

## Demographics of the Bonelli's eagle *Aquila fasciata* population in Cyprus

Nicolaos Kassinis

**Abstract.** Bonelli's eagle *Aquila fasciata* is the only eagle species that breeds in Cyprus. Its population is estimated at 31-39 breeding pairs (0.52-0.65 pairs / 100 km<sup>2</sup>). The SPA network covers 80% of all nest sites. The majority of nests (70%) were built on large Calabrian pine trees *Pinus brutia* with an average altitude of 625m. Nearest neighbor distance (NND) for 27 nesting sites was  $7.4 \pm 1.1$  km (4.1-11.5 km). The mean number of fledglings / successful pair was  $1.44 \pm 0.53$  (1999-2009). Radio telemetry (2002-9) showed that shooting and poisoning are the most significant problems of direct persecution.

Game Fund, Ministry of the Interior, Nicosia, Cyprus, nkassinis@cytanet.com.cy

### Introduction

The Bonelli's eagle *Aquila fasciata* is a fairly large-sized eagle typical of Mediterranean landscapes of southern Europe and western Asia. It is considered an important top avian predator in the food-chain of Mediterranean ecosystems (Cheylan 1977, Donazar *et al.* 2005). Since it's a diurnal raptor representative of Mediterranean ecosystems it can be also regarded as a flagship species for their conservation. This is reinforced by the species unfavourable conservation status (SPEC 3) (BirdLife International 2004) throughout its European range during the last decades. Its European population is estimated at 862-1072 pairs, 65% of which is in the Iberian Peninsula (Arroyo & Ferreiro 2000).

The Bonelli's eagle is the only eagle species that breeds in Cyprus since the extinction of the Imperial eagle *Aquila heliaca* as a breeding bird in the 1980s (Kourtellarides 1997). It inhabits mountainous terrain, nests mostly at forest edge but usually hunts in more open areas. Immature eagles during dispersal tend to hunt in lowland maquis and agricultural areas where prey is more abundant and more easily obtainable. Also, a few, mostly immature migratory birds appear annually in coastal areas during fall migration. During the late 1950s it was considered common with a population estimate of > 50 pairs (Flint and Steward 1992) however this estimate was based on anecdotal observations. In the 1980s to early 1990s the population declined to less than 20 pairs (BirdLife International / EBCC 2000).

Bonelli's eagle in Cyprus preys mainly on medium-sized birds and small mammals. Its main prey are Chukar Partridge *Alectoris chukar*, Common Woodpigeon *Columba palumbus*, Rock and feral pigeon *C. livia*, Eurasian Jay *Garrulus glandarius glaszneri*, Corvids (mainly Black-billed Magpie *Pica pica* and Hooded Crow *Corvus corone cornix*), water birds found near wetlands (Coot *Fulica atra* and Little Egret *Egretta garzetta*) and domestic fowl. Game farm chukars released in late summer for augmenting the wild stock for hunting purposes are utilized by eagles that regularly hunt the vicinity of release pens in the countryside.

(Kassinis & Miltiadou 2010). Small mammals, mainly the abundant Black Rat *Rattus rattus* but also the European Hare *Lepus europeus* come second. Reptiles follow in importance, especially large lizards such as the Starred Agama *Laudakia stellio* (occasionally also Schneider's Skink *Eumeces schneiderii*) and to a lesser degree Persian Large Whip Snake *Coluber jugularis*. In 2009, the remains of a Cyprus mouflon lamb *Ovis orientalis ophion* were found for the first time near an eagle's nesting site. The mouflon is the largest mammal on the island and is sympatric to the eagle's stronghold, Pafos forest.

## Study area

Cyprus is located at the northeast end of the Mediterranean basin and is the third largest island after Sicily and Sardinia. The island's maximum length and width are roughly 240 km and 100 km, respectively. Neighbouring countries are Turkey 75 km to the north, Syria and Lebanon to the east (105 km and 108 km, respectively), Israel 200 km to the southeast, Egypt 380 km to the south, and Greece 280 km to the west-northwest (the island of Kastellórizo). The island is dominated by two mountain ranges, Troodos Mountains and the smaller Kyrenia Range with the large, central plain of Mesaoria in between. Troodos Mountains cover most of the southern and western parts of the island with their highest peak of Mount Olympus at 1 952 m, located in the centre of the range. Kyrenia Range is narrow, smaller in area and extends along the northern coastline with lower elevations reaching a maximum of 1 024 m (Kyparissovouno peak).

Cyprus is characterized by a typical Mediterranean climate of the extreme type with dry, hot summers, wet, mild winters and short autumn and spring seasons. The island's proximity to the Middle East makes it one of the hottest parts of the Mediterranean. From May to September, temperatures are generally over 30°C, with cloudless skies and virtually no rain. Spring temperatures average between 23°C and 27°C. The winters see milder weather; with January average temperatures ranging from 10°C on the central plain to 3°C on the higher parts of Troodos mountains. The average annual precipitation for the year is 462 mm (1971-2000) but it varies from a minimum of 182 mm in 1972/73 and a maximum of 759 mm in 1968/69. Precipitation occurs usually between November and March (80% of the total), with the island averaging 40 days of rainfall every year. Snowfall is frequent in the Troodos range above 1000 m.

Cyprus coverage with high forests (mainly Calabrian pine *Pinus brutia*) reaches 17% of its surface, mainly on the 2 mountain ranges. The endemic Golden oak *Quercus alnifolia* exists in either pure stands or under the conifers in altitude over 700 m across the Troodos range. Dominant shrubs typical of Mediterranean landscapes occur; *Olea / Ceratonia* maquis with lower thorny phrygana are typical at lower ground whereas *Juniperus phoenicea* matorral is characteristic of the coastal areas (Tsintides *et al.* 2007).

## Methodology

This study presents a summary of the species monitoring during the last decade (1999-2009) in the area controlled by the Cyprus government (excluding the Turkish-occupied northern part of Cyprus). In the northern part of the island the species is present in the Kyrenia range, but the situation is obscure; with a possible population of 3 breeding pairs (Whaley & Dawes 2003). In most Mediterranean countries the Bonelli's eagle nests on cliffs.

In Cyprus however, nests are mainly found on large Calabrian Pine trees. Given this fact, all past information on breeding sites was used as much as possible. We collected also data by means of personal inquiries to local people, and by driving along main and secondary roads in potentially suitable habitat. Since the eagle resides in mountainous areas, all mountain ranges were rated as potentially suitable nesting habitat and surveyed. The initial field visits started in mid November when the eagles start displaying and carrying nesting material. Monitoring was carried out in all potential nest sites that were marked on a map (Gilbert et al. 1998). Potential nest sites were mainly steep forest slopes with large Pine trees and relatively scarce vegetation. Nesting trees are usually large in order to support the massive nesting structure. Large cliff formations in remote areas were also searched.

All eagle observations were mapped. The large state forests of Pafos, Troodos, Adelfoi, Macheras and Limassol were searched more intensively due to the availability of more potentially suitable habitat for the species and due to existing knowledge for the species' presence. The number of occupied territories and breeding pairs were recorded. Proof of occupancy of a territory (home range) was established by evidence of territoriality (either seeing 2 eagles together, or witnessing display) or by observing birds carrying nest material. Evidence of a breeding pair was established if copulation, courtship behaviour and finally incubation were witnessed (Hardey *et al.* 2006). When an active nest was spotted (presence of eggs, incubating female or young), regular follow-up checks were carried out (March-April for incubation, May-June for estimating number of fledglings leaving the nest) with a spotting scope from a safe distance in order to record the beginning of the nesting period (incubation, hatching, care of young and fledging). The number of nesting trees in the vicinity of each nest site was recorded. The location of nest sites was recorded with a Garmin GPS receiver (Model GPS map60Cx; Garmin International, Olathe, Kansas, U.S.A.).

Radio tracking information was collected during a parallel eagle tagging project (2002-2009) when eagles were trapped outside the breeding season in areas they were known to frequent in order to hunt. The traps were set with a live bird-bait and eagles of any age group caught were measured, blood sampled, radio-tagged and released. Tags used were backpack transmitters with a mortality /activity sensor provided by BIOTRACK (Wareham, BH20 5AX, UK). The harness used to adjust the tag on the eagle followed Kenward (1987). Radio signals were checked at least once a week usually from fixed, well distributed high observation points.

## Results

### Breeding population

Thirty-one pairs were located holding breeding territories. Eight more sightings need further investigation to prove territorial occupancy. Twenty six nest sites were located. The current Bonelli's eagle population in Cyprus is estimated at 31-39 breeding pairs. Its stronghold is the Pafos Forest, a large, state-owned area of 62 000 ha with a high eagle density estimated at 2-2.5 breeding pairs per 100 km<sup>2</sup> with a total nesting population of 12-15 breeding pairs, with most nesting sites located at the forest's edge. The average island-wide Bonelli's eagle density was estimated between 0.52 and 0.65 pairs / 100 km<sup>2</sup>. Nearest neighbour distance (NND) for 27 monitored nesting sites (Figure 1) was  $7.4 \pm 1.1$  km (range min 4.1-max 11.5 km) whereas in Pafos Forest the average distance between neighbouring pairs was smaller (6.2 km)

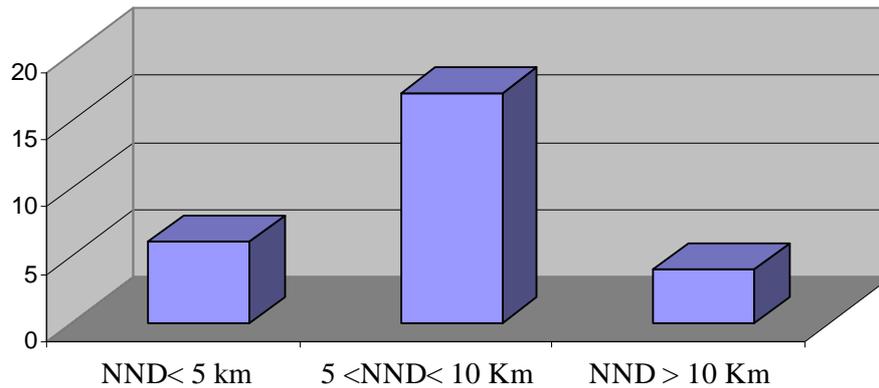


Figure 1. Nearest neighbour distance (NND) for Bonelli's eagle nest sites in Cyprus (N=27).

### Productivity

Most pairs start incubation at the end of January – beginning of February. Clutch size is usually 2 and rarely 3 eggs. Young start hatching the last week of February to mid-March and the first eaglets fledge from late April - beginning of May until the beginning of June. Productivity was measured as the number of young fledged per successful pair (Hardey *et al.* 2006). From 1999 to 2009, 89 chicks fledged from 62 successful nests that were closely monitored (average brood size at fledging was  $1.44 \pm 0.53$  fledglings / successful pair). From these, 36 nests (58 %) produced 1 young, 25 nests (40 %) produced 2 young, and 1 nest produced 3 fledged young (Figure 2).

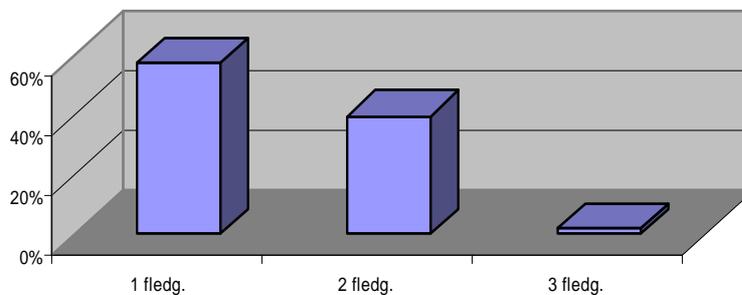


Figure 2. Brood size frequency from 62 successful nests, 1999-2009.

### Nest sites

Seventy percent (70%) of the pairs (17 pairs) monitored nested on large Calabrian pine trees (> 15m high), 6 pairs occupied cliff nests (about 24%) whereas 2 pairs had both a tree and a cliff nest. The average number of alternative nesting trees per nesting site was  $2.23 \pm 0.66$  (range 1-3) for 17 exclusive tree-nesters. Nesting cliffs were usually on remote and extensive cliff formations, or deep, high-walled ravines. The average nest site altitude

was  $625 \pm 257$  m a.s.l ( N = 22), even though it varied substantially from a minimum of 55 m up to a maximum of 1200m a.s.l. (Figure 3).

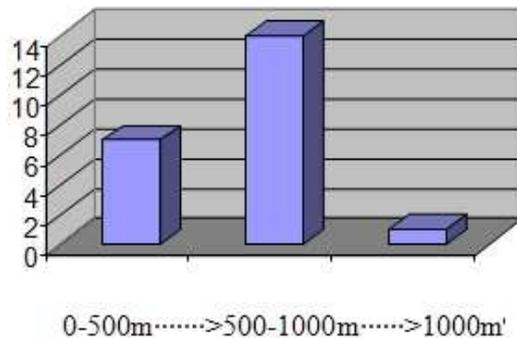


Figure 3. Nest site altitude (mean =  $625 \pm 257$  m a.s.l) for Bonelli's eagle in Cyprus (N=22).

#### Radio telemetry – causes of mortality

From 2002 to 2009 14 eagles including 4 adults, 7 immature and 3 juvenile birds were radio-tagged. Three of the 4 adults caught, tagged and released were part of breeding pairs and were caught 23 km (in January), 4 km (in September) and 1.5 km (in October) from their respective nesting sites.

One eagle caught and tagged as a juvenile in 2005, paired and bred successfully in 2008 and fledged 1 eaglet. This eagle was caught and tagged 38 km away from its recent nesting site of 2008. Another eagle caught and tagged as immature in 2008, paired and bred successfully in 2010 and fledged 1 eaglet. This eagle was caught 46 km away from its current nesting site. During this 8-year of radio-tracking, 4 tagged eagles (28%) died due to direct human persecution: 2 immature birds were shot, 1 juvenile bird was poisoned whereas only the tag was found from the 4<sup>th</sup> bird (adult). The cause of death was probably human-related.

#### Discussion

The Bonelli's eagle population in Cyprus is considered stable and in good status. The average brood size at fledgling estimated in this study was similar to studies in Israel in the mid 1970s (Newton 1979). Its population density is higher compared to densities recorded in Spain and south France (Real & Manosa 1997). The species is well distributed across the island, possibly due to the abundance and even distribution of its major prey species such as the Chukar partridge, *Columbidae*, rats and common reptiles (mainly the Starred Agama lizards and Persian Large Whip Snakes). The availability and utilization of such a wide range of locally abundant prey is a major factor contributing to the survival of a raptor such as the Bonelli's eagle (Carrete *et al.* 2002).

The spatial nest site distribution is probably affected by both the local topography and by the availability of suitable nesting trees away from disturbance. The mean number of alternative nesting trees / nest site is relatively small compared to Ontiveros (1999) wide range of 1-18 nests / nest site. The species weaker preference for cliff nest sites may be attributed to their closer proximity to human habitation and to the extensive road system near cliffs (compared to the more distant forest slopes), but also to the expansion during the last decade of a smaller raptor, the Long-legged Buzzard *Buteo rufinus*, a cliff-nester. In the vicinity of two eagle eyries (< 1.5 km), active Long-legged Buzzard nest sites have been located (Kassinis, 2007).

Radio telemetry data showed that shooting and poisoning are still the most significant problems of direct persecution even though such incidents have declined since the 1980s. Poisoning is a local problem in areas with extensive livestock husbandry where shepherds poison carcasses to decrease lamb/kid depredations by foxes. Moreover, the current development of wind farms in wilderness areas pose a new threat to the species along with other resident raptors such as the endangered Eurasian griffon vulture *Gyps fulvus* but also migratory raptors that pass through the island in large numbers such as *Pernis apivorus*, *Buteo* spp. In addition, unlimited access even in the most remote areas through an extensive network of secondary dirt road, forest tracks and firebreak lanes, causes disturbance to breeding pairs. Housing development in the countryside also increases encroachment, habitat degradation and disturbance.

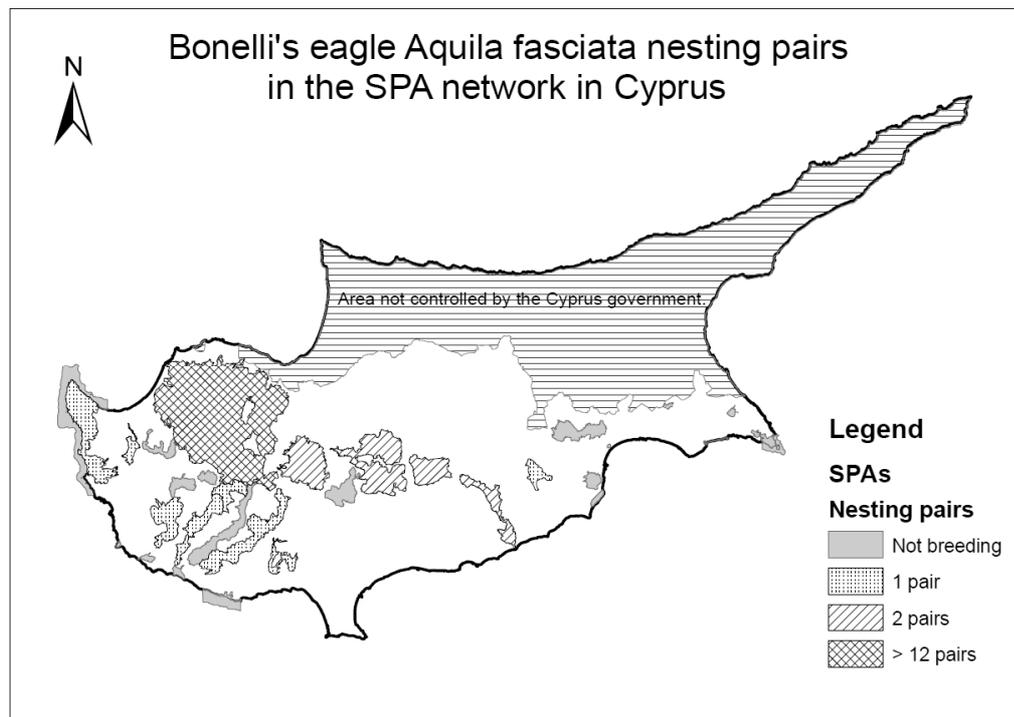


Figure 4. Nesting pairs of Bonelli's eagle in SPAs in Cyprus

The Bonelli's eagle is an Annex I species of the EU Bird's Directive and thus enjoys a strict protection status. This is achieved through the protection of its nest sites in the NATURA 2000 network and the designation of its major breeding areas as Wildlife Conservation Areas where hunting is prohibited according to Cypriot legislation. In Cyprus the total coverage of the 29 Special Protection Areas (SPAs) is 148 313 ha or 16% of the island's surface (24% of the area controlled by the Cyprus government). The SPA network covers 80% of all nest sites for Bonelli's eagle including all the high-density eagle areas (Figure 4).

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