variety of animal species, especially mammals with more than 24 wild mammal species (Cuzin 2003, El Alami 2016). Since the beginning of the 20th century, habitats were subject to destruction and pressures from human activities, and consequently many species went extinct. The last observations of several mammal species in Morocco come from this area, as is the case for the panther (*Panthera pardus*, 1983; Cuzin 2003), the Barbary lion (*Panthera leo*, 1942; Black et al. 2013), and the striped hyaena (*Hyaena hyaena*; El Alami et al. 2022). Our previous studies indicated that biodiversity has been declining in this area at an alarming rate in recent years and blamed this decline on habitat destruction, the impact of livestock grazing, habitat and population fragmentation, illegal wildlife capture, and general disturbance effects of human activities (El Alami et al. 2013, El Alami and Chait 2014; El Alami 2016;

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El Alami and El Alami 2018; El Alami 2019a; El Alami 2019b; El Alami et al. 2020, El Alami and Fattah 2022, El Alami et al. 2022).

Since 1939, the African wolf (*Canis lupus lupaster*) and the golden jackal (*Canis aureus*) were considered a single species (Allen 1939). Until 2012 most researchers believed that two wild canid species occur in the central High Atlas: the golden jackal and the red fox (*Vulpes vulpes;* e.g., Aulagnier and Thevenot 1986, Cuzin 1996, 2003). In 2012, Urios et al. (2012) published the first publication mentioning the discovery of the African wolf in the Moroccan Atlas Mountains. Recent studies indicated that the African wolf still survives in this area, as in many other regions of Morocco (Urios et al. 2012, Waters et al. 2015). In addition, recent genetic analyses questioned the overall presence of golden jackals in North Africa (Moutou and Aulagnier 2021). Another study on the mitochondrial genome of the canids found in Morocco shows that it is neither wolf nor golden jackal (Urios et al. 2016). According to Rueness et al. (2015), the African wolf is distinct from the golden jackal and the grey wolf (*C. lupus*) and it should be considered a unique species that has not resulted from a historical hybridization event. In addition, the results of the study by Mallil et al. (2020) showed a significant level of differentiation between North African and West African wolves. It still seems urgent to further characterize the status of the African wolf in relation to the golden jackal (Gaubert et al. 2012). In 2019, we started a larger project about carnivores in the central High Atlas. The project aimed to identify which species of the genus *Canis* live in this area (DNA analysis of samples, results pending and hence not reported here), to determine the current distribution and status of the canid species, to assess the human-canid interactions, and to develop effective carnivore species conservation strategies. The objective of this study was to assess the human-canid conflict in the central High Atlas Mountains and to find possible solutions for the protection of the canid species and the coexistence between humans and these carnivores. In this paper, we will use the term "wild canids" to designate the species of the genus *Canis* living in the study region. Until today, there are no scientific data confirming whether this genus is only represented by the African wolf or by two species (the African wolf and another species of the genus *Canis*).

Methods

Study area

The study was conducted in the central High Atlas Mountains, Morocco (Figure 1). The central High Atlas encompasses an area of 10,502 km² and has a rich and varied biological diversity. The terrain, mainly calcareous, consists of steep mountain slopes and rocky gorges dissected by swiftly running streams. Altitudes range between 600 m and 4,071 m and the climate varies from semi-arid to humid (Ouchbani and Romane 1995). The habitat types are principally pure forests of holm oak (*Quercus ilex*), forests of holm oak mixed with *Juniperus phoenicea*, *Juniperus oxycedrus*, *Pistacia lentiscus*, *Phillyrea* sp., and *Arbutus unedo*, forests of Barbary thuya (*Tetraclinis articulata;* pure or mixed with other junipers), forests of Aleppo pine (*Pinus halepensis*), sparse cork oak (*Quercus suber*), and open forests of *Juniperus thurifera* (El Alami et al. 2013). These Mountains are the source of many important Moroccan rivers, especially the Oued El Abid, Oued Lakhdar, Assif Melloul, and Oued Ahansal.

Survey participants

The study focused on inhabitants of nine regions located in the central High Atlas Mountains: Bni Ayat (32°12'0"N, 6°42'0"W), Ait Attab (32°3'36"N, 6°37'48"W), Taguelft (32°15'0"N, 6°7'48"W), Ouzoud (32°1'48"N, 6°46'48"W), Afourer (32°13'00"N, 6°30'00"W), Aït Ouarda (32°06'32" N, 6°30'34"W), Tabaroucht (32°9'0"N, 6°13'48"W), Agoudi N'Lkhir (32°03'55"N, 6°45'04"W), and Ait Abdi (31°96'66"N, 5°91'59"W; Figure 1). A total of 76 local people participated in the pilot survey. A description of the sample is provided in Table 1. The sample consisted of 90.79 % of men. The number of women is lower compared to men because it is generally the men who work in the forests. The level of education is poor, and the major occupations of the interviewees are shifting agriculture and pastoralism. We focused on shepherds and firewood collectors because of their knowledge of local wildlife. The questionnaire was administered in the local language (Tamazight) which is the first language of the authors and in some villages, where the authors were known, it motivated people to speak freely. At the end of the interview, we conducted with each interviewee a general discussion about the ecological roles of canid species, especially their roles in the regulation of populations of some pest mammals, such as the wild boar (*Sus scrofa*). Finally, we asked each respondent to propose some ideas and solutions for the conservation of the carnivore species and their habitats.

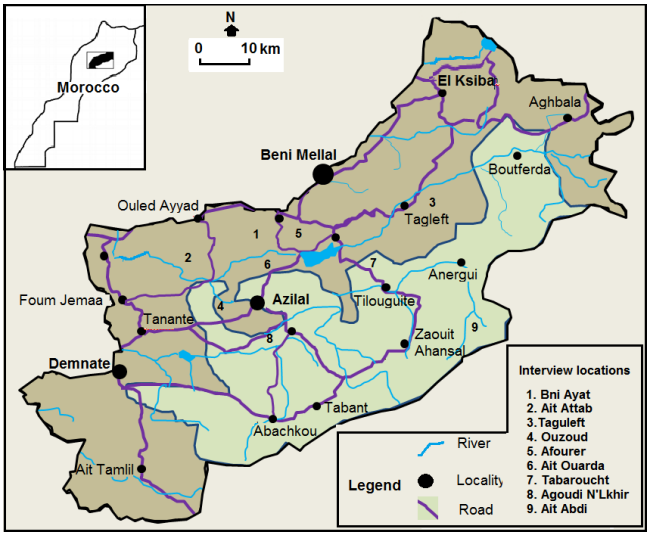

Figure 1. The central High Atlas Mountains, showing the main rivers, roads, localities, and the villages where the surveys were carried out. The rectangle on the inset indicates the location of the study area in Morocco.

Data collection and analysis

Data on human-canid interactions were collected between November 2019 and May 2021. In response to the progression of the Covid-19 epidemic, Morocco's state of health emergency came into effect on 20 March 2020. For this reason, we did not carry out surveys during the period of March-July 2020. Surveys were carried out using questionnaires (Table 2) among the villages around forests in the central High Atlas Mountains. Simple random sampling was carried out in nine regions. The local name (in the Tamazight language) of the red fox is Ahliw or Aâlboun. The species of the genus *Canis* (wolves or jackals) have the same local name: Ouchen. Generally, local inhabitants reported that two species of canids exist in their area: Ouchen Amzan (small *Canis sp*.) and Ouchen Akhatar (large *Canis sp*.). But we do not yet have scientific evidence confirming this hypothesis. Based on our previous studies on wild fauna and natural habitats in the central High Atlas Mountains, 13 variables were selected to assess the human-canid interactions. These variables were grouped into two subscales: Local People-Canid Conflict (LPCCI; 6 variables) and Knowledge and Opinions (7 variables; Table 2). The human-canid interactions were measured using a five-point Likert scale (1. Completely disagree, 2. Slightly disagree, 3. Neither agree nor disagree, 4. Slightly agree, 5. Completely agree). LPCCI 5 and LPCCI 6 are direct questions that the respondents answer based on the wild and domestic animals attacked by canid species. To assess the internal consistency of the questionnaire, Cronbach's alpha was used. Using the SPSS 10.0 software, the reliability (α-Cronbach), the means, and the standard deviations were calculated (Table 2).

Table 1. Overview of interviewees participating in the study on human-canid conflict in the High Atlas Mountains, Morocco.

	Number	Percent %
Gender		
Male	69	90.79
Female	7	9.21
Total	76	100
Age		
18-29	14	18.42
30-44	35	46.05
45-59	16	21.05
60+	11	14.47
Educational qualification		
No formal	38	50
Primary-Middle (college)	27	35.53
Secondary (secondary school)	9	11.84
Tertiary	2	2.63

Table 2. Results of interviews on local people-canid interactions: reliability (α-Cronbach), means, and standard deviations. (SD).

Local People-Canid conflict (α = 0.70)	**Mean**	**SD**
LPCCI 1: The presence of wild canids near my village is unfavourable.	4.80	0.40
LPCCI 2*: My village has problems with canid species (*Ouchen*).	4.07	0.74
LPCCI 3: My village has problems with foxes (Ahliw).	3.76	0.89
LPCCI 4: I contributed to the poisoning or the killing of wild canids.	3.55	1.31
LPCCI 5*: Which domestic animals are attacked by the canid species? Number of cases?		
LPCC 6*: Which wild animals are attacked by the canid species?		
Knowledge and Opinions (α = 0.72)	**Mean**	**SD**
KO1: Habitats have been destroyed in the last 20 years.	4.28	0.62
KO2: There is a decline in the populations of canids and other carnivore species in my region.	4.51	0.50
KO3: I know that it is forbidden to capture or kill wild canids.	4.17	0.73
KO4: I agree that it is necessary to fight wild canids to protect livestock.	3.89	0.66
KO5: I know that the extinction of wild canids and other wildlife is harmful to the wild habitats.	2.10	0.75
KO6: I agree that it is important to conserve wildlife, including the canid species living in my region.	1.97	0.51
KO7: I benefit from an awareness session about ecological problems.	1.18	0.39

**LPCCI 2, LPCCI 5, were asked about the problems caused by the species of the genus Canis because we do not know exactly which species of the genus Canis exist in the study area; LPCCI 5 and LPCCI 6 are not multiple choices questions and are not included in the calculation of α-Cronbach.*

Results

According to the rule of George and Mallery (2003), the human-canid interactions subscales revealed acceptable levels of reliability on LPCCI (α = 0.70) and KO (α = 0.72). Interview results showed that the majority of the interviewees slightly agreed or completely agreed that the wild canid presence near their villages is unfavourable, that 81.5% slightly agreed or completely agreed that they have problems with wild canids, and 68.2% slightly agreed or completely agreed that they have problems with foxes (Table 3). Results showed that 55.3% of the interviewees were contributing to the poisoning or the killing of wild carnivores. Some inhabitants have shown us the carcass of canids killed by local people and of live young individuals captured in the study area (e.g., in Figure 2).

Interview results showed that 90.8% of the interviewees slightly agreed or completely agreed that natural habitats have been destroyed in the last 20 years and that all the interviewees slightly agreed or completely agreed that there is a decline of canid populations in the central High Atlas Mountains (Table 3). Although 80.2% of the interviewees slightly agreed or completely agreed that they know that it is forbidden to capture or kill wild canids, 73% of them slightly agreed or completely agreed that it is necessary to fight wild canids (Table 3). Results also showed that most of the interviewees completely disagree or slightly disagree that the extinction of wild canids and other wildlife is harmful to the wild habitats and that it is important to conserve wildlife, including canid species (Table 3). In addition, the majority of the interviewees did not benefit from any awareness session about ecological problems (Table 3).

According to the interviews, the canids living in the study area prey on wild and domestic animals. In this area, results showed that the main domestic animals attacked by wild canids are goats and sheep (Figure 3). Some local people confirmed that wild canids killed some young cattle in the region of Bni Ayat. The main natural prey of these species is the wild boar. The numbers of domestic animals killed by canids in the six regions belonging to the study area are given in Figure 4. Between November 2019 and May 2021, a total of 150 sheep and 78 goats were killed by canids in the regions of Bni Ayat, Afourer, Ait Abdi, Agoudi N'Lkhir, Tabaroucht, Aït Ouarda, and Ait Attab. Information from interviews showed that the number of domestic animals killed by an attack range between 1 and 13. In this area, foxes prey on wild animals (birds, reptiles, insects, small mammals, etc.), but they also attack domestic animals, especially poultry and rabbits.

Figure 2. (A) The carcass of a wild canid killed by inhabitants in the region of Bni Ayat, central High Atlas of Morocco, (B) a young individual of a wild canid with visible injuries captured by an inhabitant in the central High Atlas of Morocco.

Table 3. Percentage of responses for each ecological variable. 1 = completely disagree, 2 = slightly disagree, 3 = neither agree or disagree, 4 = slightly agree, 5 = completely agree.

Local People-Canid conflict	**1**	**2**	**3**	**4**	**5**
LPCCI 1: The presence of wild canids near my village is unfavourable.	0.00	0.00	0.00	19.7	80.3
LPCCI 2: My village has problems with the *Canis* species (*Ouche*n).	0.00	2.6	15.8	53.9	27.6
LPCCI 3: My village has problems with foxes (*Ahliw*).	0.00	6.6	34.2	35.5	32.7
LPCCI 4: The poisoning and the killing of wild carnivores are present in my region.	9.2	13.2	22.4	23.7	31.6
Knowledge and Opinions	**1**	**2**	**3**	**4**	**5**
KO1: Habitats have been destroyed in the last 20 years.	0.00	0.00	9.2	52.6	38.2
KO2: There is a decline in the populations of canids and other carnivore species in my region.	0.00	0.00	0.00	48.7	51.3
KO3: I know that it is forbidden to capture or kill wild canids.	0.00	0.00	19.7	43.4	36.8
KO4: I agree that it is necessary to fight wild canids to protect livestock.	0.00	0.00	27.6	55.3	17.7
KO5: I know that the extinction of wild canids and other wildlife is harmful to the wild habitats.	23.7	42.1	34.2	0.00	0.00
KO6: I agree that it is important to conserve wildlife, including the canid species living in my region.	14.5	73.7	11.8	0.00	0.00
KO7: I benefit from an awareness session about ecological problems.	81.6	18.4	0.00	0.00	0.00

Figure 3. Corpses of (A, B, C) sheep and (D, E) goats killed by wild canids. And (F) a chicken hunted by foxes (*Vulpes vulpes*) in the regions of Ait Attab, Ait Abdi and Bni Ayat regions, in the central High Atlas of Morocco.

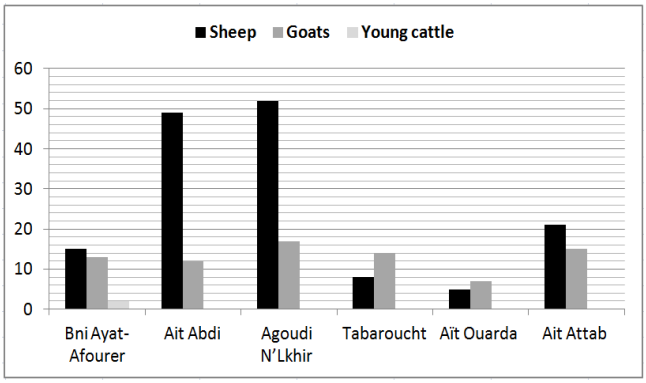

Figure 4. The number of domestic animals killed by *Canis* spp. in six regions belonging to the central High Atlas Mountains, Morocco, in 2019 – 2021.

Discussion

The perception of local people plays a vital role in the conservation of canid species living today in the central High Atlas Mountains, Morocco. In this region, the different canid species are threatened by overhunting, habitat destruction, a highly fragmented population, and the risk of local extinction (Cuzin 1996, 2003, El Alami 2016). In this area, the effect of humans on canid populations is among the major problems responsible for the decline of carnivore species and human-canid conflict may act as an additional factor in the decline of canid populations (Cuzin 2003, El Alami 2016, El Alami and Fattah 2022). This study finds that there is a conflict between local people and wild canids in the central High Atlas. The survey results reveal that local people reported a high level of knowledge about the degradation of habitats and the decline of canid species. Nevertheless, they continue to kill canid species. Local people have problems with wild canids and agreed that it is necessary to control their populations. The predation of livestock is the main cause of the local people-canid conflict and negative attitudes towards these carnivores. The red fox is among the species that have been identified as potentially problematic in many regions of the world because they may prey upon livestock and domestic birds (Bateman and Fleming 2012, Perry et al. 2020, Basak et al. 2022). The canid species most frequently reported for predation on domestic animals in the world was *C. lupus* (Torres et al. 2018). Our study confirms that human-canid conflict is mainly due to livestock depredation. Livestock and domestic bird depredation incur a heavy economic loss to the villagers, resulting in negative attitudes toward wild canids. Several studies also reported that the loss of livestock caused by canids was the main reason for people's conflicting attitudes (Xu et al. 2015, Torres et al. 2018).

In the study area, although the inhabitants know that it is forbidden to capture or kill wild canids, they continue to use illegal techniques such as poisoning for killing these carnivores. Canids prey on a range of wildlife (mammals, birds, reptiles, and insects) and domestic animals (cattle, sheep, goats, and birds) and they attack and injure humans on very rare occasions (Fritts et al. 2003, Eddine 2017). Consequently, canids have frequently been vilified by people, classed as vermin, and actively sought out and killed (Sillero-Zubiri and Switzer 2004). Poisoning is one of the most frequently used methods for poaching or carnivore control and the use of this non-selective practice to kill canids is still active in many regions of the world (Mateo-Tomás et al. 2012, Estrada Pacheco et al. 2020, de Lange et al. 2021). Results of the study by Olea et al. (2022) showed that illegal poisoning is a major driver of wildlife population declines of threatened species such as vultures, raptors, and carnivores around the world.

The extinction and decline of carnivore species have negative impacts on ecosystems and the economic activities of local people (LeFlore et al. 2019). In the study area, canid species have major roles in the regulation of prey populations, especially the wild boar and some rodents, reptiles, birds, molluscs, and insect species. Although wild boars are frequently the favourite wild prey of canids (Oubellil 2011), they prefer some domestic animals because they are easy to catch. The number of wild boars has increased

significantly in the two last decades in the central High Atlas and this increase is due mainly to the decline of its natural predators (El Alami 2019a). In general, the predators of wild boar have declined in the study area, especially the panther, and canids including the red fox (Cuzin 1996, 2003, El Alami et al. 2022). Today, the wild boar is considered the main pest animal in the central High Atlas, where it has a negative impact on biodiversity and causes important damage to agricultural harvests (El Alami 2016, El Alami 2019a). The persecution of apex predators resulted in their decimation and has consequently affected the structure of animal communities through the alteration of prey-predator interactions (Fulgione and Buglione 2022). Free-ranging domestic dogs (*C. l. familiaris*) also can kill wildlife and livestock, and likely exert intraguild competition with native carnivores (Wierzbowska et al. 2016). Conservation efforts on behalf of the canid species should consider the local people's opinion regarding human-canid conflict and the advantages and disadvantages of the presence of these carnivores. This study showed that there was considerable conflict between local inhabitants and wild canids. Without adjusting local agricultural and herding practices, it may not be possible to protect the remaining carnivore populations. Several techniques have been proposed to reduce the risk of depredation of livestock by wild carnivores (e.g., Fritts et al. 2003, Beyer et al. 2006, Mateo-Tomáas et al. 2012, Torres et al. 2018).

Based on this study, we recommend several measures to reduce the likelihood of the canid species becoming extinct in the central High Atlas of Morocco. (1) Encouraging development projects involving inhabitants, local authorities and associations in the surveillance of the canid species and of their habitats, (2) establishment of additional protected areas in the central High Atlas, (3) increasing surveillance of wild habitats to minimize the effects of humans on canid species, (4) the enforcement of the existing laws against illegal capturing, poisoning, and killing of wild carnivores, (5) education to raise the awareness of local people about the ecological and economic roles of wild carnivores and provide the public with information on the benefits of wild canids, (6) conduct scientific research on the effects of human activities and behaviors on canid species populations, (7) manage human-canid interactions to increase public tolerance for wild canids, (8) encourage residents to use non-lethal techniques to protect livestock and to keep carnivores away, such as a livestock guard dogs, prompt and proper disposal of livestock carcasses to eliminate attractants that could draw canids, and monitoring and pasturing of livestock, and (9) preparation and elaboration of compensation programmes to assist local people by reimbursing them for losses attributable to wild canids.

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