Evaluating potential threats to birds in Greece: an analysis of a 10-year data set from a rehabilitation centre

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Abstract In an attempt to identify the critical threats to avian biodiversity in Greece we present and analyse a data set of the birds received at a rehabilitation centre. During a 10-year period (1996−2005) a total of 21,190 birds were admitted to the Hellenic Wildlife Hospital from throughout Greece. Our results indicate that shooting is by far the most important threat to birds in Greece, followed by accidents. Although greater numbers of shot birds were received during the autumn and winter months, when hunting is allowed, birds were received year-round. Birds were received from all areas of Greece, with the highest number received during the summer months. The high number of shot birds received during the months in which hunting is prohibited demonstrates the lack of law enforcement. We argue the need for direct political decisions concerning the enforcement of existing regulations on hunting. Decision makers and managers could use the findings of our study to re-evaluate and design conservation policy in Greece, including reduction of the hunting period and restriction on hunting activities.

Keywords Bird conservation, Greece, hunting, mortality, potential threats, rehabilitation centre, shooting.

Introduction

Declines in biological diversity have accelerated the need for efficient conservation plans (Pullin, 2002), and the determination of the main threats to wildlife is fundamental for the formulation of such plans (Soulé & Orians, 2001). Quantitative assessment of threats is important for two main reasons: it improves our ability to protect wildlife and ecosystems according to their conservation status and requirements (Letcher et al., 1998; Wemmer et al., 2001; Sullivan et al., 2006; Leston et al., 2006), and helps sustain and justify calls for support and action to govern-

mental and international bodies (Johnson et al., 2005; Mishra et al., 2006).

The migratory nature of birds, with many species covering great distances in seasonal and reproduction migrations, and also during daily foraging, make it difficult to collect a comprehensive data set on threats. However, wildlife rehabilitation centres can provide information (International Wildlife Rehabilitation Council, 2007) that could also be used to improve our knowledge of factors affecting the viability and persistence of both species and populations (Rijksen, 1974; Barten, 1986; Underhill et al., 1999; Parsons et al., 2006). Data collected at rehabilitation centres include treatment, success of rehabilitation and post-release survival of wildlife (Clumper et al., 2000), especially with respect to treatment and rehabilitation success of wild animals affected by oil spills (Mignucci-Giannoni, 1999; Tseng, 1999; Parsons & Underhill, 2005) and the rehabilitation of animals released after fire (Lunney et al., 2004).

Data on the main causes of morbidity and mortality of wildlife species is recorded by rehabilitation centres (Burton & Dufour, 2000; Casey & Casey, 2000). Studies that focus on particular groups (Miller, 1997; Deem et al., 1998; Morishita et al., 1998; Brown & Sleeman, 2002), species of particular interest (Schulz, 1986; Porter & McEntyre, 1988), and specific types of injuries or diseases (Jones, 1999) can help evaluate potential threats and population trends at local or regional scales (Casey & Casey, 2000).

Here we use data collected over a 10-year period at the Hellenic Wildlife Hospital, Greece, to provide insights into the main threats to wild birds in the country. To our knowledge this is the first such study in the eastern Mediterranean. Greece, as a member of the European Union, has rights and obligations under international and European law, and our findings could help identify possible gaps in law enforcement or conservation efforts.

We have four main objectives: (1) To examine the numbers of birds admitted to the Hospital during a 10-year period, documenting the main reasons for entry and whether these causes of morbidity and mortality vary over time. (2) To examine seasonal patterns in numbers of birds admitted and reasons for admittance. (3) To examine and describe possible links between specific threats, species and areas by comparing records of birds received from the zoogeographical regions of Greece. (4) To study whether

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particular groups of species are more sensitive to specific threats.

Methods

Data collection

Data used in this study were collected during a 10-year period (1996–2005) from the Hellenic Wildlife Hospital, established in 1984 in Aigina, Greece. The centre receives birds, mammals, amphibians and reptiles from throughout Greece. All animals admitted receive a physical examination and individual records include the date and reason of admission, taxon, area of origin, and suggested treatment. In our analysis we classified the reasons for admission of birds as: (1) shooting, (2) poisoning/illness, (3) accident, (4) weakness, (5) orphan/newborn, (6) captivity. Accidents include electrocution, oiling and vehicle-caused injuries, weakness includes exhausted birds, and captivity includes illegally captured birds or abandoned pets.

Data analysis

To evaluate any differences among the birds received from different areas, we determined their distribution based on the 11 zoogeographical regions of Greece (Dafis et al., 1997; Fig. 1). Bird records were subdivided into raptors, aquatic and migratory. Species of conservation interest were determined based on the Birds Directive of the European Union 79/409/EEC; this Directive lists species that need protection and occur in the wild in European territory. Date of admission data were classified into four 3-month periods (autumn, September–November; winter, December–February; spring, March–May; summer, June–August) to facilitate seasonal analysis. To interpret our findings with respect to hunting and non-hunting periods we assumed that autumn and winter are the hunting period and spring and summer the closed season. However, the opening and closing dates for hunting in Greece vary depending on species (starting dates 15 August–20 September; closing dates 30 October–28 February), and variations in these dates occur for the same species between years.

We used Kruskal-Wallis tests to examine differences in the number of birds admitted per season, from different zoogeographical regions, and per season according to the reasons for admittance, and the Nemenyi test for non-parametric multiple comparisons (Zar, 1999). We used a χ^2 test for the hypothesis that the number of birds received per season is uniform among the 10 years of the study.

We used non-metric multidimensional scaling analysis (NMS) to examine the association among the 11 zoogeographical regions regarding the taxonomic composition of species received at the hospital. NMS is an ordination technique that attempts to explain the observed similarities or dissimilarities between the studied objects. All pairwise similarities or dissimilarities (distances) between the objects are expressed in correlation matrices that are then analysed

Fig. 1 Zoogeographical regions of Greece (based on Dafis et al., 1997, as modified by Kuehnelt, 1965, and Willemse, 1984).
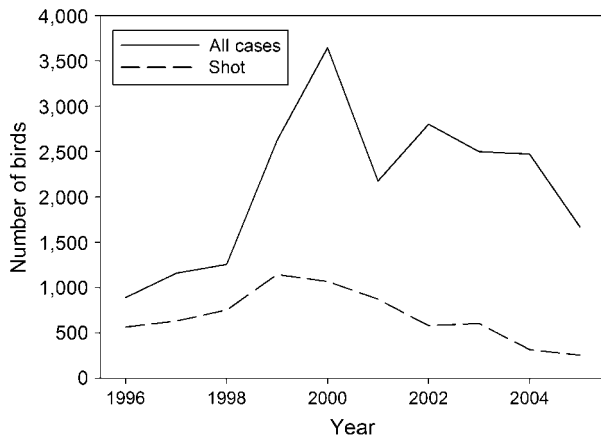
FIG. 2 Numbers of all birds and shot birds admitted each year over 1996–2005 to the Hellenic Wildlife Hospital.
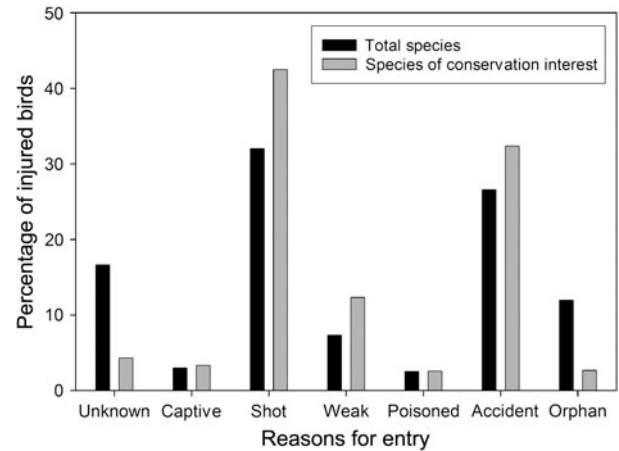

FIG. 3 Percentage of all birds and of birds of conservation interest in Europe received by the Hellenic Wildlife Hospital over 1996–2005, categorized according to the reason for entry.

to identify the orthogonal axes that are able to explain most of the variation. The depiction of those axes in ordination diagrams allows the visual detection and exploration of similarities or dissimilarities within the data. A goodness of fit test, the stress value, was used to assess whether the ordination plot reproduces the observed distance matrix successfully; lower values of stress demonstrate a better representation, with values < 0.1 suggesting an acceptable configuration of the data. We performed a further NMS to investigate the relationships between the 11 zoogeographical regions based on the causes of mortality or morbidity. Prior to NMS analysis data were square root transformed. Bray-Curtis similarity was used as a similarity measure. The minimum stress results were obtained after 100 iterations. NMS ordinations were performed using the *PRIMER* package (Clarke & Gorley, 2001). Other statistical analyses were performed using *SPSS v. 13* (SPSS, Chicago, USA).

Results

During the 10 years a total number of 21,190 individuals belonging to 469 bird species were admitted to the Hellenic Wildlife Hospital, with a marked increase from 1998 to 2000, and a general reduction thereafter (Fig. 2). Almost 15% (73 out of 469) of the species admitted to the Hospital are listed in the Birds Directive of the EU.

It was not possible to determine clearly the reasons for entry of 16% of the individuals received (Fig. 3). The greatest number of admissions (32%) were due to shooting, with accidents and orphans/newborns the second and third most common reasons for admission (26 and 12% respectively; Fig. 3). The reasons for admission differed between raptors, migratory and aquatic species (Fig. 4). Gunshot wounds were the most frequent cause of injury for raptors
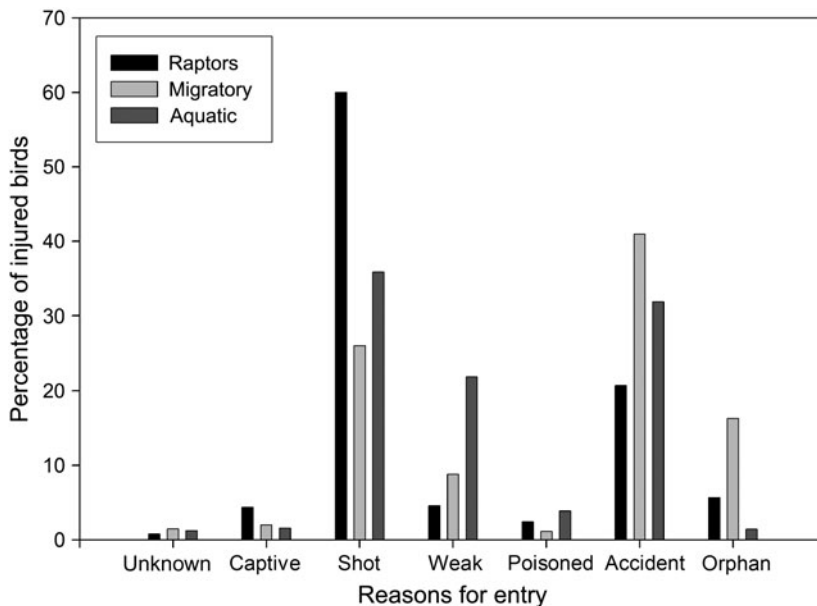

FIG. 4 Percentage of raptors and migratory and aquatic birds received by the Hellenic Wildlife Hospital over 1996–2005, categorized according to the reason for entry.
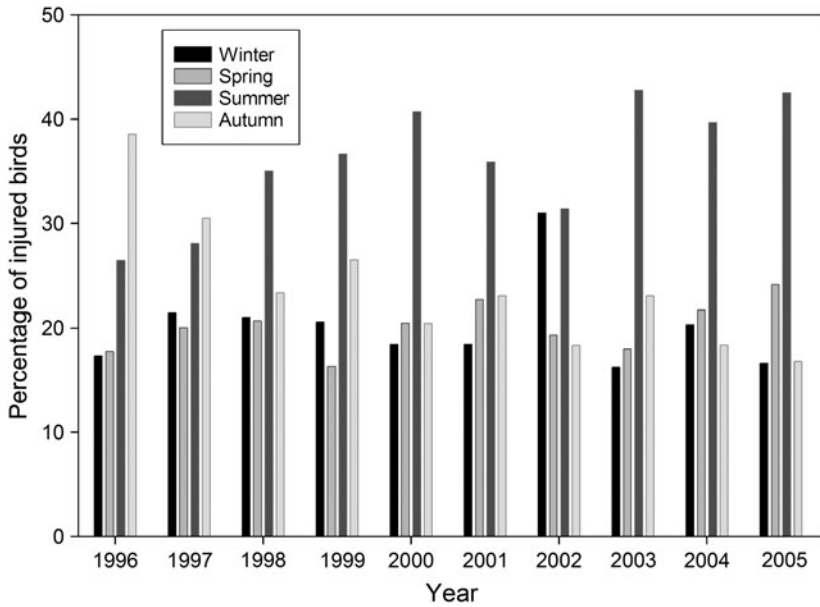
(60%) and aquatic (36%) species, followed by accidents (raptors, 20%; aquatic, 32%). Accidents were the most frequent reason for injury of migratory (41%) species followed by gunshots (26%). Weak individuals and orphans were more frequently recorded among migratory and aquatic species, respectively, and less frequently for raptors. Shooting was the main cause of morbidity or mortality for species of high conservation importance, followed by accidents.

There were significant differences in the mean number of birds received per season (Kruskal-Wallis $H=8496.437$, $P < 0.001$), and the number of birds per season differed between years ($\chi^2 = 63.570$, $P < 0.001$). The greatest number of injured birds were received during the summer

(Fig. 5). Except for the first 2 years, when autumn was the season with the highest contribution to the annual number of birds received, no clear seasonal pattern was apparent.

Multiple comparisons indicated significant differences in the number of shot birds received during winter and spring ($q = 4.085$, $q_{crit,0.05} = 3.858$), winter and summer ($q = 5.653$, $q_{crit,0.05} = 3.858$) and autumn and summer ($q = 3.922$, $q_{crit,0.05} = 3.858$). There were also significant differences in the number of cases recorded as accidents and in injured birds with undetermined cause of injury during summer and winter (accidents: $q = 4.761$, $q_{crit,0.05} = 3.858$; unknown: $q = 6.438$, $q_{crit,0.05} = 3.858$).

Ordination analysis demonstrated a clear association among zoogeographical regions regarding the taxonomic
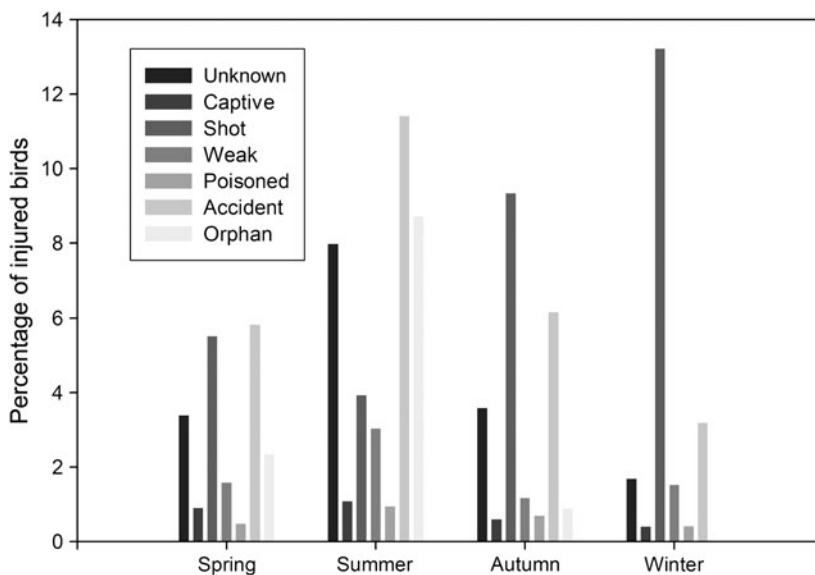

FIG. 6 Percentage of birds received by the Hellenic Wildlife Hospital per season (see text for details) over 1996–2005, categorized by reason for entry.
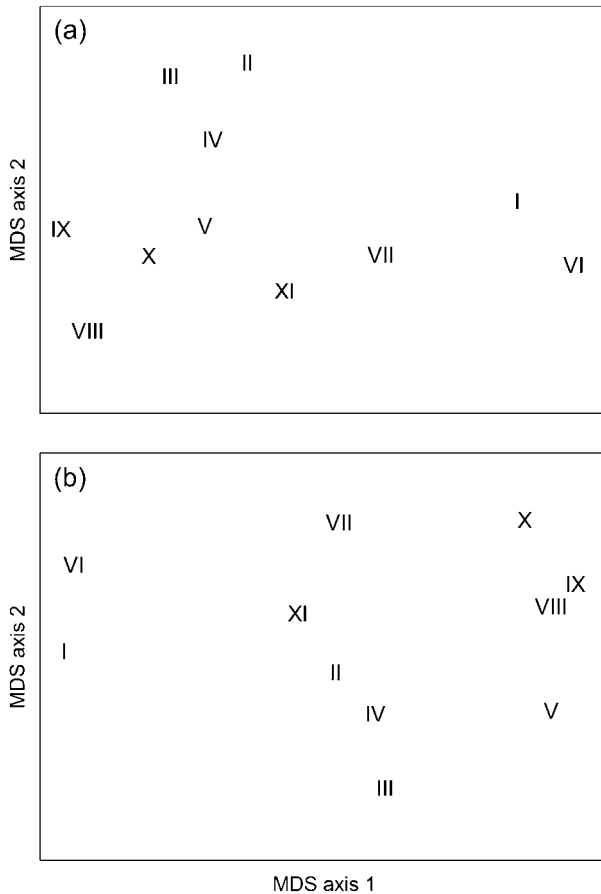
FIG. 7 Non-metric multidimensional scaling ordination plot (see text for further details) of zoogeographical regions (Fig. 1) based on (a) species composition of admissions, and (b) causes of mortality and morbidity of admissions. Bray-Curtis similarity was used for both ordinations. I, North-eastern Greece; II, North-western Greece; III, Heperus; IV, Thessaly; V, Ionian Islands; VI, Central Greece; VII, Peloponnesus; VIII, Cyclades; IX, Northern Aegean; X, Dodecanese; XI, Crete.

composition of species received at the centre (NMS stress 0.01). A strong grouping occurs between North-eastern and Central Greece, which are clearly separated from other regions of the country (Fig. 7a).

The number of birds received differed significantly among the 11 zoogeographical regions (Kruskal-Wallis test, $H = 73.288$, $P < 0.001$), with $> 60\%$ received from North-eastern and Central Greece. Ordination based on the causes of mortality or morbidity revealed a clear grouping among regions (NMS stress 0.04). There were three clusters (Fig. 7b). North-eastern and Central Greece were grouped together and clearly separated from the Ionian Islands, Cyclades, Dodecanese and Crete, which comprise marine areas of the country (Fig. 1). There was greater variation among the remaining regions, although they were grouped together. With the exception of North-eastern and Central Greece, in which most of the cases were due to accidents (35 and 39%, respectively), shooting was the dominant reason for

injury, contributing to *c.* 50% of the injuries in other regions (41–72%).

Discussion

Data collected at rehabilitation centres could provide an additional tool to recognize wildlife threats because it allows the evaluation of the impact of several factors that are difficult to study directly. Our analysis has demonstrated that shooting was the main cause of injury to birds admitted to the Hellenic Wildlife Hospital during 1996–2005. Most shooting incidents occur during autumn and winter, which coincides with the hunting period in Greece (end of August to end of February), although shot birds were admitted throughout the year. However, the lack of significant differences in the number of shot birds between autumn and spring and spring and summer indicates that even though shooting is limited during the non-hunting period it is nevertheless an ongoing activity. This finding highlights the inefficiency of law enforcement against illegal shooting. In addition, the high number of shot birds admitted to the Hospital from throughout Greece during the non-hunting periods demonstrates that these breaches of the law are a national, rather than regional, phenomenon. The fact that several of the shot species are large bodied and have a characteristic flight (e.g. *Ciconia nigra*, *Pelecanus onocrotalus*), and are therefore easily identifiable, demonstrates the severity of illegal hunting.

Hunting regulations in Greece comply with European Union directives, international conventions and treaties for the protection of wildlife. These include the Bern Convention on Nature Protection, the Bonn Convention on the Conservation of Migratory Species of Wild Animals, the RAMSAR International Convention, the Habitat Directive of the European Council 92/43/EEC, the Birds Directive of the European Council 79/409/EEC, and CITES. Hunting is prohibited for all species included in the IUCN Red List (IUCN, 2007) and in the Birds Directive of the European Council. However, the inefficiency of law enforcement and the lack of compliance of hunting regulations with international conventions have been criticized (Hellenic Ornithological Society, 2006). The results of this study support such criticisms. In contrast to most European countries, where the location and spatial extent of hunting sites is explicitly determined, no private areas for hunting exist in Greece. Hunting is allowed at all public sites except for areas of particular interest (defined by the law on Measures for the Management of Wild Avifauna ref. no. 414985/29-11-85-O.G.R. 757/B'/18-12-85).

Fewer birds were admitted because of poisoning than for any other mortality factor. It is probable that poisoned birds die immediately and therefore only a limited number of poison victims are admitted to wildlife centres, leading to an underestimation of the significance of poisoning as

a mortality factor (see also Mineau *et al.*, 1999). Similar studies have also highlighted the relatively high contribution of orphaned young to the number of animals admitted to rehabilitation centres (Fix & Barrows, 1990; Wendell *et al.*, 2002).

Most of the birds admitted to the Hospital originated from North-eastern and Central Greece. This could be because of the higher density of people in this urbanized region, a higher degree of ecological awareness, or better facilities for shipping birds to the Hospital. The reduced admissions from other regions is most likely because of limited transportation options in rural areas and the expenses of shipping. Nevertheless, causes of morbidity and mortality varied between regions. Accidents were the most frequent cause of admission for animals received from North-eastern and Central Greece probably reflecting the increased human pressure in this area, which has a dense human population and busy transportation network.

The high number of shot raptors admitted during non-hunting periods provides clear evidence for the persecution of this group of species. Both gunshots and accidents were the main causes of injury to migratory and aquatic species, further demonstrating the significance of shooting as a major threat. The relatively high number of migratory and aquatic species admitted due to accidents may reflect increased public concern regarding specific species that could also be used as flagship species (*sensu* Bowen-Jones & Entwistle, 2002). Public awareness programmes and research projects in Greece often focus on such species.

The types of injuries of animals submitted to rehabilitation centres are likely to be associated with human activities (Spalding & Forrester, 1993) reflecting local conditions or threats (Casey & Casey, 2000). This could produce biased evaluations of the causes of mortality or morbidity. We attempted to reduce this sampling bias by analysing data from all regions of the country (Brown & Sleeman, 2002) but we acknowledge this limitation and suggest that complementary data from field surveys are also required. We consider the information collected at the Hellenic Wildlife Hospital to be a comprehensive data set for analysing threats for bird species in Greece. However, we caution that fluctuations in the number of individuals could reflect public awareness and concern (Brown & Sleeman, 2002).

Habitat loss, fragmentation and degradation are critical factors affecting population viability but hunting has also led to extinction of several species in the past and is still one of the main threats to wildlife (BirdLife International, 2004). In addition to being a major source of mortality, hunting is also an important source of disturbance, affecting migratory behaviour and distribution of species (Fox & Madsen, 1997; Béchet *et al.*, 2003). However, large scale assessments of its impact on population sizes and composition are difficult to conduct because of practical difficulties. To estimate hunting pressure, data are collected by combining environmental and social surveys (Kaul *et al.*, 2004; Johnson *et al.*, 2005; Lehman *et al.*, 2006). The collected information is often analysed with the use of a geographical information system and time series of satellite or aerial images (Ostwald, 2002; Campbell, 2005), although the applicability of such combined methods is limited to local studies.

There is an urgent need for conservation actions to conserve the bird populations of Greece. Actions need to focus on strengthening the enforcement of existing regulations. We are preparing a detailed report for submission to the Greek governmental agencies responsible for hunting regulations. The results presented will provide evidence highlighting the need for strict enforcement of the existing legislation for protecting birds and closer compliance with EU regulations.

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