

The Golden Eagle in Israel



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The last century has seen a dramatic decline in the diversity of breeding raptors in Israel. Seven raptor species are already extirpated and many of the remaining species are at various levels of threat. The case of the Golden Eagle (*Aquila chrysaetos*) is particularly severe, as its population is small, exhibits low nesting success rates and is affected by numerous threats.

With only about 10 pairs currently left of the 40 pairs that nested in Israel in the early 1980s, the status of the species is

extremely critical. Threats to breeding success and survival are unclear. Beyond that, the small Israeli population is probably isolated, with neighboring populations (of Lebanon, Syria, Jordan and Egypt) gone.

This short chapter presents the results of Golden Eagle breeding surveys in Israel conducted between 2014 and 2021, as well as older data from the 1980s. We also suggest possible conservation measures to reduce the risk of extirpation.

DISTRIBUTION, POPULATION AND TRENDS

The Golden Eagle was discovered nesting in Israel in 1972 in the northern Judean Desert (Brodetsky 1972), although previous reports from the 1950s and 1960s of Eastern

Imperial Eagles (*A. heliaca*) nesting on cliffs in the southern Negev Desert were probably misidentified Golden Eagles (Leshem 1979, Shirihai 1996). Additional breeding pairs were



discovered in the 1970s, and by the early 1980s, the Golden Eagle was known from many more areas. In 1984, 22 nesting pairs were known from the southern Golan Heights to the mountains of Eilat, at the southernmost tip of Israel (Fig. 1, Table 1; Frumkin and Man 1984). A detailed study carried out during Ofer Bahat's thesis work (1989) brought the population in Israel to 37–41 breeding territories (Fig. 1, Table 1), and

to a further 3 territories in northern Sinai. The distribution of breeding pairs in the Judean Desert and the Negev was described at that period as uniform, where the distance between neighboring territories was influenced mainly by intra-specific competition and inter-specific competition with Bonelli's Eagle (*A. fasciata*) for nesting sites and food (Bahat 1989).

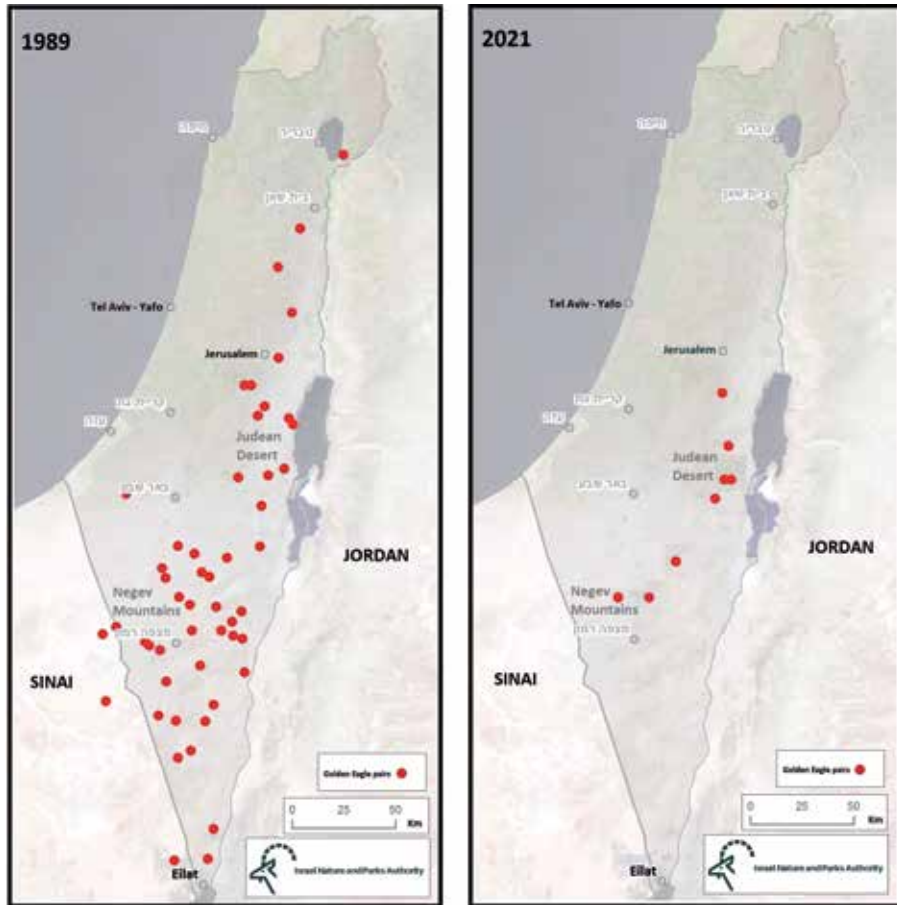


Figure 1. Distribution of Golden Eagle territories in 1989 compared to 2021.

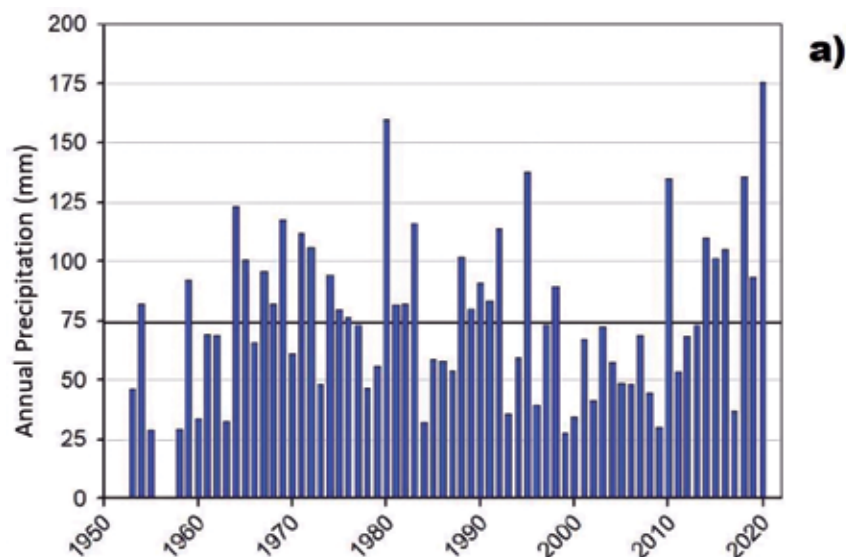
Table 1. Number of Golden Eagle pairs known in the different regions of Israel between 1984 and 2021.

Year	Negev and Eliat regions	Judean Desert	Samaritan region	Golan Heights	Total
1984	11	8	2	1	22
1989	23	9	4	1	37
2003	6	5	0	0	11
2015	3	5	0	0	8
2016	2	5	0	0	7
2017	3	4	0	0	7
2018	2	4	0	0	6
2019	2	4	1	0	7
2020	5	4	1	0	10
2021	5	4	2	0	11

More than a decade passed before a 2003 survey found only 11 nesting pairs. Pairs had already disappeared from the Golan Heights and the Samaria region, indicating a sharp decline in population size and distribution (INPA unpubl. data). Between 2003 and 2018, the number of breeding pairs continued to decline, reaching a minimum of 6 pairs in 2018 (with only a single eaglet fledged that year).

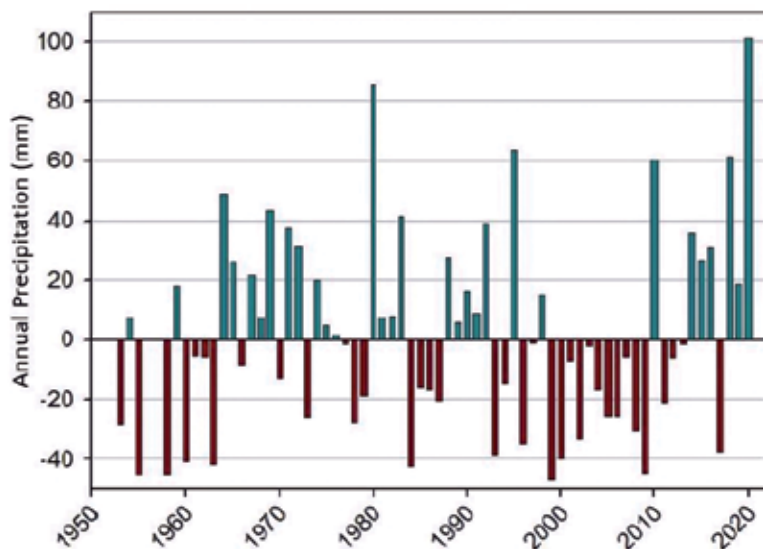
Then, between 2019 and 2021, the population underwent an increase, especially in the Negev region (3 new pairs) and in Samaria (2 new pairs) that have recolonised the region since the disappearance of the species in the 1990s (Table 1). However, some of this increase may be attributed to enhanced monitoring efforts. Since 2015, the population has been carefully monitored every year, with some of the nests being guarded to prevent disturbance.

The species is known to be very sensitive to annual precipitation, which varies dramatically in the Negev Desert (Bahat and Mendelssohn 1996); hence, the sharp fluctuations in the number of breeding pairs may be a natural response to climatic conditions which influence prey abundance. Examination of annual precipitation records in the Negev Mountains (Fig. 2; Babad and Silver 2021) reveals a sequence of comparably dry years between 1993–2013 (with 18 yr below the annual average and only 3 above it), whereas the period 2014–2020 was exceptionally rainy (with 6 yr well above the average and 1 below) This may have created the conditions for Golden Eagle increased breeding success, which resulted in increased recruitment and gradual population growth.



a)

Figure 2. a: Annual precipitation amounts in the Negev Mountain (Mitzpe Ramon). The black line represents the multi-annual mean. b: Precipitation annual deviation from the multi-annual mean in the Negev Mountain (Mitzpe Ramon). Negative values represent lower than the average, positive values represent higher precipitation than the average (Babad and Silver 2021).



b)



NESTING HABITAT

Currently, all known nests are on cliffs (Fig. 3), but in the past there were also a few records of tree nests and nests on electricity poles (Leshem 1979, Bahat 1989, Shirihai 1996). Most of the Golden Eagle pairs in Israel are in the very arid Negev and Judean Deserts, where mean annual precipitation varies from 23 mm in the southern edge, to about 150 mm in the northern part (Sa'aroni et al. 2012, IMS 2021). The average number of rainy days/year varies accordingly from 5 in the southern Negev to 27 in the north. The maximum temperature in summer sometimes reaches 50° C in most desert areas. The

few pairs that breed in northern Judea and eastern Samaria inhabit a more temperate, semi-desert (Irano-Turanian) climate, with annual rainfall of 200–550 mm (Yom-Tov and Tchernov 1988, IMS 2021).

The elevation of eagle-inhabited areas ranges from about 1,000 masl in the Negev highlands and the Samaria mountains to 430 m below sea level along the shores of the Dead Sea. This sharp transition of altitudes, between the central mountain ridge and the Rift Valley, has led to the creation of numerous wadis and deep canyons that cross the desert from west to east



Figure 3. Golden Eagles nest exclusively on cliffs in Israel today. Examples of cliff nests in the Judean Desert. Photos: Yoram Shpirer.

(Fig. 4). These canyons are home to Golden Eagles, as well as many other birds of prey including Bonelli's Eagle, Lanner Falcon (*Falco biarmicus*), Barbary Falcon (*F. peregrinus pelegrinoides*), and Sooty Falcon (*F. concolor*), and scavengers

such as the Egyptian Vulture (*Neophron percnopterus*) and Griffon Vulture (*Gyps fulvus*). In these areas, Golden Eagles nest in rugged, mountainous landscapes, with erosion-ravaged canyons and cliffs, mostly far from human presence.



Figure 4. Characteristic nesting habitat (upper) and hunting habitat (lower) of the Golden Eagle in the Judean Desert. Photos: Yoram Shpirer.





Table 2. Prey consumption by the Golden Eagles in the Israeli Desert (Bahat 1989), divided to 4 regions ordered from north (Judea) to south (Eilat).

Common Name, Scientific name	Average weight (gr)	Judean Desert	Northern Negev	Southern Negev	Eilat Mountains	Prey totals
Birds						
Chukar, <i>Alectoris chukar</i>	520	133	7	11		151
Sand Partridge, <i>Ammoperdix heyi</i>	175	2			1	3
Common Quail, <i>Coturnix coturnix</i>	90	1				1
Domestic chicken, <i>Gallus gallus domesticus</i>	2,500	75				75
Rock Dove, <i>Columba livia</i>	250	58	1			59
White Stork, <i>Ciconia ciconia</i>	3,000		2			2
Long-legged Buzzard, <i>Buteo rufinus</i>	1,175		1			1
Common Kestrel, <i>Falco tinnunculus</i>	225	2	1		1	4
Eurasian Thick-knee, <i>Burhinus oedicanus</i>	350		1			1
Dove, unidentified, <i>Streptopelia</i> sp.	130	3				3
Eurasian Jay, <i>Garrulus glandarius</i>	180	6				6
Thrush, unidentified, <i>Turdus</i> sp.	80	2				2
Brown-necked Raven, <i>Corvus ruficollis</i>			1			1
Common Hoopoe, <i>Upupa epops</i>	65	1				1
Swift, unidentified, <i>Apus</i> sp.	40	1				1
Passerine, unidentified, Passeriformes	30	2				2
Bird, unidentified, Aves	400	130				130
Total Aves Biomass (kg)		330	13.5	5.7	0.4	
% Birds in the diet		33.6	11.9	9.7	0.2	
Mammals						
Cape hare, <i>Lepus capensis</i>	2,000	76	37	23	10	146
Rock hyrax, <i>Procavia capensis</i>	2,500	1				1
Indian crested porcupine, <i>Hystrix indica</i>	2,500	2		1		3
Mountain gazelle, <i>Gazella gazella</i>	2,500	1				1
Dorcas gazelle, <i>Gazella dorcas</i>	2,500		1	1		2
Domestic goat, <i>Capra aegagrus hircus</i>	3,000		1			1
European badger, <i>Meles meles</i>	1,000	1				1
Domestic dog, <i>Canis lupus familiaris</i>	2,500	2				2
Marbled polecat, <i>Vormela peregusna</i>	300	1				1
Rodent, unidentified, Rodentia	60	3		1		4
Mammal, unidentified, Mammalia	2,000	33				33
Total Mammals Biomass (kg)		287	86.5	51.1	20	
% Mammals in the diet		50.6	76.4	87	10.6	
Reptiles						
Greek tortoise, <i>Testudo graeca</i>	750	155				155
Kleinmann's tortoise, <i>Testudo kleinmanni</i>	220		3	3		6
Starred agama, <i>Stellagama stellio</i>	150	1				1
Desert agama, <i>Trapelus mutabilis</i>	15		1	1		2
Egyptian spiny-tailed lizard, <i>Uromastix aegyptia</i>	1,250		10	1	125	136
Desert monitor, <i>Varanus griseus</i>	1,500				1	1
Snake, unidentified, Serpentes	400	4				4
Total Reptiles Biomass (kg)		118.2	13.2	1.9	169.4	
% Reptiles in the diet		15.8	11.7	3.3	89.2	

DIET

Dietary information for Golden Eagles in Israel is based on observations of prey brought to nests and the collection of pellets and food remains below roosts and nests (Bahat 1989). We also collected prey remains when tagging nestlings. There are significant regional trends in diet (Table 2) and diet also differs greatly from pair to pair.

The most frequently observed prey in the Judean Desert are Greek (spiny-thighed) tortoises (Fig. 5). However, tortoises do not inhabit the arid desert near the nests, so some of the nesting eagles

must fly at least 10 km to collect the tortoises. In the southern Negev, the Arava and Eilat Mountains, the most common prey was the Egyptian spiny-tailed lizard, which is common, heavy and slow, making it ideal prey for the eagles (Fig. 6).

In general, the diversity of prey decreases moving south (Bahat 1989). In the north (Judean Desert), the diet includes many birds (34% of the biomass), while in the south (Eilat Mountains) it contains mostly reptiles (89% of biomass; Fig. 7, Table 2).



Figure 5. Upper: Greek tortoises are one of the main prey of the Golden Eagle in the Judean Desert during chick rearing. Lower: Cape hares are also important prey of the Golden Eagle in Israel. Photos: Yoram Shpirer.



Figure 6. Upper: Food items in a Golden Eagle nest in the southern Negev. Lower, left to right: rock hyrax, Nubian ibex (*Capra nubiana*), and Egyptian spiny-tailed lizards. Photos: Asaf Mayrose.



Prey composition according to area

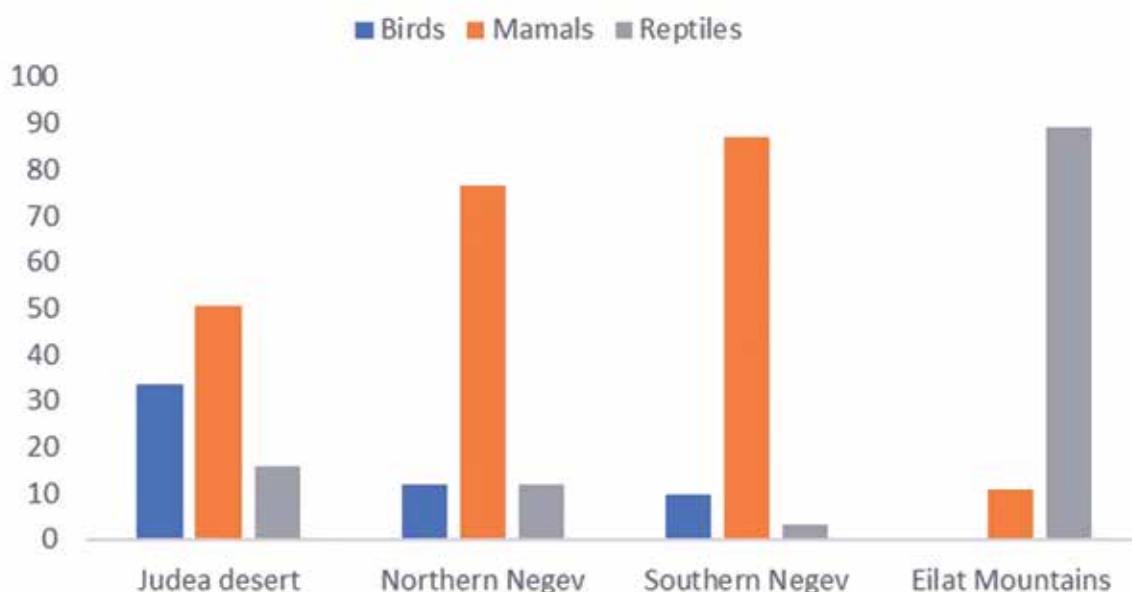


Figure 7. Proportion of food by Class in 4 regions of the Israeli deserts. From Bahat (1989).

REPRODUCTION

The breeding season begins in November. The first eggs are laid in mid-December; the last are laid in mid-February, with an average laying date around 31 December ($n = 23$ clutches). Breeding parameters are presented in Table 3.

Bahat (1989) examined 119 nesting attempts from 1972–1989 at 19 sites in the Negev and Judean Deserts, and found significant differences in breeding success between regions. The northern area (Judean Desert) had the highest breeding success (1.67 ± 0.87 young fledged/pair). The northern Negev, that holds some irrigated agriculture, showed a lower breeding rate (1.19 ± 0.97), while the lowest breeding success rate was

found in the arid and desolate southern Negev (0.98 ± 1.08).

Breeding success was correlated with precipitation amount in the previous year. This correlation was most significant in the southern Negev. The meaning of this correlation is that, in general, the more arid the nesting area, the greater the positive effect of rainfall on breeding success (Bahat and Mendelsohn 1996). This correlation explains, at least in part, the disappearance (or non-breeding) of Golden Eagle pairs in the southern Negev during the early 2000s, and the partial recovery in recent years (as described in Distribution, Population and Trends).

Table 3. Golden Eagle nesting success rates 2015–2021.

Year	N° of pairs	Pairs starting breeding	Pairs reaching fledging stage	Number chicks fledged	Productivity (all pairs)	Productivity (all breeding pairs)	Productivity (successful pairs)
2015	8	7	5	6	0.75	0.86	1.2
2016	7	3	3	3	0.43	1.00	1.0
2017	7	5	4	7	1.00	1.40	1.75
2018	6	3	1	1	0.17	0.33	1.0
2019	7	6	6	8	1.14	1.33	1.33
2020	10	9	8	13	1.30	1.44	1.63
2021	11	10	6	9	0.82	0.90	1.5
Total	56	43	33	47	0.80 (± 0.37)	1.04 (± 0.37)	1.42



MOVEMENTS

Based on satellite-PTTs and GPS-GSM tagged individuals ($n = 26$), juvenile Golden Eagles wander over most of Israel and large parts of the Middle East, especially in the neighbouring countries of Egypt, Syria and Jordan (Fig. 8–10). Most of the juveniles moved a few hundred to ca

1,000 km from their natal sites, while a few individuals moved up to 2,300 km north or south, reaching as far as northern Turkey and southern Yemen, where the sea barrier seems to prevent them from continuing onward (Fig. 8).

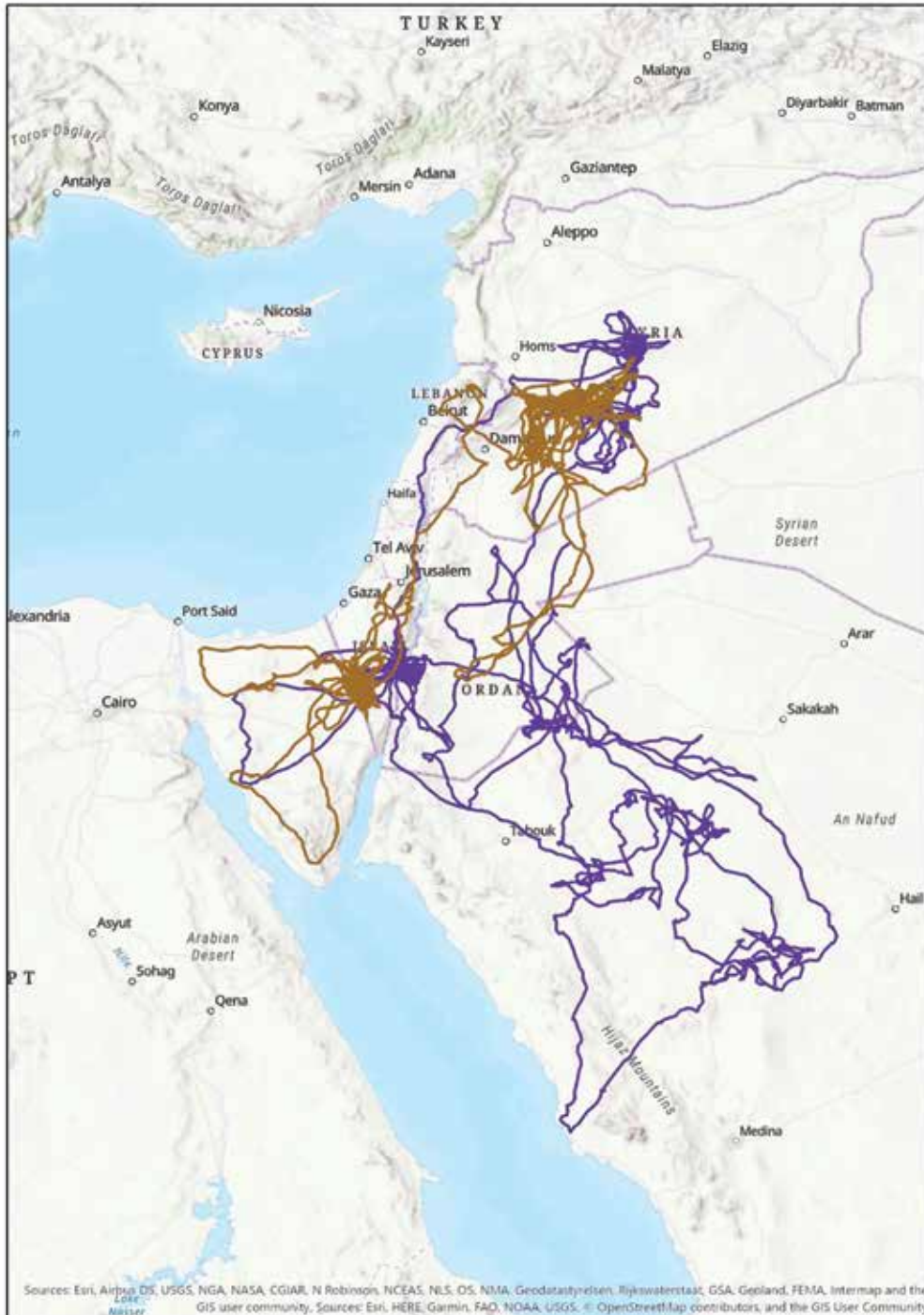


Figure 8. Medium-distance movements of 2 juvenile Golden Eagles from the Negev.



Figure 9. Medium-range movements of 3 juvenile Golden Eagles.



Figure 10. Long-range movements of 3 immature Golden Eagles tagged in Israel before fledging.

THREATS AND CONSERVATION

The main threats to Golden Eagles in Israel are those influencing breeding success, juvenile survival, and recruitment rates.

Factors Affecting Breeding Success.

Nest Robbing. Nest robbing is more common in eastern Samaria and the Judean Desert (mostly among the Palestinian and Bedouin people) than other areas. Typically, young are removed when they near fledging time. Removing young

has likely had a major impact on the population and has probably led to the abandonment of most of the territories in Samaria and the northern Judean Desert (either directly by the disturbance, or indirectly by fewer young fledging and being recruited into the breeding population). Since the mid-1990s there have been at least 7 documented incidents in which at least 10 chicks were taken (Fig. 11). The last known

event occurred in 2014 in the Judean Desert, and since 2015, the nests that are prone to such actions are being guarded constantly during the chick rearing period and for 2–3 weeks after fledging. By then, the eaglets are more capable of escape (see also Conservation).

Low-Altitude Aircraft Flights. Low-altitude aviation may affect nesting success, both in the Judean Desert and the Negev highlands, although its impacts are difficult to quantify. These activities are carried out by: (1) Low-altitude training flights of the Israeli Air Force near the nesting cliffs (Fig. 12). In 1996, a pair of Golden Eagles was killed in a collision with a fighter aircraft, flying low over the Judean

Desert. The collision also caused the loss of the jet fighter. (2) Civilian or commercial flights, carried out mainly by private individuals as a leisure activity, involving helicopters and light aircraft such as ESM (Ultralight). (3) Helicopter rescue operations of rock climbers and hikers that are lost or injured in or around the eagle breeding canyons. Such rescues are most frequent in early spring, the most sensitive period for eagle breeding, and unfortunately also the favoured season for human outdoor activities. Most of these hiking and climbing activities are being done illegally, because large parts of the breeding canyons are closed to visitors during that season.



Figure 11. Two juvenile Golden Eagles stolen from a nest and seized in a Bedouin camp. Photos: Doron Nissim, Israel Nature and Parks Authority (INPA).





Figure 12. Israeli Air Force helicopters frequently approach the nesting cliffs, causing disturbance during the breeding period. This may lead to the abandonment of eggs. Photo: Meidad Goren.

Prey Scarcity. Although this subject has not been thoroughly researched, there is no doubt that eagle feeding grounds have undergone drastic changes in recent decades. The Bedouin people have changed their life style from nomadic to settled, and their herds of camels and sheep have increased many fold. These herds are reaching the heart of the nature reserves and impact the vegetative cover and wild herbivores. This factor surely affects Golden Eagles, which do not usually hunt inside their nesting canyons (like Bonelli's Eagles do), but rather forage for their preferred prey (hares, partridges and tortoises) in the grasslands of the desert plains above the nesting canyons.

Diseases and Parasites. Pathogens may intensify as a result of changes in the eagle's diet, especially as they become more dependent on domestic animals, such as chickens and goats in or near the Bedouin camps. This is evidenced by Golden Eagle chicks that died from trichomonas infections in the Judean Desert during 2013, 2016 and 2021, and a single nestling that was rescued and treated in 2020 (Table 4). Trichomonads are transmitted largely by domestic pigeons (*Columba livia domestica*) and chickens. The high likelihood of *Trichomonas* infestation in the last decade, as opposed to the lack of previous evidence of this problem, may be related to changes in eagles' diet and to domestic prey becoming a more frequent part of it.

Table 4. Causes of nesting failure and mortality of Golden Eagles in Israel (2012–2021). Individual (*) was treated in the wildlife hospital and returned to the nest.

Causes	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Nesting Failure											
Nest robbing			1								1
Disease (<i>Trichomonas</i>)		1			1				1*	1	3
Unknown causes				3	2	1					6
Total		1	1	3	3	1				1	10
Mortality (adults and non-breeding individuals)											
Electrocution				1 Sub		1 Juv		1 Juv	2 Juv		5
Collision with vehicle	1 Sub					1 Juv					2

Risk Factors Affecting the Survival of Dispersing Juveniles and Adults.

Electrocution. Although Golden Eagle electrocutions are less frequent than for the Bonelli's Eagle, it is still exacting a heavy toll on the population. Since 2005, 7 Golden Eagle electrocutions have been documented, 5 of them inside Israel and 2 in Jordan and Saudi Arabia (Table 4).

Poisoning. Over the last few decades, there were no documented cases in Israel of Golden Eagle poisoning with pesticides. One individual arrived at the Israeli Wildlife Hospital for medical treatment; the bird had been shot and

also suffered from acute and chronic lead poisoning.

Direct Persecution by Shooting. Although there is only one documented case of a Golden Eagle shot in Israel, there is no reason to believe that the species is less affected than other large raptors. The threat exists, especially for young individuals that venture into neighbouring countries and areas where shooting and trapping of birds of prey are common. Worth mentioning is the disappearance of 2 out of 15 eagles that were tagged during 2018–2020, and stopped transmitting over Syria and Lebanon, where this problem is known to be especially severe.

POPULATION ANALYSIS AND ON-GOING MANAGEMENT

To examine the viability of the population under different scenarios and to determine where more effort should be invested, a Population Viability Analysis (PVA) was performed. The analysis was conducted using Vortex version 10.1.4.0 (Lacy 2000). The results were that the probability of extinction is 100% (mean extinction time 37 yr), if no urgent actions are taken. Despite this overall grave picture, the analysis showed that, with the addition of a small number of fledglings/year, the population can be maintained or even grow. With a reinforcement of 2 eaglets fledging/year, the population remains stable, and from 3 eaglets or more, the population gradually grows (Mayrose et al. 2019).

To remedy some of the risk factors that were identified, the INPA and “Spreading Wings” Project have launched a species management program that includes:

1. Monitoring. There is daily monitoring of all active nests every year.
2. Telemetry study. Most of the fledglings are tagged with GPS-GSM tags, to identify risk factors and check the

efficiency of management actions.

3. Nest guarding. All nests that are prone to robbery are being guarded during the nesting period.

4. Medical treatment. Nestlings identified as injured, ill or infected with trichomonas are either treated at the nest or taken to the wildlife hospital for treatment (and brought back to the nest if possible).

5. Prevention of aerial activity around nesting sites. Together with the Israeli Air Force and Israeli Civil Aviation Authority, new maps of aerial restrictions are delineated, including all current eagle breeding territories. Furthermore, to mitigate the effect of helicopter rescue operations, all the regional rescue teams are coordinated with INPA rangers, who guide the pilots in approaching the canyons to minimize disturbance to the eagles.

6. Electrocution mitigation. A program to insulate high-risk power poles is underway, especially in juvenile dispersal areas such as the Jordan Valley. This mitigation measure is slow and expensive, yet the project team is seeking ways to accelerate it.



CONSERVATION STATUS

The Golden Eagle population in Israel is fragile and in constant risk of loss. The number of breeding pairs is minimal and nesting success is low. Further, it is almost certain that the Israeli population is isolated, given the limited data that exist on raptor populations in neighboring countries. The Israeli population is on the southern periphery of its range and inhabits areas of extreme ecological stress. It is unclear whether the observed decline in the local population is related to local anthropogenic factors, or if it is influenced by wider processes such as climate change and desertification.

However, the population's reproductive capacity can be improved, especially by nest guarding and the prevention of low flying aircraft and other disturbances around the breeding areas. Survival rates can also be increased, for example, by insulating electric pylons (now ongoing). Yet, the impact of any of these actions, if taken in Israel alone, would be limited, because most of the juvenile and sub-adult eagles spend long periods of time outside of Israel.

The disappearance of most of the eagles from the southern Negev and the Eilat Mountains is particularly puzzling. Until the late 1980s, both areas were strongholds of Golden Eagle

nesting in the country. These areas are far less disturbed than eastern Samaria and the Judean Desert. Although in recent years they have become popular destinations for tourists with off-road vehicles, neither area has undergone major changes like those in the Mediterranean region of Israel. Most of the region is used as a training area by the IDF, where nature conservation is emphasized.

Even today, we do not have sufficient information to support the assumption that lack of food is a current problem affecting the breeding success of Golden Eagles. According to earlier studies conducted in the 1980s (Bahat and Mendelsohn 1996), the main climatic factor that was highly correlated with breeding rate was the amount of rainfall during the preceding year (through its effect on reproduction of herbivore prey).

The current and future situation (as described by the PVA model) has not taken into account future threats, which include the accelerated and continuous development that is taking place in Israel and elsewhere in the Middle East, especially in the number of renewable energy projects such as wind farms and solar plants. These will definitely reduce the Eastern Mediterranean Golden Eagle populations, including the one in Israel.

RECOMMENDATIONS

Due to the critical situation of the Golden Eagle population in Israel, it is important to monitor all active nests and track non-breeding individuals. The monitoring and guarding of nests that are prone to nestling robbery have proved efficient and should be continued. Nest monitoring will also allow immediate intervention to possibly supplement food or to

implement medical treatment (e.g., to reduce mortality by trichomoniasis). Electrocutation, especially of juveniles, is one of the main causes of known mortality, and urgently requires insulation of dangerous pylons, especially in areas where non-breeding eagles wander or temporarily settle, such as the Jordan Valley.

ACKNOWLEDGEMENTS

We would like to thank all who participated in the surveys and monitoring programs through the years. Their commitment and dedication have enabled the preservation of this unique population of Golden Eagles, adapted to survive in some of the harshest conditions of its entire range. The research and monitoring of the Golden Eagle population is part of "Spreading Wings" Project, a joint initiative of the Israel Electric Corporation (IEC), the Israel Nature Reserves and Parks Authority (NPA) and the Society for the Protection of Nature in Israel (SPNI), to implement direct measures that are imperative for survival of endangered raptors.

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