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## Biodiversity Conservation of Wadi Al-Quff Protected area (Central Palestine): Challenges and Opportunities

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### ABSTRACT

The Occupied Palestinian Territories (OPT) are areas of high but threatened biodiversity. Since the establishment of the Palestinian Authority, there have been increased resources devoted to capacity building and to develop nature protection systems highlighted by the introduction of the Palestinian Environmental Law 1999. One of the mandates of this law is to protect specific areas of high biodiversity and this gained even more importance with Palestine signing the Convention on Biological Diversity (CBD). Wadi Al-Quff (WAQ) region between Tarqumiya and Beit Kahil in the occupied Palestinian territories is an area of special attention as the first Palestinian administered nature reserve and the first one to receive detailed work to generate a management plan. As part of this work we report in these series of papers surveys on the flora and fauna. A significantly rich fauna and flora is noted but is facing a number of threats, with habitat fragmentation and destruction being the most significant. This survey recorded a rich fauna with more than 89 species of birds, 19 species of mammals, 21 reptiles, three amphibians, over 250 identified invertebrates, and over 230 species of plants, despite habitat degradation and limited sampling (time, resource limitations). As a result of our analysis we made four urgent recommendations and six less urgent but highly needed recommendations for biodiversity conservation of WAQ. Urgent recommendations include: 1) Cull/remove feral dogs, 2) Block roads and/or limit access in some areas of WAQ, 3) Discuss with farmers and others stake holders protection measures and limits on activities near or in the park, 4) Prevent fires. The longer-term recommendations are: 1) Monitoring and preventing unlawful activities, 2) Develop sustainable use of some areas, 3) Ameliorate habitat fragmentation and destruction, 4) Work to end the Israeli occupation and empower and educate local people, 5) Address climate change, and 6) Develop an environmental educational center in the protected area.

**Keywords:** Protected areas; Conservation; Palestine; Habitat destruction.

## INTRODUCTION

Biodiversity is variably defined as the diversity of living organisms (flora, fauna, microorganisms) produced via evolutionary diversification and is now considered integral to continuing life on earth as we now know it (Wilson & Peter, 1988). In the late 20<sup>th</sup> century the conservation of biological diversity started to be recognized as an urgent issue for humanity and this is largely due to the scientific observation of significant decline in biodiversity that accompanied industrialization that spread widely in the 19<sup>th</sup> and 20<sup>th</sup> centuries. Two key texts came out of a number of preparatory meetings that rang the danger bell at the global level: publication of the Global Biodiversity Strategy (WRI/IUCN/UNEP, 1992) and the adoption of the Convention on Biological Diversity (CBD) signed at the Earth Summit in Rio de Janeiro (also in 1992).

Palestine was represented at the 7<sup>th</sup> Special Session of the Governing Council/Global Ministerial Environment Forum in Cartagena, Colombia, 13-15 February 2002. At that time, a resolution was adopted concerning the situation of the environment in the Occupied Palestinian Territories (OPT). The governing Council requested the United Nations Environment Programme (UNEP) to carry out a desk study as a first step in the implementation of the decision to support and advance environmental conservation in the OPT. The study aimed to identify major areas of environmental threats, but was not too detailed (UNEP, 2003). However, it was seminal especially if we combine it with the report by the Environmental Quality Authority which brought in experts and collected materials also in a form of an expanded desk study in compliance with the CBD (EQA, 2015). The report estimates over 50,000 species living in Palestine.

Palestine connects the Euro-Asian and Africa continents and forms the western part of the Fertile Crescent, lands that are rich in alluvial soils near river beds stretching from Egypt to Syria and Iraq. Geologic activities, especially the formation of the Great Rift Valley, ensured varied topography which resulted in a burst of speciation producing many endemic species of plants and animals. This is because of diverse habitats covering five ecozones (Central Highlands, Semi-Coastal Region, Eastern Slopes, Jordan Rift Valley, and Coastal Regions), and four biogeographical regions (Mediterranean, Irano-Turanian, Saharo-Arabian, and Sudanese/Ethiopian). The mild weather, diverse fauna and flora, rich soils, and presence of wild plant species and certain animals in the Fertile Crescent allowed humans to go from hunter-gatherers to agricultural and nomadic shepherd lives. The domestication of animals (e.g. goats) and plants (wheat, barley, lentils), in this region also allowed for population expansion and development of civilizations and religious beliefs among the local Netufian and later Canaanitic people.

Studies of vertebrate biodiversity in the OPT were very limited by contrast to nearby areas of Palestine and Jordan. Research in general still lags behind in our area (Qumsiyeh & Isaac, 2012). As early as 1950, scientists warned of an environmental disaster in Palestine should the trends then evident persist (Ives, 1950). The environmental impacts of the geopolitical changes of the past 100 years has been dramatic (Qumsiyeh, 1996, 2004). But direct studies of our environment are still in the early stages. Most studies of fauna and flora within Palestine were completed by Western visitors who came on short trips to study the "Holy Land" and many of those visitors were connected to Western imperial powers such as France and England (Tristram, 1866, 1884).

Early European Jewish immigrants worked to study nature here (Bodenheimer, 1935). After Israel was founded in 1948, such studies of fauna and flora became a common tool including for example studies on plants (Zohary, 1966, 1972, 1973), spiders (Zonstein & Marusik, 2013), birds (Shirihai, 1996), and reptiles (Werner, 2016).

Very few studies were published by Palestinian scientists. One of the first native Palestinians who engaged in faunal studies was Dr. Sana Atallah who performed a number of studies from 1962 until his death at the age of 27 in 1970. The area of Wadi Al-Quff was not studied zoologically before but nearby areas had significant studies of mammals (Atallah, 1977, 1978; Qumsiyeh, 1985, 1996; Harrison & Bates, 1991; Qumsiyeh *et al.*, 1993, 1996, 1998; Mendelsohn & Yom Tov, 1999; Amr *et al.*, 2006; Benda *et al.*, 2010), reptiles and amphibians (Amr & Disi, 2011; Bar & Haimovitch, 2012; Damhoureyeh, 2009; Disi, 1985; Disi & Amr, 2010; Disi *et al.*, 2011; Handal *et al.*, 2016; Salman *et al.*, 2014; Werner, 1988), Arachnids (Levy, 1985, 1998; Levy & Amitai, 1980; Amr & Abu Baker, 2004b; Qumsiyeh *et al.*, 2013), mollusks (Amr & Abu Baker, 2004a; Heller, 2009) and insects (Halperin & Sauter, 1992; Katbeh-Bader *et al.*, 2002; Katbeh-Bader *et al.*, 2003). The only published research relying on specimens from WAQ itself is a brief note we published on karyotype of the scorpion *Nebo* (Qumsiyeh *et al.*, 2014b).

After the establishment of the Palestine Museum of Natural History (PMNH) in 2014, one of its obligations was to identify the neglected biodiversity of the OPT. Within the past three years, PMNH produced a number of publications in peer reviewed journals on groups of local fauna including freshwater snails, scorpions, butterflies, birds, amphibians and reptiles. We are especially interested in studying vulnerable areas because environmental degradation in Palestine accelerated in the 19<sup>th</sup> century with industrialization and large-scale deforestation. Under the Ottoman Empire for example, large tracts of forests in the Eastern Mediterranean region were cut down for fuel and tracks for the railroads (e.g. the Damascus to Hijaz railroad). During the British rule (1917-1948), some reforestation efforts were carried out.

In the areas of Palestine that came under Israeli and Jordanian rule (1948-1967) programs of forestation were common but unfortunately without ecosystem considerations. In the case of Israel, European pine trees were used to cover-up the destroyed Palestinian villages and agricultural lands. But also many areas that had native flora and fauna were converted to residential settlement/colonial projects that generated far more pollution than similar settlements inside Israel proper (where there was more regulation). Alon Tal, Founder of the Israel Union for Environmental Defense, acknowledged that: "...it's a Zionist paradox. We came here to redeem a land and we end up contaminating it" (Beyer, 1998). It is now well recognized that there is a decline of biodiversity in our area due to habitat destruction and other human activities (Qumsiyeh, 1996; Qumsiyeh *et al.*, 2014a; Handal *et al.*, 2016).

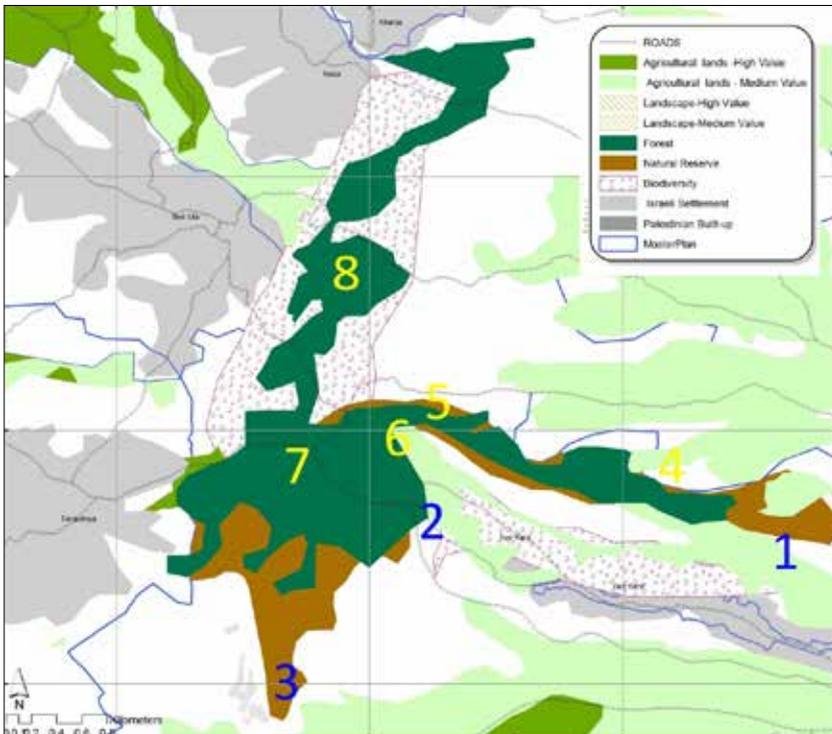
Wadi Al-Quff (WAQ) protected area near Hebron falls into a Mediterranean forested area considered by the WWF as Global 200 priority biomes (Olson & Dinerstein, 2002) and an area of significance for the global plant bioiversity (WWF and IUCN, 1994). It was designated as a protected area of some 145 hectares and a management plan was developed for the area in 2014 (EQA, 2014). The aim of this study is to evaluate status and distribution of fauna and flora in WAQ area in order to make a more informed and detailed management plan and integrate data with ecosystems and habitats to make recommendations in regards to management strategies of the existing fauna in the context of ecosystems. Biodiversity research related to conservation measures is hampered by sampling and distributional limitations (Williams, 1996). Our study is certainly not a comprehensive sampling of the local fauna and flora but is a needed step as plans are made and hopefully executed to protect the declining fauna and flora of the area.

## METHODS

Surveys of biodiversity are usually very expensive endeavors especially for selected difficult groups such as beetles, moths, and spiders (Mandelik *et al.*, 2010). Our nascent Palestine Museum of Natural History is in the process of accumulating reference collections from fauna of Palestine to use in these studies of Wadi Al-Quff and other protected areas. The National Agricultural Research Center has developed a reference plant collection (herbarium). What we were able to survey shows a remarkable degree of faunal biodiversity studied by us over the years 2013-2015.

## STUDY SITE

Wadi Al-Quff (WAQ) protected area is located in the western part of the Hebron Governorate and consists of two confluent valleys between Beit Kahil and Tarqumiya of a total of 145 hectares (EQA 2014; Figure 1).



**Figure 1:** Habitat structure of the WAQ area. Numbers in blue indicate water sources of significance for vertebrate biodiversity and numbers in yellow indicate habitats that we noted with significant other conservation value discussed in detail (Figure adjusted from a baseline figure by Applied Research Institute of Jerusalem). Numbered areas will be discussed in details in the text.

The area of WAQ is on the western escarpment of the Hebron hills and falls in the Mediterranean botanical and zoogeographical region (Zohary, 1973). It has elevations ranging from 520 m to about 820 m asl. The area is steep, with rocky limestone with light soil on the rock surface (from which the name Quff comes). It is an important part of the system that replenishes the western water aquifer. The hill structures of WAQ originated through folding and restructuring mainly in the Mesozoic to Cenozoic geological eras. The mean annual temperature in this area is 19-20° C and annual rainfall is 400-500 mm. The soil is *terra rossa* and brown rendzina. Significant cultivation of introduced trees was done in four stages. The first one was started 1927 in the British mandate. The area is around 100 hectares, planted mainly by *Pinus halapensis*. The second stage in 1962 with an area of 150 hectares planted by the Jordanians. The area is called Al Husein Camps since it was the place for the Jordanian soldiers. The third stage was in 1970 with 90 hectares. The fourth stage was in 2010 with 2 hectares for the establishment of Tarqoumia

Park since part of the protected area belongs to Tarqoumia land. The main plantation was *Pinus halapensis* and *Cupressus sempervirens* in addition to the natural oak, *Pistacia* and many other shrubs. It has to be mentioned that there are some trees of *Pinus canariensis* which are considered as fire resistant.

While this was intended to help preserve the soil, it affected the local forest ecosystem and created a rather artificial environment not conducive to the local species. The native areas are typical Palestinian Mediterranean forested and shrub habitats including a few wetland habitats (near Ain Hasaka). The tree cover included *Pinus halepensis*, *Pistacia palaestina*, *Quercus calliprinos*, *Cupressus sempervirens* and *Rhamnus palaestinus*. These areas still occur in small non-contiguous patches (see below) but could be used as seeding areas to expand with proper forest management policies.

**Area 1. Ain Hasaka** and its effluence: These are agricultural lands of high value in the valley from Lat: 31° 33' 53.7582" Long: 35° 5' 25.5042" to Lat: 31° 34' 30.4818" Long: 35° 4' 15.5166". To the east of the reserve and following the dirt road to Wadi Hasaka we find significant agricultural development highly dependent on the Hasaka springs (Figure 1). This area was picked because there are open water resources and agricultural fields which attracted bats and insects. Both frog species (*Hyla* and *Rana*) came from this area and nowhere else in the park. Also many species of insects with preference for streams were from here (e.g. dragonflies). This is a very rich insect habitat with many species of butterfly, beetles and bees. It was also a habitat for several bats which fed on two dozen species of moths collected in this area. One particular noteworthy record (initially by ultrasound and later by capture was *Pipistrellus pipistrellus*, the southern-most (and new) record for this species. Here we also collected 12 of the 22 species of reptiles in WAQ, and two frogs. Also this was a rich habitat for spiders, scorpions and birds. A well-balanced ecosystem exists in this area but is threatened with a growing population. The area might even be classified as Wetlands worthy of nomination under the Ramsar convention with at least five of the 9 criteria of Ramsar seeming applicable here.

**Area 2. Ain Beit Kahil:** Area centered at Lat 31° 34' 32" Long 35° 2' 45". This used to be open water sources releasing into the WAQ area many years ago. At least four sites are noted that have been closed completely and used for human consumption and agriculture primarily supplying the main nurseries in the valley. With exception of small leakages and the water containers that are open, these water sources are no longer available for wildlife usage. Bats (primarily *Pipistrellus*) were noted to use the main water storage container but this structure is not usable by other land animals. One possibility to help biodiversity reclamation is to divert some water into the small area to the west which could also act as a natural bridge between the naturally protected area 7 and area 6.

**Area 3: Spring (Ain) and western side of colony of Telem.** This area is centered at Lat 31° 33' 55" Long 35° 2' 1". This is an area that is heavily overgrazed with shepherds bring their goats and sheep to the water and hanging around the area. The valley leading up to the spring is dry but seems to have regular floods in winter and we collected many snail shells there as well as observing *Ptyodactylus guttatus*. A small protected area to the east of a tributary to the Wadi and near the spring was promising and had a number of the noted butterfly species and other invertebrates collected here.

**Area 4.** Area centered at Lat: 31° 34' 45" Long: 35° 3' 34". This is a small secluded valley of the park with mixed forest area in the northwestern side of the reserve. To the north of it is Halhul urban development and all around it are some agricultural development. Here we observed good faunal biodiversity because of the rather undisturbed nature of the habitat. However, there is logging at the edge of this area and encroachment of agricultural development.

**Area 5.** This area is centered at Lat 31° 34' 58" Long: 35° 2' 34". The south facing cliffs in this area of the Wadi Hasaka are less protected than the opposite side of the valley. However, the geologic formation here is rather interesting and the calcite cliffs (likely Cretaceous) include good roosting sites for fauna that feeds in other places of WAQ. The example is the main fruit bat cave and crevices and smaller caves that provide roosting sites for other bat and bird species. These are primarily roosting sites and ecologically vulnerable areas whose protection can maximize biodiversity maintenance. Between this area and the next area is a dirt road that leads to Hasaka. This road is used by farmers and visitors to the park especially on weekends. Significant dumping occurs in this area (see Figure 5). As this habitat destruction spreads in the valley, both the roosting sites (north side of the valley) and the foraging sites (the valley and the south side) are impacted. One of our recommendations is to block access to this dirt road at least from the asphalt road at the intersection Halhul-Tarqumia-Beit Kahil (see below).

**Area 6.** North facing side of Beit Kahil hill. Starting from behind the amusement park 31° 34' 43" N 35° 2' 38" E going NW to the valley there is an unpaved road that passes first through pine forest then through native *Quercus* patch ending at 31° 34' 51" N 35° 2' 32" E. There is a good preserved natural area at the end of the path where we found reptiles and trapped large numbers of forest mice feeding on oak (*Quercus*). Due to steep nature of this area, it seemed to have been maintained well. There are many of the species of reptiles noted here (list at the end) and the area also provides foraging grounds for bats, birds (e.g. the little owl, *Athene noctua*) and mammals.



**Figuer 2:** Area 6 habitat.

**Area 7.** Area centered at Lat 31° 34' 44" Long 35° 2' 11". Area 7 is to the south of the road from Tarqumia to Beit Kahil and has a very rough dirt road (only navigated by 4-wheel drive) that separates it into two areas: we call them 7a and 7b (Figure 4). Because of the terrain being not very accessible, it seems this area provided a natural protected area of WAQ. Here we recorded many of our lizard species and also here is where the rare *Mediodactylus (Cyrtodactylus) kotschyi* Mediterranean Thin-toed Gecko was found. This represents the southern-most record of this species and while IUCN does not consider the species of concern, in this area it is likely threatened (we noted only one specimen even after significant search). Also we noted the locally rare Snake-eyed lizard *Ablepharus rueppellii*. Another notable finding in this area is the tiny land snail of the genus *Ena*. The area is also foraging ground for the bats.

**Area 8.** Area above the road to Halhul (centered at Lat 31° 35' 27" Long 35° 2' 24") and encompassing the area of the protected area that is most disturbed but is an important habitat for butterflies (especial the swallow-tail *Papilio*, the largest of Palestinian butterflies), reptiles, and a vantage point for observing migratory birds.

## RESULTS AND DISCUSSION

We studied biodiversity in the first nature reserve administered by Palestinians of the occupied Palestinian Territories (OPT). According to the IUCN Protected Areas Categories System, seven types of categories have

been proposed to suit certain requirements for protected areas. Wadi Al-Quff falls under the IUCN category of V (less likely VI) based on the criteria of the different categories (approved by the Environmental Quality Authority). The survey data published in the accompanying papers recorded a rich fauna with more than 89 species of birds, 19 species of mammals, 21 reptiles, three amphibians, over 250 invertebrates, and over 230 species of plants. This biodiversity is surprising considering habitat degradation and limited sampling due to time and resource limitations.

Our area around the Mediterranean is suffering from significant habitat destruction largely brought about by human development (Hoekstra *et al.*, 2005). Assessing biodiversity is critical in planning conservation measures for protected areas. As part of UNDP/PAPP assignment "Management Plan for Protected Area in the West Bank" the IUCN in cooperation with the Ministry of Agriculture, the Environmental Authority, and local experts and interested parties produced preliminary work based on an initial study in Summer 2013 of Wadi Al-Quff area followed by these studies reported in this series of papers. Increasingly, existing data point out that the environmental instability, inequality of resource distribution, and habitat destruction done over the past 120 years have led to significant damage and even catastrophic outcome in Palestine, the Holy Land (Kelly & Homer-Dixon, 1996; Qumsiyeh, 2004, 2013).

Understanding what exists in this area is integral to designing protection schemes that work to preserve the critical elements and the biodiversity in this ecosystem. Our initial and immediate goal should be to protect what exists (a still rich but highly threatened fauna and flora) and then expand the area with natural regrowth and reforestation of degraded areas. Palestinian protected areas did receive some evaluation of threats and potential mitigating factors (Garstecki *et al.*, 2010) and a management plan for the WAQ protected area was developed based on our preliminary fauna and flora survey (EQA, 2014). Here we will highlight in more detail some key points under two categories: more urgent actions and long-term actions.

## IMMEDIATE ACTION RECOMMENDATIONS

**1) Cull/remove the Feral dogs.** The Palestinian Canaan dog has lived as feral in our lands for thousands of years around human habitation. Some two dozen feral Canaan dogs were counted primarily in the center of the WAQ area. These dogs have had a devastating impact on the environment including killing of wildlife, removing some natural prey for wild carnivores (foxes, jackals, hyenas, badger), and also in terms of forcing other wildlife to leave and/or do less foraging. There are humane ways to remove those including tranquilizer guns and humane euthanasia or relocation with proper neutering/spaying done. We discussed with the local governments who are tasked by Palestinian law for doing his. Unfortunately there were periods when poisoning was done which killed many of the local carnivores.

**2) Block roads and/or limit access in some areas of WAQ.** This is especially helpful in the valley leading to Ain Hasaka and to areas below Beit Kahil Safa park. At least two blocks can be established for vehicles. Another option is to apply a fence to protect areas on both sides of the road below the x marks in figure 3. These are areas of high biological/biodiversity value.



**Figure 3:** Suggested alterations to critical areas (for areas 5, 6, and 7). Either blockage of dirt access roads at yellow X mark and/or apply fence to protect areas on both sides of the road below the X.

**3) Discuss with farmers and other stake holders protection measures and limits on activities near or in the park.** This is especially needed in the farm area shown in Figure 3 above to protect the environment while maintaining access (if they are legitimately farming their lands). One concern is use of pesticides which would impact the insect fauna and as such also the predator animals that eat them including bats, shrews, reptiles etc. Other stakeholders need to be brought into the picture as partners in the protection of WAQ area: the Environmental Quality Authority, Ministry of Agriculture, local governments, nature lovers, university students, and Ministry of Education among others.

**4) Prevent Burning:** There are occasional burnings in the area and in one instance a large fire that erupted on 21 February 2014 burned over 13 dunums of forested area.

## LONG TERM RECOMMENDATIONS

**1) Monitoring and preventing unlawful activities.** This includes tree cutting (Figure 4), dumping (Figures 5), hunting (we noted shells of khartoush guns), overgrazing, and taking of products from the forest without license (plants, mushrooms, etc).



**Figure 4:** Some forest cutting in Area D. Habitat of Jericho giant scorpion



**Figure 5:** Illegal dumping near area 7

Habitat use can guide conservation measures, for example for local bats (Carmel & Safriel, 1998) and more detailed studies over time in these areas are needed. It will be important to study impact of local changes including habitat destruction and habitat changes for example by soil acidification on the fauna of the area (see Graveland *et al.*, 1994; Gärdenfors *et al.*, 1995).

**2) Develop sustainable use of some areas:** In our numerous trips to the area we saw much use of its resources including grazing, wood cutting, collection of animals and plants for food, plants collected for medicine etc. Wood culling of the non-indigenous species may be permitted in some areas to reclaim the more natural forest. In some areas replanting of the natural forest is possible. One possible scenario is to also plant and manage a section of the forest specifically for medicinal plants. For a list of Medicinal Herbs used by Palestinians from nature, see Said (2002). For a list of 103 edible plants (62% of them also used medicinally) harvested regularly from the Palestinian areas, see Ali-Shtayeh *et al.* (2008). To organize this better we suggest a partnership with a university like Bethlehem University (and its new Institute of Biodiversity and Sustainability and the Palestine Museum of Natural History) to create a center that would run this facility. See also recommendation 6 below.

**3) Ameliorate habitat fragmentation and destruction:** The area of the proposed reserve is being fragmented and each segment has its own challenges (and opportunities) with regards to faunal assemblages studied briefly here (but this is not separate from the bird and the floral studies done by separate investigators for this project). Briefly per the areas we studied:

Area 1: Expanding agricultural activities including use of pesticides. Though technically not actually part of the reserve but has a reservoir of amazing biodiversity of species, as the open waters that attract bats and amphibians and odonata.

Area 2: Building development, dumping, over extraction of water for the plant nurseries.

Area 3. The presence of the Israeli colony of Telem and the overgrazing by domestic animals should be considered in this otherwise very promising area.

Area 4: Extensive wood-cutting, agriculture, human encroachment.

Area 5 and 6: Recreational activities especially risk of expansion of those from the muntazah area. Also agricultural activities.

Area 7: Perhaps best protected by nature of terrain but the dirt road is splitting the area and there is human development and encroachment from top of the hill.

Area 8: the northern hill parts of the protected area. This is a good section for butterflies and reptiles and provides a great vantage point for observing migratory birds. There is significant overgrazing by Bedouins in the area.

Agricultural activities can significantly impact biodiversity (e.g. for butterflies, see Pe'er *et al.*, 2011). Besides stopping these threats, we can envision reforestation with endemic trees that could potentially link some of the fragmented areas. To protect the vulnerable bat species in the area, we suggest there is a need to protect the key habitats which are mostly the riparian *Quercus* habitats that generate much of the prey species used by these bats (see Carmel & Safriel, 1998)

#### **4) End the Israeli occupation and empower and educate local people:**

For proper management of this and future reserve, Palestine must become a free country so that it can do national planning such as having appropriate laws and enforcing them. There is a very damaging impact of the occupation including limiting development of Palestinians in other areas of Palestine due to ethnic cleansing squeezing Palestinians into small areas. Many of the people we met living near the park and using its resources are refugees from 1948. We also noted significant potential impact coming from polluting industries to the reserve (e.g. recycling Israeli computers in Idhna see also Hammad & Qumsiyeh, 2013) and impact of the wall once it is built nearby (see EQA, 2010). The issue of enforcement perhaps needs to be put in a separate recommendation. In the nine days and five nights of wandering the reserve for hours and hours, we never encountered any of the supposed reserve rangers that should be guarding the reserve.

**5) Start to deal with the impact of Climate Change.** Climate change will have a dramatic impact on our country in the next two decades (Evans, 2009; Willis & Bhagwat, 2009; World Bank 2012) and it was shown that it is important to look at how habitats which will change in the coming years might also impact distributions and health of the local fauna (Bilgin *et al.* 2012; Blaustein *et al.*, 2010; Yom-Tov, 2001).

#### **6) Develop an environmental educational center in the protected area.**

We need to educate the youth about the importance of biodiversity and the ecosystem as an integrated system critical for survival of all species living in it including humans. One way we can work to implement a plan of faunal biodiversity protection is to educate young people. We propose that a national nature education center and natural history museum be established in this reserve (we in Bethlehem University are ready to assist). This would begin to transform both biodiversity research and environmental conservation in Palestine.

Local people in Palestine lived in harmony with nature for millenia except for a few documented cases of overuse of the environment for example in Ain Ghazal in Jordan. The more dramatic changes witnessed in the past 100-150 years are exceptional. The impact on the Middle East of Global warming is/will be more pronounced than other areas (Evans, 2009). The World Bank report in November 2012 on the impact of human induced

climate change on the Arab world revealed unsustainable trends (Evans, 2009; Willis & Bhagwat, 2009; World Bank, 2012). Over the past 20 years, climate monitoring stations across the Arab world have already shown an increase in average annual temperature. Computer models predict that in the next two to three decades annual rainfall will decrease in our area by nearly 25% and average annual temperatures will climb by 4-5° degrees. Disentangling the causes of a decline or adverse effect on species is not easy and this includes climate change. Yom-Tov (2001) suggested that decline in body mass of four species of birds between the 1950s and 1999 is due to global climatic change. Per Bergman's rule higher temperature can lead to micro-evolutionary changes producing smaller size. But phenotypic plasticity may also play a role in this case (Teplitsky *et al.*, 2008) as may other changes in the environment/resource availability. Bilgin *et al.* (2012) used models and concluded that bat species will be most significantly affected in our area due to climate change. However, caution must be taken in putting out predictive models about effect of climate change on biodiversity because models cannot take into consideration issues like topography, microclimates, and individual species adaptability (Willis and Bhagwat, 2009). We thus feel that direct studies like the preliminary study we presented above are important for monitoring changes in biodiversity (see recommendations section above).

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