



Navigating complex geopolitical landscapes: Challenges in conserving the endangered Arabian wolf

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ABSTRACT

Grey wolf (*Canis lupus*) populations are beginning to increase globally after centuries of decline. While protective legislations and policy implementations have been driving this increase, evidence suggests that these work because of a general rise in public acceptance of wolves. As people have become more knowledgeable of the important ecological roles played by wolves, protection has gained increasing community support, with human-wolf coexistence now being achieved in some areas. However, this is not universal, and some subspecies remain endangered. This is the case for the little-known Arabian wolf (*Canis lupus arabs*), which inhabits arid regions of the southern Levant and Arabian Peninsula: a geopolitically diverse region crossing multiple jurisdictions with disparate cultures, legislations, and attitudes towards wildlife and conservation. Here we review global efforts within the wolf conservation sphere to explore potential opportunities and challenges in the Middle East, acknowledging and accounting for the unique geopolitical complexity of this region. We bring together what is known about this wolf's taxonomic status, distribution, ecology, and conservation across eleven countries in which it resides, collating decades of legislation, governmental, and non-governmental conservation efforts, and summarising literature pertinent to the Arabian wolf. Cross-border collaborations remain challenging in the Middle East, but we identify practical and culturally-based solutions that may improve coexistence and conservation goals, building upon areas where coexistence already occurs. We write this review in the hope that it will highlight the synergies, opportunities, and obstacles that require more serious deliberation and collaboration to conserve one of the region's remaining apex predators.

1. Introduction

Large predators like the grey wolf (*Canis lupus*) have experienced major decline and range contraction over the last few centuries, primarily because of persecution resulting from efforts to protect livestock (Ripple et al., 2014). The loss of large predators has wide-ranging and cascading ecological effects, contributing to what some describe as 'trophic downgrading' (e.g., Estes et al., 2011). In response to this, conservationists have focussed on increasing legislative protection, and prioritising ecological restoration (i.e., rewilding) and reintroduction programs. The result of these programs is that global wolf populations

are beginning to increase as protective legislation and policy implementations have proven successful in supporting recovery (Boitani, 2003; Mech, 2017), while public support for tolerance of predators like wolves has increased (Treves and Bruskotter, 2014). Yet protection of wolves is not universal across their wide range as conflict remains and conservation actions are lacking in some areas. This is particularly the case in Asia, where wolves do not get the same attention as their European and North American counterparts (Chakrabarti et al., 2023).

Seven subspecies of grey wolf have been described across Asia (Nowak, 2003), and though there is some conjecture over their status, they are thought to be extirpated or in decline across much of this range

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(Boitani, 2003; Chakrabarti et al., 2023). At the south of their distribution in the Middle East, two subspecies meet – the ‘Indian wolf’ (traditionally described as *C. lupus pallipes* but see a recent genomic study from Hennelly et al., 2021) and the Arabian wolf (*C. lupus arabs*). The Indian wolf has a broad distribution, encompassing much of southern and western Asia from India to Turkey, and favours Mediterranean or temperate climates. The Arabian wolf, on the other hand, inhabits arid environments of the southern Levant and Arabian Peninsula. We focus this review on the ecology and conservation of this unique desert-adapted subspecies threatened with extinction (Mallon and Budd, 2011).

The increase in wolf populations in other parts of the world brings hope. However, the circumstances for the Arabian wolf differ in two important ways: it resides in ecosystems that are far less productive than the temperate ecosystems of Europe and North America (Barocas et al., 2018), and the geopolitical mosaic and distinct forms of human land use in the Middle East present unique challenges. Hence, to align with the UN's push to promote transboundary cooperation in biodiversity conservation (United Nations General Assembly, 2021), policy initiatives targeting the conservation of the Arabian wolf require careful and culturally appropriate consideration. Today, Arabian wolves occur within multiple jurisdictions shaped by disparate cultures that manifest various attitudinal contexts towards predators. Despite this, apart from a single recent study (Bensen et al., 2022), almost all previous research on relationships between Arabian wolves and people has been limited to individual jurisdictions. Here, we synthesise available information across the entire distribution of the Arabian wolf to highlight current knowledge and identify challenges, pitfalls, and gaps in knowledge, with the aim to improve awareness and stimulate robust conservation initiatives for this endangered wolf.

To begin this process, we draw upon conservation experiences of wolves in other regions to understand the history, including the drivers, mechanisms, failures, and successes, of wolf conservation. We acknowledge that each region will give rise to its own unique opportunities and insights, but we start by examining global wolf conservation efforts, with a focus on social and political factors that have facilitated wolf recovery. We then review what is currently known about the Arabian wolf, including its taxonomic status, ecology, distribution, and how people's values and attitudes towards wolves differ across the Middle East. We end by articulating how cross-jurisdictional planning and collaboration are vital to ensure the ongoing conservation of this keystone and iconic subspecies of grey wolf.

2. Methods

We reviewed the scientific literature, governmental and non-governmental reports, and policy implementations to outline key patterns and motivations behind successful wolf protection efforts in Europe and North America. We searched *Google Scholar* using combinations of keywords related to key factors associated with wolf conservation (e.g., human attitudes towards wolves; tolerance of wolves; wolf protection/conservation in Europe/North America; trophic cascades driven by wolves), and searched *Google* for any regional reports and policy implementations. We then brought together the literature, where available in English, related to wolf conservation and protection within the Middle East. We acknowledge, of course, that knowledges occur other than those encountered in English literature; hence, our work summarises existing knowledge available in English academic literature and can be used to stimulate discourse and engagement with other knowledges.

To put this into context for the Arabian wolf, we also searched *Google* and *Google Scholar* for any scientific and grey (e.g., web articles, news articles) literature pertaining to wolves in the Middle East, using both scientific (*Canis lupus [arabs/pallipes]*) and common (English: wolf, Arabian wolf, Indian wolf; Arabic: ذئب, “the’eb”; Hebrew: זאב, “ze’ev”) names, and browsed books and conservation reports containing

information about wolves and other predators in the Middle East. To focus this review on the Arabian wolf and discern between other subspecies such as the Indian wolf, we collated available genetic and morphological studies of both Arabian and Indian wolves and compared these records to arid zone borders in the countries these wolves were recorded. From this, we hypothesised a potential distribution of the Arabian wolf, as distinct from the Indian wolf.

We then compiled an in-depth overview of governmental and non-governmental conservation efforts and legislation relating to wildlife protection across the range of the Arabian wolf. Information was again gathered from scientific and grey literature, governmental and non-governmental reports, and websites. Some websites were either no longer active or had not been updated for several years. In the case of legal frameworks, individual legislations were verified against official documents or their translated versions. The FAOLEX database on the Food and Agriculture Organisation of the United Nations (FAO) website (<http://www.fao.org/faolex/en/>) was used as the primary repository for sourcing legislation as it was the most comprehensive. However, for some nations the full suite of legislation did not feature in this database, so additional legislations were found in governmental reports.

3. Lessons from global conservation efforts

3.1. Ecology and importance of wolves globally

Emerging as arguably the most important body of research to inspire appreciation of wolves and conservation initiatives to protect them over the last few decades, their ecological roles as apex predators and trophic regulators has increasingly been recognised as vital for the functioning and regulation of many ecosystems (Ripple and Beschta, 2011, 2004; Terborgh and Estes, 2010; Wallach et al., 2015b). As large-bodied apex predators, wolves can have cascading effects on ecosystems, either through direct predation or by indirectly influencing biota in lower trophic levels. These top-down forces affect the abundance and modify the behaviour of lower-trophic animals (Ripple and Beschta, 2011; Wallach et al., 2015b), in turn influencing a broad range of biotic and abiotic processes (Ripple and Beschta, 2004). The suppression of this function through the removal of wolves results in a series of cascading effects that can ultimately lead to species loss, functional shifts in community complexity, and declines in vegetation productivity (Ripple and Beschta, 2011). The most high-profile example of this comes from Yellowstone National Park in North America, where ecologies transformed following the reintroduction of previously extirpated wolves (Ripple and Beschta, 2011, 2004).

Trophic cascades are, however, more complex than these simple, albeit significant, three-level linear chains of species interactions. Rather, they can involve multifaceted networks of species with various types and strengths of interactions (Wallach et al., 2016). For example, vegetation recovery in Yellowstone promoted the return of several species (Ripple and Beschta, 2011), and ultimately increased the complexity of interactions occurring there (Smith et al., 2003; Beschta et al., 2023). Wolves also interact with and shape the distribution and behaviour of other predators, through intraguild predation (Polis et al., 1989), interspecific competition (Berger and Gese, 2007), and predation risk effects (Suraci et al., 2016). One implication of this is that they suppress populations of medium-sized predators (i.e., mesopredators; Ripple et al., 2013), and the cascading effects of ‘mesopredator release’ have been documented in places where wolves have been suppressed – as evidenced by continental range expansions of coyotes (*Canis latrans*) in North America and jackals (*Canis aureus*) in Europe with widespread wolf removal (Krofel et al., 2017; Newsome et al., 2017).

3.2. Conflict, persecution, and mitigation

Wolves have experienced persecution and extirpations during the last several centuries across Eurasia and North America. Various

countries in Central and Western Europe eradicated wolves in the 16th and 17th centuries, and by the early 20th century, wolves were nearly extinct across most of Europe. This pattern was repeated in North America (Boitani, 2003). While the International Union for the Conservation of Nature (IUCN) now lists the grey wolf as least concern (Boitani et al., 2018), several populations and unique subspecies remain imperilled. Included in these are the three most southern subspecies, all listed as endangered: the Arabian wolf (Mallon and Budd, 2011) and Indian wolf (Sharma et al., 2019) of Eurasia, and the Mexican wolf (*C. l. baileyi*) of North America (Paquet et al., 2001).

Along with loss of habitat and declining prey species, pervasive lethal control and exclusion of wolves from agricultural landscapes have exacerbated this demise. For millennia, predators like wolves have conflicted with people and their interests (Fritts et al., 2003). At the turn of the 21st century, livestock depredation was the most frequently reported reason for conflict between humans and wolves (Sillero-Zubiri and Laurenson, 2001). Targeting of wolves and other predators can also be due to other interests related to aesthetics (Childes, 1988), fear of threatening encounters (Linnell et al., 2003), conservation concerns (Cohen et al., 2013), or simply because of perceptions that they 'don't belong' (Van Dooren, 2011; Wallach et al., 2015a). As a result of such conflicts, large predators continue to experience substantial population decline and range contraction (Ripple et al., 2014).

One conservation approach used globally as an attempt to combat such losses is land sparing (i.e., the setting aside of land for conservation). During the last 100 years, more than 200,000 terrestrial protected areas such as national parks and nature reserves have been established worldwide, covering around 17 % of the Earth's terrestrial land surface (UNEP-WCMC and IUCN, 2023). However, this strategy of 'separating people from nature' is not sufficient to protect wide-ranging species from hunting and persecution, particularly those whose home ranges extend beyond protected area boundaries and into agricultural landscapes, as is often the case with large predators (Johansson et al., 2016). Protected areas are also not 'pristine' environments outside of human influence. Management often involves pervasive and intrusive measures that disturb the ebb and flow of ecosystems: lethal control and harvest of unwanted or abundant species can cause cascading ecosystem effects (Colman et al., 2014); tourism and recreational activities bring pollution, environmental degradation, and wildlife disturbance (Pickering et al., 2003); and roads cut through protected areas, causing vehicular collisions with wildlife (Ramp and Ben-Ami, 2006; Roger et al., 2012), habitat fragmentation (Roger et al., 2011), and edge effects (Ben-Ami and Ramp, 2006). As such, other forms of human-caused wildlife mortality may not be altered by protection, and in some cases can be higher than non-protected areas (Hill et al., 2020). Recognition of the shortcomings of protected areas has led to broader social initiatives linked to coexistence and land sharing (Fischer et al., 2014).

For wolves, the frontline of coexistence is often within agricultural landscapes. Predator-friendly farming is an all-encompassing term for non-lethal strategies that farmers can use to protect livestock from depredation (Johnson and Wallach, 2016), and it has been implemented to ease tensions between farmers and wolves (Bogezi et al., 2019). In both modern agricultural and traditional pastoralist systems of livestock production, the move by some to non-lethal predator control has enabled human-predator coexistence in intensive livestock growing regions (Ohrens et al., 2019; Stone et al., 2017). Non-lethal methods often combine improved livestock husbandry practices with tools that act as deterrents to prevent encounters between livestock and predators (McManus et al., 2015). Livestock guardian dogs have been used for millennia (Gehring et al., 2010) and continue to be an effective deterrent against predators (van Eeden et al., 2018), while technological deterrents such as fladry, livestock collars, and flashing lights also show promise in reductions in livestock depredations (McManus et al., 2015; Miller et al., 2016; Ohrens et al., 2019). Compensation schemes offered by governmental agencies or non-governmental organisations (NGOs) have also relieved agriculturalists from potential hardships associated

with predator-related livestock loss (Naughton-Treves et al., 2003). Such strategies promoting human-predator coexistence have been gaining traction, particularly in regions with targeted public education and conservation programs aimed towards increasing acceptance of predators (Wallach et al., 2015a).

3.3. Human attitudes and social research

As awareness and knowledge of the ecological roles of wolves have increased globally, so have intentions and efforts to conserve them. North America and Europe are prime examples, where wolf populations have made an incredible comeback thanks to efforts over the last 25 (Jimenez et al., 2017; Mech, 2017) and 40 (Chapron et al., 2014; Randi, 2011) years, respectively. Wolf populations are now recovering in seven states in the US (Mech, 2017), ending more than 60 years of extirpation (Jimenez et al., 2017). While protected areas played a large part in this success story, similar recoveries have been documented in Europe where recovery has been less reliant on protected areas (Boitani, 2003; Mech, 2017). Across much of Central and Western Europe and Scandinavia, wolves have recovered since the 1970s (Chapron et al., 2014), particularly in refugia where they were able to maintain resilient populations (Salvatori and Linnell, 2005). The recovery of European wolf populations can largely be attributed to the development of transboundary policy initiatives (Epstein et al., 2016; Linnell and Boitani, 2012), where coordinated legislation is enforced across the continent through international collaboration (Linnell et al., 2008). However, the derivation of these policies and their ability to protect wolves is fundamentally a result of a positive shift in public sentiment towards wolves (Bencin et al., 2016; Kinsky and Knight, 2014; Treves and Bruskotter, 2014).

Conservationists and wolf advocates have long utilised social research to assist with large carnivore conservation efforts (Bruskotter and Wilson, 2014; Carter et al., 2012). Human attitudes towards predators, which range from acceptance to intolerance, are primary determinants of the success of long-term conservation of wolves (Bruskotter et al., 2014). Attitudes towards wildlife are shaped by social and cultural factors (Arbieu et al., 2019; Sagie et al., 2013), such as educational (Holsman et al., 2014; Manfredo et al., 2003; Williams et al., 2002) or socio-economic (Rode et al., 2021) differences, and vary across spatial (Bencin et al., 2016; Karlsson and Sjöström, 2007) and temporal (Fernández-Llamazares et al., 2020; George et al., 2016) scales. For example, positive attitudes towards wolves prevail in people that live further from wolf territories (Ericsson and Heberlein, 2003; Karlsson and Sjöström, 2007) and have access to higher levels of education (Manfredo et al., 2003; Naughton-Treves et al., 2003; Williams et al., 2002). Conversely, people that live near wolves and have had direct experiences with wolves (e.g., through livestock loss or threatening encounters) tend to hold more negative attitudes towards wolf recovery (Ericsson and Heberlein, 2003; Karlsson and Sjöström, 2007).

Overall, public attitudes towards large carnivores shifted significantly during the latter half of the 20th century (Kellert et al., 1996). A driving factor in this shift is the transition of wildlife value orientations from dominion to mutualism (Manfredo et al., 2009); where dominion holds that wildlife exist for human use, mutualism emphasises the interconnectedness of wildlife and humans, holding that wildlife are deserving of care and compassion (Ramp and Bekoff, 2015). While such values have a long history in certain spiritual domains (Yeshey et al., 2023), these changes have been particularly prevalent in Western post-industrialised cultures after WWII (Inglehart and Baker, 2000), and generally in social groups with higher levels of education (Williams et al., 2002). Although general education has contributed to such change, carnivore education focussed on tolerance and ecological roles has been important for increasing support for predator conservation (Arbieu et al., 2019; Bruskotter and Wilson, 2014). It remains common, however, for predators such as wolves to be viewed with widespread hostility in regions where knowledge of their ecological importance, low threat to human life, and alternative, non-lethal, methods of livestock

protection are lacking (Seddon and Khoja, 2003). It is often these regions where people generally have strong adherence to social norms, which can exacerbate cultural resistance to the acceptance of novel beliefs and practices.

4. State of knowledge of the Arabian wolf

4.1. Taxonomy of *Canis lupus arabs*

Taxonomic debate about Middle Eastern wolves is evidenced by different perspectives in the literature (Afik and Alkon, 1983; Cunningham and Wronski, 2010; Mukherjee et al., 2009; Reichmann and Saltz, 2005; von Jaffa, 2013; Wronski and Macasero, 2008). However, most generally accept that two subspecies of wolf occur in the Middle East. The Indian wolf occurs in temperate regions characterised by Mediterranean or semi-arid climates (Ferguson, 2002; Khosravi et al., 2013), while the Arabian wolf inhabits the deserts of the southern Levant and Arabian Peninsula (Bray et al., 2014; Cohen et al., 2013; Hefner and Geffen, 1999; Nowak, 2003). Though the two subspecies share similarities – for example, both being small relative to those in northern regions (Ferguson, 2002; Nowak, 2003) – Arabian wolves are noticeably smaller than Indian wolves, with the latter being up to 1.5 times larger than the former (Ferguson, 2002). Clear genetic distinctions have also been documented between the two subspecies, with the wolves of Arabia being more closely related to Eurasian wolves (*C. l. lupus*) than Indian wolves (Bray et al., 2014).

Despite clear differences in climatic conditions between the distributions of Arabian and Indian wolves, it is unclear where and how

spatial divergence occurs. Limited genetic and morphological evidence available suggests that primarily Indian wolves occur in Iran (Khosravi et al., 2012, 2013) and Arabian wolves in Arabia (Bray et al., 2014). Furthermore, Khosravi et al. (2012) state that wolves are absent from the central deserts of Iran (i.e., Dasht-e Kavir and Dasht-e Lut); however, they occur in semi-arid environments (Tourani et al., 2014). With current evidence as it stands, it seems plausible that the range of the Arabian wolf extends more than 3 million km² throughout the arid region southward from the southern deserts of Iraq and possibly Syria, encompassing the southern Levantine and Arabian deserts (Fig. 1). Some degree of overlap between the two subspecies may occur in the northern part of the Arabian wolf's range; however, no empirical data shows where or if this is the case. Further genetic testing across a broader range is required to truly understand the divergence between Arabian and Indian wolves.

4.2. Ecology and importance

Is it necessary to differentiate between the two subspecies? When it comes to setting conservation goals, it may be. The Arabian wolf is the only wolf specifically adapted to arid environments (Fig. 2). While other wolves venture into deserts – the Gobi Desert in eastern Asia is home to populations of the Mongolian wolf (*C. l. chana*; Kaczensky et al., 2008) and the Mexican wolf previously occurred in North American deserts (Hendricks et al., 2016) – none of these subspecies are exclusive to arid regions, unlike the Arabian wolf. There are certainly similarities between Arabian and Mexican wolves: the Arabian wolf is the smallest subspecies in the Old World, while the Mexican wolf is the smallest in



Fig. 1. Regions that are likely to encompass distributions of the two grey wolf subspecies that occur in the Middle East. The Indian wolf (*C. l. pallipes*) inhabits temperate climates from India to Turkey while the Arabian wolf (*C. l. arabs*) resides in the deserts of the southern Levant and Arabian Peninsula (photo credit: N Dragić and D. Kwan).

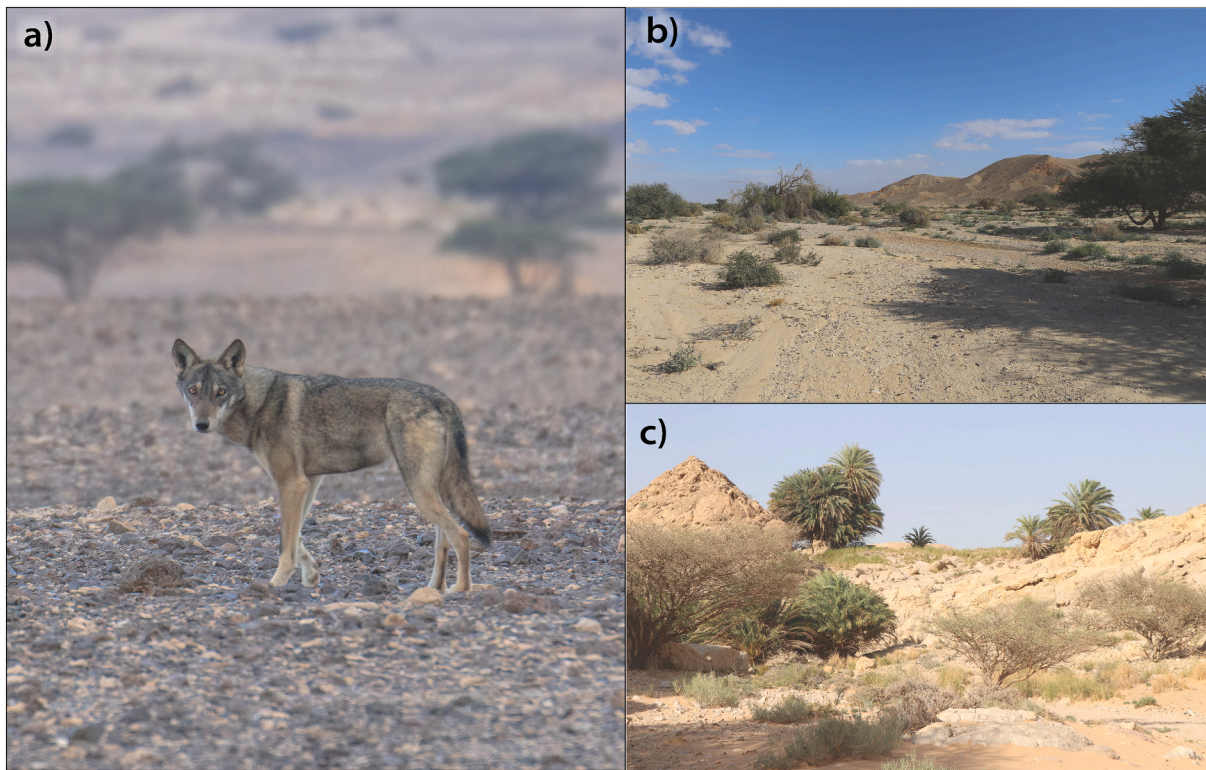


Fig. 2. The Arabian wolf commonly uses wadis (dry riverbeds) and springs in Middle Eastern deserts: (a) an Arabian wolf during winter in the Arava Valley of Israel (credit: N. Dragić), (b) a wadi in Sheizaf Nature Reserve, Israel, and (c) Ein Salamani, a spring in Dana Biosphere Reserve, Jordan.

the New World (Nowak, 1995). Sadly, the Mexican wolf is also the most endangered wolf subspecies, and it has been at the centre of conservation efforts in North America for the last 40 years (U.S. Fish and Wildlife Service, 2022, 1982). Efforts have included ongoing reintroduction programs and stringent enforcement of protective legislation (Hendricks et al., 2016), however, populations of Mexican wolves continue to be precarious because of a lack of tolerance (Paquet et al., 2001).

There is no doubt that the Arabian wolf is of considerable ecological and functional importance to the desert ecosystems of the Middle East (Bonsen et al., 2022). Since the widespread eradication of other large carnivores throughout its range, the Arabian wolf remains the last surviving apex predator with a wide distribution. Until relatively recently, the wolf shared this role with two large felids: the Asiatic cheetah (*Acinonyx jubatus venaticus*) and the Arabian leopard (*Panthera pardus nimr*). Today, with the cheetah extinct throughout the Arabian wolf's range (Farhadinia et al., 2017) and the leopard likely confined to a few protected areas (Spalton et al., 2006), the sole remaining large carnivore to fill a similar niche is the striped hyaena (*Hyaena hyaena*); albeit not as apex predator. While the Arabian wolf periodically hunts gazelle (*Gazella* spp.), ibex (*Capra nubiana*), and young onagers (*Equus hemionus*), striped hyaena are not successful hunters of ungulate prey (Kruuk, 1976). However, both share a largely omnivorous diet. Each actively hunts small mammals, birds, and reptiles, and scavenges from agricultural crops, carrion, and garbage (Afik and Alkon, 1983; Kruuk, 1976; Qarqaz et al., 2004; Shalmon, 1986). In regions where wild prey densities are low and free-range livestock farming common, domestic ungulates form a considerable part of each species' diet (Qarqaz et al., 2004; Shalmon, 1986).

The difference between the two lies in their methods of acquiring prey. The striped hyaena is primarily a scavenger, and mostly feeds on carcasses of livestock that have died from prior causes (Tourani et al., 2012). Apex predators like wolves, on the other hand, are known to prey on livestock (Yom-Tov, 2003), especially where natural prey resources are diminished or when domestic animals are not adequately secured

(Khorozyan et al., 2015). Throughout most of the Arabian wolf's range, wild ungulate abundance is low because Middle Eastern arid and hyper-arid environments couple low productivity with strong hunting pressure from people, pushing many of the region's ungulate species to extensive decline or extinction (Mallon and Kingswood, 2001). Local and regional efforts to revive ungulate populations are largely confined to protected areas (Amr et al., 2004; Barichievsky et al., 2018; Mallon and Kingswood, 2001), leaving few suitable alternatives for large prey, other than livestock, outside of protected areas.

For over a thousand years, Middle Eastern deserts have been farmed by Bedouins: nomadic or semi-nomadic tribal pastoralists whose shepherding methods often require them to travel for days on end. Across much of the region's deserts, Bedouin pastoralism remains the primary source of agriculture. However, in the latter half of the 21st century, technological advances in groundwater acquisition and farming practices saw a rapid increase of agricultural areas in arid regions. These transformed 'oases' provide an abundance of fruits, vegetables, and water accessible to wolves, reducing their reliance on the ungulate prey populations (Shalmon, 1986). In such areas, and those where livestock are well protected, livestock depredation by wolves can be rare (Nemtsov and King, 2001). This is the case in Israel's hyper-arid Arava Valley, where shepherding is minimal, and crop farming is the predominant form of agriculture (Lewin et al., 2021). Here, wolves have developed such an affinity for human habitation that several GPS-tracked individuals were observed to seldom venture more than five kilometres from human infrastructure (Barocas et al., 2018). It is possible that their reduced tendency to hunt large prey may partially explain why current pack sizes are generally smaller than those reported in Europe and North America (Hefner and Geffen, 1999), with solitary or pair sightings of wolves common.

4.3. Distribution and abundance

Arabian wolf numbers vary considerably throughout its wide

distribution (Fig. 3). Evidence suggests the Negev Desert of Israel, which includes the Arava Valley, has the most stable population of Arabian wolves. The population here was estimated at 90 to 150 individuals a decade ago (Cohen et al., 2013); thought to be a stable number for an arid to hyper-arid region with an area of less than 15,000 km². West of Israel, the wolf's range extends into the Sinai Peninsula of Egypt. While we were unable to find published data regarding population estimates or how far across Sinai wolves occur, they were recently recorded in St Katherine Protectorate in the south (Gecchele et al., 2017), and they continue to cross the border from Israel (Barocas et al., 2018).

In the eastern part of its range, the most recently published estimated population size across the three largest countries on the Arabian Peninsula (i.e., Saudi Arabia, Yemen, and Oman) was 500–600 individuals, but declining; however, this was nearly twenty years ago (Sillero-Zubiri et al., 2004). Wolves appear to be common in remote and protected areas of Yemen (Khorozyan et al., 2014). In Oman, wolves have been recorded throughout the country, but again seem to be confined to remote and protected areas (Mazzolli et al., 2017; Spalton, 2002a). Records are common throughout Saudi Arabia; however, most of these records derive from killed individuals (Aloufi and Amr, 2018; Zafar-ul Islam et al., 2019). The Arabian wolf is now thought to be locally extinct in Qatar (Mallon and Budd, 2011), the United Arab Emirates (UAE; Cunningham, 2004), and Kuwait (Mallon and Budd, 2011).

Between the Negev/Arava and Arabian Peninsula populations lies Jordan, where wolf numbers are unknown, but they are believed to be rare (N. Hamidan pers. comm.). Past surveys confirmed wolf presence in

north-eastern Badia (Bunaian et al., 2001), and wolves were recently recorded during camera-trapping and passive tracking surveys in Dana Biosphere Reserve and Fafa Nature Reserve in Jordan's Wadi Araba region (Bensen and Khalilieh, 2021). Jordan provides an important stepping-stone between the Negev population and the dwindling population of the Arabian Peninsula. However, the most critical jurisdiction for Arabian wolf conservation is likely to be Saudi Arabia due to its large area and geographic location. The country stretches 2.15 million km² and lies between the populations of the southern Levant (i.e., the Sinai Peninsula, Israel/Palestine, and Jordan) and the southern and eastern extremities of Arabia (i.e., Yemen and Oman).

5. Geopolitical diversity

5.1. Conservation of the Arabian wolf

The decline of large carnivores in the Middle East mirrors the global extirpations and range contractions of large carnivores (Ripple et al., 2014). Of 20 carnivores known to occur in Arabia, eight have been listed as threatened or near threatened (Mallon and Budd, 2011): one being regionally extinct, another critically endangered, and two endangered. Although the global status for *C. lupus* is least concern (Boitani et al., 2018), status reviews for the Arabian wolf over the last few decades list it as vulnerable (Boitani, 2003), endangered (Mallon and Budd, 2011), or critically endangered (Benson, 2009). This at least gives it the advantage of being stringently protected in Israel; aside from the authorised killing of almost 40 wolves to protect the critically

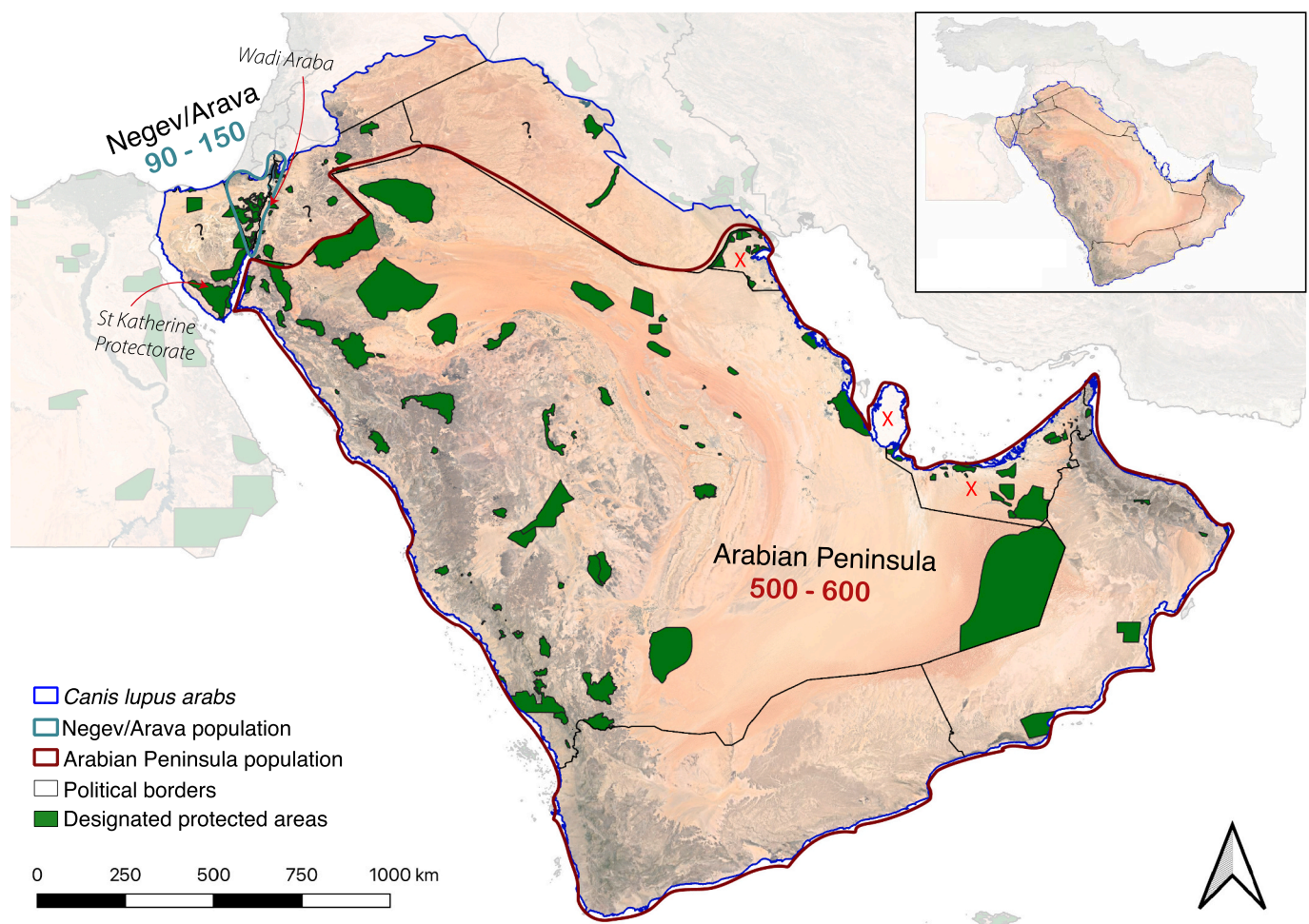


Fig. 3. Previously estimated population sizes of the Arabian wolf throughout its range (Cohen et al., 2013; Sillero-Zubiri et al., 2004), and its location within the Middle East (inset).

endangered acacia gazelle (*Gazella gazella acaciae*) in the mid 2000s, no legal killing of Arabian wolves is sanctioned (Cohen et al., 2013). While the subspecies is currently legally ‘protected’ across its range, the reality of this protection is not homogeneous. In areas of human-wolf conflict, this protection can be rather lax.

Small population sizes and low densities make the Arabian wolf particularly susceptible to stochastic events (e.g., disturbance, disease) and changes in protection status. Without concerted and coordinated conservation efforts, the Arabian wolf might end up following the path already traversed by the region's large felids. The critically endangered Arabian leopard (Stein, 2020), which was sympatric to the Arabian wolf, is now likely confined to small pockets of protected areas in Saudi Arabia, Yemen, and Oman (Khorozyan et al., 2014; Spalton, 2002b; Spalton et al., 2006). The leopard's demise is recent, with extirpations in Israel, the Palestinian Territories, and Jordan likely to have occurred within the last 20 to 30 years (Farhadinia et al., 2019). The Asiatic cheetah, on the other hand, has been restricted to central Iran since the 1980s (Farhadinia et al., 2017). Remaining leopard populations are being closely monitored in the three countries they are known to remain, with little hope of widespread recovery without systemic changes in tolerance and accommodation for predators (Farhadinia et al., 2019). Cheetahs are unlikely to return without the aid of reintroduction programs (Durant et al., 2017). For canids like wolves, the situation is potentially less dire as they seem better adapted to human environments (Barocas et al., 2018).

5.2. Scale of jurisdictional crossover

The Arabian wolf possibly navigates one of the most complicated and fraught geopolitical landscapes on Earth. Its distribution crosses a socio-politically complex region with diverse historical and contemporary cultural heritage. In the current political mosaic, the Arabian wolf's range covers eleven recognised states, intertwined with swathes of disputed land. Of course, each nation has its own set of legislations

related to wildlife protection and levels of enforcement. For wildlife with large home ranges like the Arabian wolf, traversing this complex geopolitical landscape can be precarious and troublesome as actions and behaviours in one location may not cause conflict with people, but in another may result in them being shot (Hefner and Geffen, 1999). A review of the protection status and conservation efforts across different jurisdictions led to insights that may be used to shape further discussion (please see Table S1 in Supplementary Material for sources of information for this section).

Interest in wildlife conservation has proliferated throughout the Middle East, with governmental and non-governmental effort continuing to be established. The UN's Convention on Biological Diversity, launched during the 1990s, spurred many nations to become active participants. By the turn of the century, most nations across the region had ratified the convention and subsequently produced a National Biodiversity Strategy and Action Plan (NBSAP), with all eleven nations now having concrete plans to conserve biodiversity. These involve defining pitfalls within the current legal and institutional frameworks and developing solutions to improve strategies for biodiversity conservation. It has also led to many governments forming focused ministries or agencies to act as authorities for environmental affairs.

Although protective legislation now exists throughout the region, awareness and enforcement vary considerably across and within state boundaries. An overview of the legal frameworks, governance, and conservation efforts within each country highlights key differences and similarities, pertinent to the conservation of the Arabian wolf (Table 1). Currently, all countries have legislation that prohibits or regulates hunting. It is universally illegal to hunt or kill protected species and to hunt or kill wildlife inside protected areas. However, legal frameworks vary between countries. For example, some countries have had consistent legislation relating to wildlife protection in place for decades, while the legal frameworks in others are still in their nascent stages. Some countries have had endless repeals and amendments, whereas others

Table 1

Overview summary of Arabian wolf status, protection, and conservation effort in the eleven countries likely to be within its distribution. PA = protected area. For further details, see Table S1.

Country	Enforcement of protective legislation	Conservation effort	PA as % land area	Arabian wolf status (Density; trend; persecution)
Egypt (Sinai Peninsula)	Some inside PAs ^a	Active network of NGOs across Egypt working towards hunting reduction.	13.14	Rare ^a ; unknown; widespread ^a
Iraq	Negligible	Signed Convention on Biological Diversity (2009) and produced National Biodiversity Strategy and Action Plan (2015). Has active network of conservation NGOs.	1.53	Unknown; unknown; widespread
Israel / Palestinian Territories (West Bank and Gaza)	Israel: Strong inside and outside PAs Palestinian Territories: Strong in some areas	Israel: Strong governmental and NGO support for wildlife protection and conservation. Palestinian Territories: Network of NGOs but many are inactive due to cuts in overseas funding.	Israel: 24.49 Palestinian Territories: 8.36	Israel: Common; stable; negligible Palestinian Territories: Unknown; unknown; unknown
Jordan	Strong inside PAs, some outside	Strong semi-governmental support for wildlife protection and conservation, and a large network of NGOs.	3.09	Occurs in PAs; declining ^a ; widespread
Kuwait	Strong inside PAs	Well-established network of NGOs with an increase in prioritising biodiversity conservation.	17.10	Extinct; NA; NA
Oman	Strong inside and outside PAs ^a , but poaching common	Strong governmental and NGO support for wildlife protection and conservation.	2.57	Occurs in PAs; declining ^a ; unknown
Qatar	Some inside PAs	An increase in governmental and NGO effort.	13.23	Extinct; NA; NA
Saudi Arabia	Some inside PAs	Several governmental and non-governmental pushes towards wildlife protection and conservation, but difficulty in moving from policy to practice.	4.76	Common; declining; widespread
Syria	Negligible	A small network of NGOs exists, but civil and political tensions have caused conservation efforts to cease.	0.69	Unknown; unknown; unknown
United Arab Emirates (UAE)	Strong inside PAs, some outside	Strong governmental and NGO support for wildlife protection and conservation.	17.95	Extinct; NA; NA
Yemen	Negligible	Predator protection efforts increasing (e.g., focused on the Arabian leopard), but civil and political tensions hinder sufficient expansion.	0.77	Occurs in PAs; declining; unknown

^a Considerable level of uncertainty due to either a lack of, or conflicting, information.

have had few regulations added to their long-standing laws (see Table S1 for a more detailed review of legislation and conservation effort).

Inconsistencies in legal frameworks create confusion within policies; legislations that are present in some countries seem to exist solely on paper, but not in reality. Adding to this confusion is the fact that many governments continue to lack solid institutional structure attributed to biodiversity conservation or environmental matters. Such muddled institutionalisation often results in a lack of trained staff, funding, and infrastructure. Most nations acknowledge such shortcomings in their NBSAPs and aspire to improve (see Table S1 sources). However, even with institutional and strategic improvements being made, shortfalls remain in moving from policy to practice. For example, considerable effort went into implementing Saudi Arabia's conservation strategies and action plans. The relevant governmental authority engaged in dramatic transformation, prioritising the structured support for their protected area network and protected species lists. Yet, actions assigning protective status, enforcing laws, and acting upon violations have been noted as unsatisfactory (Barichievy et al., 2018). Although wolves persist within Saudi Arabia's designated protected areas (Abuzinada, 2003; Seddon et al., 1997; Wronski and Macasero, 2008), it is unclear how much actual protection they are afforded (Cunningham and Wronski, 2010; Seddon, 2000). What is known is that Arabian wolves are subjected to heavy persecution outside protected areas (Aloufi and Amr, 2018; Cunningham et al., 2009; Cunningham and Wronski, 2010; Wronski and Macasero, 2008; Zafar-ul Islam et al., 2019).

Protected areas remain a key legislative protection action for the Arabian wolf. However, the status and meaning of these protected spaces differ between countries. For example, while some countries have a single managing agency, authoritative control of protected areas can be variable within a country. Jordan's Royal Society for the Conservation of Nature actively enforces protection laws in areas under their governance; however, they are not authorised to govern all the country's protected areas (UNEP-WCMC, 2020). Another example of difference is in enforcement. On Yemen's mainland, protected areas do not yet afford strong protection for wildlife (Schlecht et al., 2014). Although areas have been designated, they are not included in official registries and lack institutional governance (Environmental Protection Agency, 2017). Along with the gulf countries, Yemen's mainstream conservation effort tends to focus on marine and offshore biodiversity (e.g., Socotra Island). Plans and proposals for extending the protected area network were presented a decade ago (Schlecht et al., 2014); however, the country has since been engulfed in a civil war and conservation priorities have taken a step down.

To mitigate these differences, non-governmental conservation effort appears to be increasing throughout the region, with domestic NGOs now established in all countries. In countries where conservation is yet to become a national priority, local NGOs fill the void to conduct much-needed research and monitoring surveys. The Foundation for the Protection of the Arabian Leopard in Yemen is a non-profit dedicated to Arabian leopard conservation. In Iraq, Nature Iraq has been working with governmental ministries towards implementing conservation strategies since 2003, liaising with the Iraqi government on policy change for issues relating to wildlife protection and biodiversity conservation.

Implementing protective legislation and designating protected areas can only go so far towards the conservation of the Arabian wolf. Making it illegal to kill them does not necessarily stop people from doing so (Eid and Handal, 2018). It is more important to understand the needs and struggles of the people that share the land with such wildlife, and compassionately work with them towards peaceful coexistence. Resolution of any conflict is only possible once the situation has been addressed from the perspectives of those most affected.

5.3. Society, culture, and human-wolf relationships

Humans and wolves have shared a vibrant coexistence across the

Middle East throughout history. Archaeological (Davis and Valla, 1978; Dayan, 1994) and genetic (Freedman et al., 2014; Vonholdt et al., 2010) evidence points to early domestication of wolves or a wolf-dog ancestor in the Levant at least 12,000 years ago, suggesting that humans and canids have been forming close relationships in the region for thousands of years. With the advent of agriculture not long after (Zeder, 2011), conflicts between humans and wolves would undoubtedly have ensued. From this point, dogs were introduced and selectively bred for practical purposes such as livestock protection (Gehring et al., 2010) and hunting (Guagnin et al., 2018), and which we have observed are still used today by Bedouins for livestock protection.

Conflict continues to dominate the narrative of coexistence between wolves and people. Pastoralists frequently lose unsecured sheep and goats to wolf depredation, often sparking retaliation (Cunningham et al., 2009). On top of livestock-related persecution, age-old beliefs that wolves endanger human lives (Seddon and Khoja, 2003), and that wolf body parts can be used for therapeutic purposes (Aloufi and Eid, 2016) persist. Moreover, widespread cultural fables depicting canids as malevolent and impure have triggered large-scale eradication attempts (Subasi, 2011). Legal and illegal hunting and persecution are common where these beliefs prevail (Eid and Handal, 2018; Giangaspero and Al Ghafri, 2015), and many threatened species, including Arabian wolves, are largely confined to protected areas (Amr et al., 2004).

Conversely, Arabian wolves are accepted and even appreciated in other regions. In Israel's Negev, particularly in crop farming landscapes of the Arava Valley, wolves and people peacefully coexist. Farmers assist wolves and other wildlife by intentionally providing water in this hyper-arid landscape, where wolves are free to roam through agricultural fields. A series of incidents in 2017, in which a few wolves came uncomfortably close to people at a village adjoining a nature reserve, generated outrage among the locals; but this was quickly resolved with education programs around the importance and hazards of nature and wildlife (Bensen, 2018). Likewise, villagers and pastoralists coexist with wolves in Yemen's Hawf district, the location of the country's only mainland designated protected area (Schlecht et al., 2014), where acceptance of wolves and other predators is reportedly higher than in other parts of the Arabian Peninsula (Khorozyan et al., 2014).

Despite this, coexistence between people and Arabian wolves appears achievable but requires systematic, cross-jurisdictional, and coordinated efforts to promote coexistence. Although livestock loss is not a major concern in Israel's crop farming landscapes, farmers are not free from economic costs associated with living with wildlife (Moran, 2003). However, where conservation management and enforcement are common, they have accepted and learnt to adapt to the presence of wolves; strategizing to minimise such costs and ultimately appreciating the many benefits of having wildlife on their doorsteps. With improvements in cooperation and planning, coexistence is possible elsewhere.

6. Collaborative planning

The key challenges for the Arabian wolf are that a) they live in arid environments where resources are scarce and conditions harsh; b) as large predators, they rely on populations of wild herbivores; c) availability of livestock puts them into conflict with pastoralists; d) while laws protecting them are essential, they must also be enforced and garner local community support; and e) their range crosses many political borders, encompassing disparate jurisdictions, each with its own values, laws, and motivations. These challenges may in themselves be influenced by climate change and conflict between people.

Considering this, we suggest that successful protection of Arabian wolves must involve coordination and collaboration at both local and regional scales. At local scales, there is good evidence that it is important for conservation groups and authoritative bodies to form caring relationships with local stakeholders to cooperatively plan solutions for mitigating potential costs and hardships associated with coexistence (Jiren et al., 2021; Kansky and Maassarani, 2022). Rather than forcibly

implementing policy and legislation, in which violators (often unwary) are automatically penalised, better outcomes can arise when authorities take time to codevelop solutions to underlying issues. A good example comes from recent collaborations with Bedouin pastoralists, who are often marginalised when promoting conservation goals. It has been reported that authorities have failed to act on environmental damage reported by Bedouins, penalising them more than other societal groups for environmental violations (Gilbert, 2013). In contrast, conservation groups in Jordan recognised early flaws when failing to consider pastoralists in the establishment of a nature reserve in Jordan, and hence began involving Bedouins as primary stakeholders and collaborators in developments of further conservation projects (e.g., Wadi Rum Nature Reserve), greatly improving their success (Chatty, 2002). Co-development of action plans with local people, including First Nations people, is now being recognised as an important breakthrough in local conservation efforts around the world (Campion et al., 2023).

The cultivation of efforts and achievements from conservation groups and authoritative bodies throughout the Middle East is certainly promising, but these are largely unilateral and confined to individual jurisdictions. For example, the United Arab Emirates is currently one of the most committed Arab countries to wildlife protection: local NGOs have spearheaded international reintroduction projects and residents are encouraged to report any environmental or wildlife-related violations (Salama, 2018). Likewise, Israel is generally conservation-minded, with clear goals and objectives, as well as strong public adherence to wildlife protection (Nemtsov and King, 2001). However, collaborative regional-scale efforts across international borders, like those in Europe, must improve if Arabian wolf populations are to recover. All European countries have subscribed to the Bern Convention (Convention on the Conservation of European Wildlife and Natural History, 1979), by which all wolf populations and habitats are fully protected (Boitani, 2003). During the 1990s, the Large Carnivore Initiative for Europe (within the IUCN's Species Survival Commission) was established to improve coexistence between people and wolves throughout the region, while prioritising heightened consideration of both parties (Linnell et al., 2008). Although transboundary conservation initiatives have also been carried out within the Middle East, these have mostly focussed on local-scale projects across individual borders (Knight et al., 2011).

International research collaborations have increased over the last decade or so; however, regional-scale and multi-jurisdictional policy implementations are yet to be pushed. For example, the Middle Eastern Biodiversity Network was established in 2006 between universities and research institutes from Iran, Jordan, Lebanon, and Yemen in a collaborative effort to conserve biodiversity across the Middle East (Krupp et al., 2009). More recently, Compassionate Conservation Middle East (CCME) was established as a research group collaboration between various institutes and NGOs in Israel and the Palestinian Territories. CCME has developed wolf research and conservation projects across Israel and Palestine with the primary objectives of improving both human-wolf coexistence and regional collaborations – based on the hopeful politically-focused adage ‘nature knows no borders’ (Roulin et al., 2017). Unfortunately, transboundary cooperation can be difficult to achieve in regions as politically tense as the Middle East.

7. Concluding remarks

The Arabian wolf is likely to be an important trophic regulator of desert ecosystems of the southern Levant and Arabian Peninsula. To ascertain just how important it is, there are significant knowledge gaps that need to be filled. Although populations are sparse across most of its wide range, the Arabian wolf remains the most widespread apex predator inhabiting the deserts of the Middle East. Yet, little is known about its potential influence on these arid ecosystems. Considering its close association with human infrastructure and reliance on anthropogenic food resources in Israel, there is some conjecture as to how important a role the Arabian wolf plays in shaping trophic cascades like its larger,

temperate counterparts.

That it might do so, however, is only within the context of its acceptance by people. Demarcations of tolerance or persecution can override the trophic position of these desert-dwelling wolves. Conservation conflicts are often interrelated with intra-human conflicts, and the Middle East is one of the most complex geopolitical landscapes in the world. Any solutions to conserve the Arabian wolf must be cognisant of this complexity and strive to ameliorate the internal conflicts shaped by the distinct attitudes and values that are ingrained among the peoples that share this extensive landscape.

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CRediT authorship contribution statement

Gavin T. Bonsen: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Visualization, Writing – original draft. **Arian D. Wallach:** Conceptualization, Funding acquisition, Investigation, Methodology, Visualization, Writing – review & editing. **Dror Ben-Ami:** Conceptualization, Funding acquisition, Visualization, Writing – review & editing. **Oded Keynan:** Conceptualization, Funding acquisition, Visualization, Writing – review & editing. **Anton Khalilieh:** Visualization, Writing – review & editing. **Yara Dahdal:** Visualization, Writing – review & editing. **Daniel Ramp:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Visualization, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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Appendix A. Supplementary data

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