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ARTICLE

An assessment of threats to Anatidae in Iran

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Abstract

The network of wetland systems in Iran provides valuable staging and wintering areas for waterbirds in the African-Western Eurasian flyway. The West Siberian/Caspian/Nile population of Anatidae (ducks, geese and swans) regularly overwinters and stops-over in Iran, and is considered an economically and culturally important group of birds in the country. Conservation of such migratory birds requires the identification of the key threat factors impacting them throughout the flyway. Since documented data on the status and threats facing Anatidae in Iran is very scarce, in this paper, we attempted to determine the general population trend for the 26 Anatidae species in Iran using annual waterbird census data and to identify and score the most important threat factors affecting each species by consulting the top ornithologists and professional birdwatchers in the country by means of a survey. Our results indicate that the most prevalent threats affecting all 26 species are dam construction, water management practices, and hunting. Our results provide the necessary material for Red List assessment of these species at the national level, an important tool for conservation priority setting within Iran and in the flyway.

Keywords: Anatidae, threat identification, African-western Eurasian flyway, habitat loss, hunting.

Introduction

Waterbirds have long been the subject of many international conservation agreements. The Ramsar Convention on Wetlands (Ramsar, Iran, 1971) and the African Eurasian Migratory Waterbird Agreement (1999), among others, urge countries to work together to save the migratory waterbirds through the flyway concept. Flyways are defined as “the biological systems of migration paths that directly link sites and ecosystems in different countries and continents” (Boere and Stroud 2006). Implementing conservation actions for migratory waterbirds according to the flyway concept can simplify the complexities of migration and contributes to consistent international cooperation between governments and conservation organizations around the world.

Anatidae (ducks, geese, and swans) is an economically and culturally important family of waterbirds in the African-Western Eurasian flyway. The status of these birds in the flyway is unfavorable, with an overall 43% decrease in the 121 Anatidae populations supported by the flyway (Davidson and Stroud 2006). Swans and migratory geese, with 25% and 23% of populations declining respectively, have a better status in this region than do migratory ducks, with 44% of their populations thought to be in decline. Ducks that depend on West Asia/Middle East and Africa during their non-breeding season are thought to be particularly threatened (Davidson and Stroud 2006).

Iran, with its numerous wetland systems, serves as an important staging and wintering area in the African-Western Eurasian flyway. It is the country with the most numerous Important Bird Areas (IBAs) in the Middle East (Birdlife International 2013) and has the highest richness of migratory species in the Middle East region (Kirby *et al.* 2008). It supports the Western Siberian/Caspian/Nile population of Anatidae (Fig. 1). Overall, 35 species of Anatidae have been recorded in Iran of which 26 regularly occur in the country (Kaboli *et al.* 2012). The globally Endangered (EN) White-headed Duck *Oxyura leucocephala* regularly breeds and winters in Iran. Other globally threatened species regularly occurring in Iran include Marbled Teal *Marmaronetta angustirostris* (VU), a breeding and wintering visitor (Scott and Rose 1996; Kaboli *et al.* 2012) and Lesser White-fronted Goose *Anser erythropus* (VU), another common winter visitor (Mansoori and Amini 2011; Kaboli *et al.* 2012). Anatidae species that are recorded as vagrants in Iran include Bean Goose *Anser fabalis*, Red-breasted Goose *Branta ruficollis*, Barnacle Goose *B. leucopsis*, Light-bellied Brent Goose *B. hrota*, Marbled Teal *Nettapus coromandelianus*, Long-tailed Duck *Clangula hyemalis*, Common Scoter *Melanitta nigra*, and Velvet Scoter *M. fusca* (Roselaar and Aliabadian 2009; Khaleghizadeh *et al.* 2011). Old records of Falcated Duck *Anas falcata*, in Iran prior to 1960s were recently reassessed by Roselaar and Aliabadian (2009) and were considered insufficient to confirm the current occurrence of this species in Iran.

Figure 1

The largest concentrations of migratory Anatidae in Iran occur in the wetlands of the north, across the southern Caspian lowlands (Mansoori 2009), but many of the species are also observed in suitable water bodies throughout the country. Since Anatidae are dependent on wetland habitats which are rather discrete and far apart (Scott and Rose 1996), the extent of occurrence of many of these species in Iran is relatively large and the critical resources they use are scattered throughout this area in a fragmented nature, making them potentially vulnerable to a variety of threats.

Throughout the past several decades, various threats affecting wetlands, the most important habitats for Anatidae, have been identified in Iran. The most important threats to most wetlands have been identified as drainage and reclamation (Evans 1994; Scott 1995; Behrouzi-Rad 2008). However, identifying broad-scale threatening processes at a habitat scale is often not considered sufficient to implement conservation action. While a threat may be present over a broad area, species-specific responses to that threat can be highly variable, mediated by biology, environment and exposure. Thus understanding species level threats and quantifying the processes that lead to a given level of extinction risk is of great value. To our knowledge, no attempt has been made to undertake such a process for waterbird species in Iran. The current system for threat classification in Iran consists of three categories: protected, endangered, and unprotected species. The latest version of that list that was compiled in 1999 by the Department

of Environment (DOE) and serves as the only source for determining extinction risk and conservation status of waterbirds in Iran. Although this list has legal status, the criteria that have led to its establishment are not clearly defined by the DOE and the three categories are mostly based on international classifications, which in many cases do not represent the national status of species. Considering the shortcomings of this list, the only remaining source of quantitative data for determining the status of waterbirds in Iran is the annual winter waterbird censuses carried out in all major wetlands since 1967 (REF NEEDED).

This lack of information on current condition and threats to Anatidae species has hampered assessment of national level extinction risk and consequently, setting of conservation priorities. Moreover, information gathered on threats at the national scale can bolster global scale assessments of extinction risk (Zamin *et al.* 2010). Identification of threats affecting a group of migratory species within a country facilitates conservation planning both at the flyway and national scales. A clear understanding of key issues affecting migratory populations in any part of a flyway is a necessity for successful conservation (Stroud *et al.* 2006). Moreover, conservation efforts in one part of a species range are less effective if threats impacting populations and habitats elsewhere are not considered and tackled (Kirby *et al.* 2008).

With an aim to provide sufficient information for threat assessment of Anatidae species at the national and flyway scale, in the present paper we provide a picture of condition of these species by (i) determining their population trends using three decades of annual waterbird census results and (ii) identifying major threat factors affecting each species in Iran.

Methods

Identification of population trends

To provide a general picture of the condition of Anatidae in Iran over the past three decades, we collected DOE waterbird census data from 1982-2012 for the 26 species of Anatidae regularly occurring in the country and analyzed population trends using the software TRIM (Trends and Indices for Monitoring data) (Pannkoek and van Strien 2005). [It would be good to have a brief sentence here about the method used to collect the census data, and perhaps a DOE reference for it, if one exists?]. TRIM uses a log-linear Poisson regression to model population trends from site-based count data and imputes the missing values using data from other sites in the same year. We excluded years that contained zero observations at the beginning and/or end of the analyzed period and calculated trends using the linear trend model setting of TRIM using as many change points as possible (Pannkoek and van Strien 2005) and obtained a value for the average slope of population trend model for the years analyzed. This slope was then converted into one of the six trend categories by TRIM: Strong increase (increase significantly more than 5% per year), Moderate increase (significant increase, but not significantly more than 5% per year), Stable (no significant increase or decline; certain to be less than 5% per year), Uncertain (no significant increase or decline; not certain to be less than 5% per year), Moderate decline (significant decline, but not significantly more than 5% per year), and Steep decline (decline significantly more than 5% per year) (Pannkoek and van Strien 2005).

Identification of threats

Identification of threats for the purpose of supporting extinction risk assessment is usually achieved through reviewing documented and published literature (Kirby *et al.* 2008; Jennings and Rohr 2011; Croxall *et al.* 2012). For species or geographical regions with scant data,

questionnaires are used to complement the process (Ocock *et al.* 2006; Goriup and Tucker 2007). Assigning the precise threat determining a decline in population size is a complex and poorly understood process (Di Fonzo *et al.* 2013). Gathering the views of experts in a structured manner, on what are the probable causes of high extinction risk or decline, is frequently the next best approach, and is employed for the IUCN Red List. As with many countries, published data on threats to Anatidae species in Iran are very scarce. To fill this gap and obtain reliable information about threats affecting each species, we consulted ornithologists of Iran's Department of Environment, including staff at DOE Wildlife Bureau, local site managers, and rangers, and professional birdwatchers through a set of questionnaires (Appendix 1). Based on academic and professional background, 16 people were identified as knowledgeable and reliable potential contributors. The questionnaires were designed to identify the threats currently facing the 26 species of Anatidae included in this study. To clarify the aims and context of the questionnaire, to determine which threats make Anatidae species susceptible to being categorized as threatened at the national level, we asked the respondents to identify threats that they consider to be causing a decline, for species identified as declining through trend analysis, or likely to cause a decline, for species with uncertain, stable, and increasing trends. Threats were defined as detailed in the threat classification scheme devised by Salafsky *et al.* (2008), which underpins the global, and many national, Red Listing processes (IUCN and CMP 2006; Zamin *et al.* 2010). The scheme comprises 11 first level threats, consisting of (1) Residential and commercial development, (2) Agriculture and aquaculture, (3) Energy production and mining, (4) Transportation and service corridors, (5) Biological resource use, (6) Human intrusion and disturbance, (7) Natural systems modifications, (8) Invasive and other problematic species, (9) Pollution, (10) Geological events, and (11) Climate change and severe weather. Each first level threat is broken down into 2nd and 3rd level categories (we only went down to 2nd level categories for the purpose of this study). Questionnaire respondents were asked to identify the most important 1st and 2nd level threats for each of the 26 species.

Respondents were also asked to provide the timing, scope, and severity of each second level threat using a scoring system developed by Birdlife International (Birdlife International 2010). The impact of each 2nd level threat was scored from 0 to 3 for timing (past, ongoing, future, etc.), scope (the proportion of the population affected), and severity (how rapidly it is causing, or is likely to cause, a decline in the population) (Appendix 2).

After collecting the questionnaires, the internal consistency of responses was evaluated by computing Cronbach's alpha (Cronbach 1951) for questionnaires filled out for each species. Alpha coefficients range from 0 to 1, with higher scores indicating more reliability. We used SPSS v. 17.0 (SPSS Inc., Chicago, IL, USA) to calculate the alpha and considered 0.7 as the threshold for acceptable reliability (Nunnally 1978). After ensuring the reliability of questionnaires, we calculated the average of the impact scores that our respondents assigned for timing, scope, and severity for each of the 2nd level threats and calculated the overall impact of a threat to each species by adding the average scores for timing, scope, and severity (High impact: score 8, 9; Medium impact: score 6, 7; Low impact: score 3, 4, 5; No-negligible impact: score 0, 1, 2). This technique assumes that timing, scope and severity are of equal importance in determining the threat impact of each species (Birdlife International 2010).

Results

Trend categories

We were able to estimate population trends for 25 of the 26 species. Red-crested Pochard *Netta rufina* was excluded from trend analysis because data on its annual census was not available at the archives of DOE. For eight species, the resulting trend was categorized as Uncertain. Three species showed stable populations. Moderate and steep decline categories comprised eight and three species, respectively, and three species were categorized as moderately increasing (Table 1).

Threats

We received 10 completed surveys (62.5% return rate) identifying threats to the 26 Anatidae species. Each respondent completed threat evaluations for all 26 species. Computing Cronbach's alpha showed that internal consistency of all questionnaires was acceptable, ranging from 0.81-0.93 (Table 1). Averaging the impact scores for respondents for each species showed that no threat category was considered to have high impact on Anatidae species in Iran. However, many of the 2nd level threats were scored as having medium impact (Table 1). Nine of the 11 possible 1st level threat categories were identified as affecting the group of Anatidae species we evaluated (Fig. 2). "Geological events" and "Climate change and severe weather" were not identified as a threat to any of the 26 species in Iran. The most common 1st level threat was "Natural systems modifications" affecting all of the species (100%) with medium impact, followed by "Biological resource use" (25 species, 96%), "Invasive and other problematic species and diseases" (22 species, 85%), "Agriculture and aquaculture" (20 species, 77%), "Pollution" (19 species, 73%), and "Residential and commercial development," (17 species, 65%) were also identified as important medium-impact threats.

For 2nd level threats, "Dams and water management/use," was the most common, affecting all of the species in this review, while "Housing and urban areas," "Wood and pulp plantations," "mining and quarrying," "Recreational activities," and "War, civil unrest and military exercises," were identified as having medium impact on only one species each (0.4%) (Fig. 3).

Globally threatened species (those classified as VU, EN or CR by IUCN) had consistently higher numbers of threats identified as affecting the species in Iran (all had 7 level-1 threats identified). Species classified at a global level as Least Concern or Near Threatened had fewer threats on average (mean = 5.59, SE = 0.29), but were notably considered to be impacted by a variety of threats.

Table 1

Figure 2

Figure 3

Discussion

The most common threats to Anatidae in Iran were natural systems modification and hunting, the former mostly due to dam construction and unsound water management. Wetland destruction and hunting were identified as serious threats to wetlands and waterbirds during the 1970s (Derek Scott, personal communication, 2012) and 1990s as well (Evans 1994; Scott 1995), indicating that although these threats have been identified for several decades, they still remain significant and the population of most Anatidae species are facing declines or strong fluctuations in the face of these threats. Problematic species and diseases, agricultural activities, pollution, and residential and commercial development were other threats facing these species. Generally, a high number of threats were identified as impacting the 26 species evaluated, even

among those considered to be in low risk categories at a global level, adding weight to the assertion that the identification of the precise threat causing a change in population status or risk status, remains problematic and complex (Mace *et al.* 2008; Di Fonzo *et al.* 2013). To clarify the mechanism and importance of each of the top five 1st level threat categories identified in this study, they are discussed below and relevant examples, mitigation challenges, and possible solutions are provided.

Natural Systems Modification

Habitat loss due to water management and dam construction was identified as the most common threat to Anatidae in Iran. Dam construction without considering the environmental flow of rivers has led to the drying out of numerous wetlands throughout Iran. The high priority that Iran, as a developing country, places on development projects has led to inadequate consideration of the environment, conservation, and related issues in decision making (Kaffashi *et al.* 2011). Natural systems modification, in the form of dams and water management/use has become a very serious threat affecting Anatidae through habitat loss and degradation. Since Iran is a dry country with an average precipitation of 260 mm (Modarres 2006), dam construction projects are considered essential to provide water for industrial, agricultural and domestic uses. However, Environmental Impact Assessments for dam construction projects mostly overlook the ecological and environmental outcomes and especially disregard the importance of environmental flow of rivers, and the impact these changes have on biodiversity. Drying out of a number of valuable wetlands in Iran has been attributed to such unreflective decision making, with the most severe case being that of Lake Urumiyeh in the northwest, a very important breeding and wintering ground for waterbirds. A once 5650 km² lake in 1998 (Zarghami 2011), Lake Urumiyeh is designated as a National Park, Ramsar site, and UNESCO Biosphere Reserve. Over the last decade, however, 1500 km² of the lake has dried out (Zafarnejad 2009) due to intensive water extraction for agricultural irrigation (Zarghami 2011) and the construction of 40 dams over major rivers in its watershed (Zafarnejad 2009). Clearly, such reduction in water available to breeding birds can severely limit local waterbird populations, affecting breeding and feeding habitats in quality and extent.

Other examples of lakes drying out due to inadequate water management include Gav Khooni (Isfahan province), Parishan (Fars province), Aji Gol, Ala Gol, Alma Gol (Golestan province), and Ghorī Gol (East-Azarbaijan), all considered Important Bird Areas by Birdlife International. Still, restoration projects for wetlands are not a priority in Iran. Even for the case of Lake Urumiyeh, with its national and international importance, various restoration projects such as determining water transfer routes from other basins to the lake (Zarghami 2011) have been proposed but are far from implementation.

Biological resource use

Commercial and recreational hunting has long been a major threat to Anatidae especially in northern Iran (Popovkina 2006). This activity, which was found to have medium level impact on 96% of species evaluated in this study, is an important source of income for local people. Over-hunting is a major threat affecting waterbirds, especially ducks, geese, and Eurasian Coot *Fulica atra*, in large wetlands in the south Caspian lowland (Pahlavani 2007; Mansoori 2009). Hunting pressure has increased greatly since 1970s, especially at important wetlands such as Anzali wetland complex, Gilan Province, southwest of the Caspian Sea (Mansoori 2009). This rise in hunting pressure has been attributed to the increased accessibility of wetlands due to road construction, as well as the increased domestic production and import of hunting firearms that has made shotguns available to the general public through legal and illegal means. The status

of waterfowl harvest in Gilan province indicates that Anatidae are the most abundantly hunted waterbirds (Popovkina 2006). Common Teal *Anas crecca* and Mallard *A. platyrhynchos*, along with Eurasian Coot, account for over 80% of birds identified in a local market in this province (Ashoori 2008).

Illegal and highly destructive hunting methods, implemented throughout Iran, have resulted in rapid declines in Anatidae populations. An example of these methods is what is carried out in Fereidoon-kenar “Damgahs” (Mazandaran province, northern Iran) where traditional, reportedly sustainable, hunting methods are practiced followed by recently developed inhumane methods that exterminate waterbirds, especially ducks. Damgahs are rice paddies that are flooded in autumn and winter and walled up by tall hedges or trees to provide a secure food-rich habitat for attracting migrating birds. The traditional method of hunting involves training decoy-ducks to attract wild birds into traps (Scott 1995). This method, if practiced alone, is thought to be a sustainable method of hunting, since not many birds can be caught at once (Alireza Hashemi, Tarlan Birdwatching and Ornithological Group, personal communication, 2013). In Fereidoon-kenar, however, because of the high concentration of birds, other methods accompany the traditional ones in order to maximize profit. Aerial nets are set up near Damgahs at night to trap any flying flock of bird passing the area. These nets, with very small mesh size, catch not only migratory waterbirds, but also many other non-target birds flying over. With a decrease in the abundance of birds in the Damgahs, when net trapping is not profitable anymore, large-scale shoot-outs extirpate the remaining birds. Hunted birds are sold at the local market, where globally threatened species such as White-headed Duck *Oxyura leucocephala*, among other non-commercial birds that have been trapped in the aerial nets, such as Barn Owls *Tyto alba*, Bitterns *Botaurus stellaris*, and egrets Ardeidae are offered for sale.

Hunting regulations during hunting season in Iran, including the length of hunting season, daily opening and closing times, daily bag limits, and total possession limits (Popovkina 2006), although in place, do not seem to be effective in managing commercial harvest of Anatidae species. Since hunting the birds is believed to be a legitimate activity by local people, implementing effective management to reduce this important threat factor is very challenging. Near Threatened species such as Ferruginous Duck *Aythya nyroca* (Popovkina 2006; Ashoori 2008) and threatened species like Marbled Teal (VU) *Marmaronetta angustirostris* (VU) and White-headed Duck (EN) are also found among the hunted species in Iran, suggesting the incompetence of DOE in controlling hunting activities. In some regions, such as the Fereidoon-kenar Damgahs, local actions over-rule national DOE regulations and therefore any attempts for imposing control on hunting activities is unsuccessful (Mansoori 2009).

Stricter implementation of hunting regulations, increasing awareness among local people and hunters about threatened species, encouragement of traditional duck-hunting methods instead of modern destructive ones, forming hunting clubs for sport hunters to allow for managing their activities, improving protection of important wetlands under the national law (national protected areas and Ramsar sites), and the establishment of additional hunting-restricted areas at other wetlands are possible mitigation methods for this threat factor while providing legal hunting opportunities at the same time.

Invasive and other problematic species and diseases

In 2005, outbreaks of highly pathogenic avian influenza were reported in Central Asia and Eastern Europe (Defra 2005). Waterbirds, especially the order Anseriformes, are known as the natural reservoir for Avian Influenza Viruses (AIV) (Stallknecht 2003), with the viruses being

most prevalent in dabbling ducks, especially Mallard (Olsen *et al.* 2006; Vandegrift *et al.* 2010). In a study on AIV in waterbirds wintering in Iran, Fereidouni *et al.* (2010) confirmed this was true in Iran as well.

Amini and Sehhatiasabet (2007) reported an outbreak of the highly pathogenic avian influenza virus in the winter of 2005/2006 which, among other species, led to the death of 334 swans in Gilan province. The outbreak of the virus in 2006/2007 made it impossible for local people in northern Iran to harvest or sell any ducks (Mansoori 2009). Loss of wetland habitats due to unsustainable water management and droughts leads to the concentration of higher waterfowl densities in alternative wetlands which can in turn increase influenza transmission within flocks of the same species as well as cross-species transmissions (Vandegrift *et al.* 2010). Waterbird losses from various types of diseases are much greater now than they have been for nearly a century because habitat loss has reduced the resilience of wildlife populations to the impacts of diseases (Friend 2006). Monitoring the quantity of suitable habitat for Anatidae and disease surveillance programs are necessary for mitigating the problems caused by this serious threat factor in Iran.

Another second level threat category that has recently imposed negative effects on swans, geese, Shelducks *Tadorna tadorna*, and Ruddy Shelducks *T. ferruninea* is problematic native species/diseases. These waterfowl species depend on grasslands to feed. Such grassland in Bujagh National Park in northern Iran, a major wintering and stopover site for waterbirds, is gradually moving through successional stages, with an overgrowth of Sedges *Carex* spp that facilitates the establishment of Blackberry *Rubus fruticosus* scrub. If these plants are not cleared out, *Alnus* spp will replace the scrub and the grassland habitat will eventually reach its climax as Hyrcanian forest. Although this is a natural process, the gradual loss of wintering ground is a growing concern especially for the mentioned species. Management for such grasslands focus on prevention of colonization by scrub and trees (Ausden 2004). To conserve these valuable grassland habitats, actions are needed to set back succession by livestock grazing or mechanical removal of problematic plants.

Agriculture and aquaculture

Habitat loss due to agriculture is the most severe threat to birds worldwide (Birdlife International 2008; Vié *et al.* 2009). The major driver of population declines in Palearctic-Afrotropic migratory birds is agriculture and deterioration of habitat quantity and quality in non-breeding areas (Kirby *et al.* 2008). This threat factor was not identified as the most important threat affecting Anatidae in Iran. However, it's low relative ranking is likely to be because wetlands in Iran are mostly protected by law, either as national protected areas or Ramsar sites, so loss of land to agriculture is limited. National regulations prohibit changes in land use in these areas, therefore, although wetland drainage for agricultural activities affect many wetlands to various extents (Ashoori *et al.* 2007; Ra'naghad and Ebrahimi 2007; Scott 2007; Behrouzi-Rad 2008; Mansoori 2009; Faramarzi 2012), converting wetlands to agricultural lands is not commonly practiced in Iran. The problem of intensive agriculture in wetland margins remains severe, however, and other threats which result in degradation of habitat quality are present. Agricultural activities adjacent to wetlands not only cause disturbance and pollute the wetlands, but also result in the loss of marginal habitats such as grasslands and pasturelands.

Livestock ranching is a contradictory issue, affecting some species positively and some negatively. Species that depend on grasslands to feed (swans, geese, Shelducks, Ruddy

Shelducks) benefit from livestock grazing as it sets back succession and maintains the area of grassland habitats (Sutherland and Hill 1995). Nevertheless, livestock ranching is recorded as a threat for species that breed in wetland marginal habitats since it reduces reproductive success by causing damage to nests, eggs, and chicks.

Wetland agriculture is vital for poverty reduction, but requires careful planning. Elimination of agricultural activities in and around wetlands is not socially and economically appropriate unless the wetland in question is protected by national regulations where any form of human development is prohibited. Management plans therefore need to consider both the conservation issues and livelihood requirements of local people

(McCartney *et al.* 2011). The effects of agricultural activities on different species must also be considered since activities such as livestock grazing are essential for the conservation of some species but deadly for others.

Pollution

Pollution entering wetlands from various sources affect waterbirds mostly through habitat degradation. Many of the important wetlands in Iran are fed by rivers that pass through residential and agricultural lands. Untreated sewage from urban and housing areas as well as effluents from agricultural and industrial units are discharged into wetlands either directly or through polluted rivers (Behrouzi-Rad 2008; Jafari 2009). Also, effluents from industrial units such as oil refineries in the south (e.g. affecting Shadegan wetland, Khuzestan province) (Zamani-Ahmadmahmoodi *et al.* 2009; Kaffashi *et al.* 2011) and pollution from oil extraction activities in the Caspian sea in the north (e.g. Gomishan wetland, Golestan province and Anzali wetland complex) (Behrouzi-Rad 2008) are causes of degradation of some major wetland systems in Iran.

Pesticide and fertilizer run-off from intensive agriculture that is practiced at the boundaries of many of the important wetlands (Mansoori 2009; Zamani-Ahmadmahmoodi *et al.* 2009; Ghafouri *et al.* 2010; Karimi *et al.* 2012) seriously affects the ecology of wetlands and impacts waterbird communities. Livestock manure is also a source of wetland pollution caused by agricultural activities (Mansoori 2009).

The first step for tackling the problem of pollution in wetlands is to identify point and nonpoint sources of pollution and to determine the contribution of each source to the pollution of important wetland habitats which consequently threaten waterbirds depending on them. Industrial units and human habitations in northern Iran, where the most important wintering sites for Anatidae are located, lack appropriate wastewater treatment plants (Jafari 2009). The establishment of urban and domestic wastewater treatment plants as well as the use of environmental management strategies for pollution prevention and waste minimization in industrial units can be helpful for reducing the pollution load of wetlands.

Residential and commercial development

Illegal constructions around wetlands, including human habitations (e.g. in Anzali wetland complex), recreation and tourism constructions (e.g. in Lake Urumiyeh), and industrial and military areas (e.g. in Hoor-al-Azim and Shadegan wetlands, Khuzestan province) are major threats to many wetlands in Iran (Behrouzi-Rad 2008), reducing the area of suitable habitat for Anatidae.

Although residential and commercial development around and within many wetlands (those designated as protected areas or considered internationally important) is prohibited by national laws and regulations, halting such projects is almost impossible, considering the high priority that the government places on development strategies. In order to mitigate this threat factor, there is a need for more effective law enforcement and monitoring as well as implementation of Environmental Impact Assessment (EIA) for projects that affect wetlands.

Conclusion

Although our results indicate that taken as a whole, the threat factors driving change in status of Anatidae in Iran are likely to be of medium rather than high impact, the diversity of threats identified, affecting both globally threatened and non-threatened birds, shows the vulnerability of this group of waterbirds. Human-induced climate change is known as the most important threat affecting birds in the long-term (Vié *et al.* 2009). It is also known as one of the serious threats to migratory birds worldwide (Kirby *et al.* 2008). However, since the effects of climate change in Iran are not well studied, it was not possible to accurately identify and score this category of threat for Anatidae. Although habitat loss is considered an important threat to birds worldwide (Vié *et al.* 2009) and was found to be the most important threat to Anatidae in Iran, since the species under review are economically valuable, hunting also appears to be a very serious problem. It is arguable that hunting might be a more important threat than dam construction and water management, due to its targeted impact and resultant rapid reduction in population size of a given target species. The magnitude of exploitation is so high in some areas that the effects of habitat degradation in suitable habitats used by waterbirds as a stop-over or wintering area are likely to remain insignificant in comparison to the primary threat.

The published method we used for identifying and scoring threat factors was necessarily subjective but consistent, providing a broad picture of conservation threats to Anatidae in the country, but lacking detailed and quantitative data. A more quantitative understanding of the impact of threats of different magnitude, scope and severity remains problematic (Di Fonzo *et al.* 2013). Although we tried to ensure that respondents identify threats in a unified context (integrating scope and severity) and we achieved high level of consistency of answers to our questionnaire, the significance of different threats were inevitably identified differently by risk averse respondents and those who were more evidentiary in their approach. **We believe however, given the scarcity of documented data on threats to Anatidae in Iran, the threat factors identified in this study provide the necessary grounds for national Red List assessment of this important group of birds. Identification of the most important threat factors is imperative for various stages of Red List assessment, including calculating the number of "locations", choosing the best scale for calculating geographic range metrics, and inference or projection of changes in populations (IUCN 2001). Also, since the best criteria for assessing each species is chosen based on its major threat factors (Milner-Gulland *et al.* 2006), the results of this study are of paramount importance to the process of national Red List assessment as well as threat assessment at the flyway scale.**

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Conflict of interest

None

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Figure 1. Main geographical populations of Anatidae in western Eurasia: 1. Northern White Sea/North Sea population; 2. European Siberia/Black Sea-Mediterranean population; 3. West Siberian/Caspian/Nile population; and 4. Siberian-Kazakhstan/Pakistan-India population (Isakov 1966).

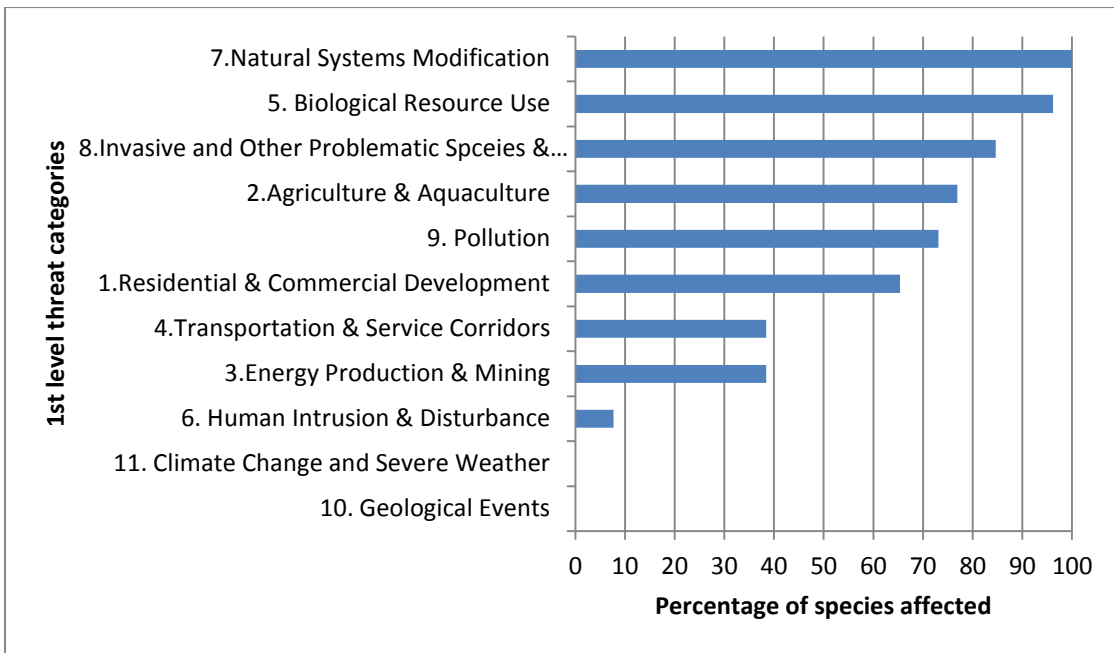


Figure 2. Medium-impact 1st level threats to Anatidae in Iran. Categories of threat follow Salafsky *et al.* (2008).

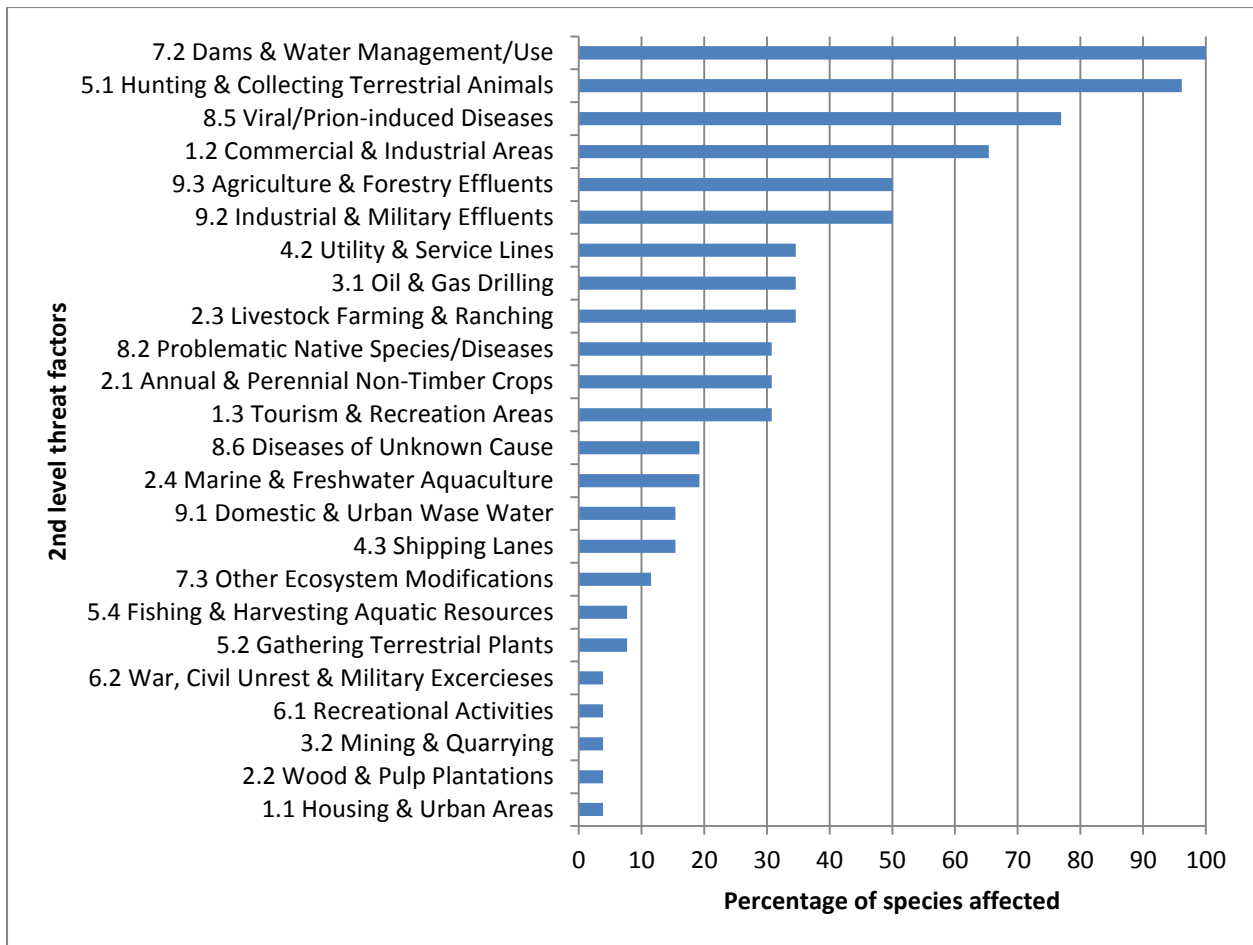


Figure 3. Medium-impact 2nd level threats to Anatidae in Iran. Categories of threat follow Salafsky *et al.* (2008).

Table 1. Medium-impact threats to Anatidae species in Iran. Categories of threat follow Salafsky *et al.* (2008). The trend categories provided by TRIM include: SI= strong increase; MI= moderate increase; U= uncertain; MD= moderate decline; ST= steep decline; S= stable.

	Red List Category	National Trend	Cronbach's α	Residential and commercial development			Agriculture and aquaculture				Energy production and mining			Transportation and service corridors				Biological resource use			
				1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4
<i>Cygnus olor</i>	LC	U	0.88		x	x					x					x				x	
<i>C. cygnus</i>	LC	U	0.92		x	x					x					x				x	
<i>C. bewickii</i>	LC	U	0.91		x	x					x					x				x	
<i>Anser anser</i>	LC	S	0.88		x					x						x				x	
<i>A. albifrons</i>	LC	MD	0.84		x	x	x									x				x	
<i>A. erythropus</i>	VU	U	0.92		x	x		x												x	
<i>Tadorna tadorna</i>	LC	MD	0.88				x												x	x	
<i>T. ferruginea</i>	LC	SD	0.84				x												x	x	
<i>Anas platyrhynchos</i>	LC	MD	0.84		x	x	x			x			x							x	
<i>A. strepera</i>	LC	S	0.81		x	x	x			x			x							x	
<i>A. acuta</i>	LC	MD	0.85		x		x						x							x	
<i>A. clypeata</i>	LC	MD	0.81		x								x				x			x	
<i>A. crecca</i>	LC	S	0.84		x		x						x							x	
<i>A. querquedula</i>	LC	SD	0.87		x		x						x							x	
<i>A. penelope</i>	LC	MD	0.87		x								x							x	
<i>Marmaronetta angustirostris</i>	VU	SD	0.93	x	x															x	
<i>A. ferina</i>	LC	MD	0.86																x	x	
<i>Netta rufina</i>	LC	-	0.86		x	x							x						x	x	
<i>A. marila</i>	LC	U	0.90		x								x						x	x	
<i>Bucephala clangula</i>	LC	MI	0.86										x						x	x	
<i>A. fuligula</i>	LC	MI	0.90																	x	
<i>A. nyroca</i>	NT	MD	0.90		x															x	

<i>Mergus merganser</i>	LC	U	0.92					x		x
<i>M. serrator</i>	LC	U	0.92					x		
<i>Mergellus albellus</i>	LC	MI	0.89							
<i>Oxyura leucocephala</i>	EN	U	0.93		x			x		x

Table 1. Medium-impact threats to Anatidae species in Iran. Continued.

	Human intrusion and disturbance			Natural systems modifications			Invasive and other problematic species						Pollution					Geological events	
	6.1	6.2	6.3	7.1	7.2	7.3	8.1	8.2	8.3	8.4	8.5	8.6	9.1	9.2	9.3	9.4	9.5	9.6	10
<i>Cygnus olor</i>					x	x		x			x			x	x				
<i>C. Cygnus</i>					x			x			x	x	x	x	x				
<i>C. bewickii</i>					x	x		x			x	x	x	x	x				
<i>Anser anser</i>					x			x				x	x	x					
<i>A. albifrons</i>					x			x				x		x					
<i>A. erythropus</i>					x			x			x	x		x					
<i>Tadorna tadorna</i>					x			x			x			x	x				
<i>T. ferruginea</i>					x			x			x			x	x				
<i>Anas platyrhynchos</i>					x						x				x				
<i>A. strepera</i>					x						x		x		x				
<i>A. acuta</i>					x										x				
<i>A. clypeata</i>					x									x	x				
<i>A. crecca</i>					x						x				x				
<i>A. querquedula</i>					x						x				x				
<i>A. Penelope</i>					x						x				x				
<i>Marmaronetta angustirostris</i>	x				x	x					x			x	x				
<i>A. ferina</i>					x						x								
<i>Netta rufina</i>					x						x								
<i>A. marila</i>		x			x														
<i>Bucephala clangula</i>					x						x								
<i>A. fuligula</i>					x						x								
<i>A. nyroca</i>					x						x								
<i>Mergus merganser</i>					x									x					
<i>M. serrator</i>					x						x			x					

<i>Mergellus albellus</i>		x		x		x	
<i>Oxyura leucocephala</i>		x		x			

Appendix 1: Sample questionnaire

Identification of threats to: Mute Swan (*Cygnus olor*)

Based on your knowledge of the populations of this species that occur in Iran, please select the appropriate threats in the table below. Please consider the threats that can be used for assessing the national threats status for the species. Specify each level-1 threat by selecting the corresponding level-2 threat(s). Please refer to the Scoring Guide to assign an impact score for timing, scope, and severity of each selected level-2 threat.

Threats (level 1)	Threats (level 2)	Impact Score		
		Timin g	Scop e	Severi ty
<input type="checkbox"/> 1. Residential & Commercial Development	<input type="checkbox"/> 1.1 Housing and Urban Areas			
	<input type="checkbox"/> 1.2 Commercial & Industrial Areas			
	<input type="checkbox"/> 1.3 Tourism & Recreation Areas			
<input type="checkbox"/> 2. Agriculture & Aquaculture	<input type="checkbox"/> 2.1 Annual & Perennial Non-Timber			
	<input type="checkbox"/> 2.2 Wood & pulp Plantations			
	<input type="checkbox"/> 2.3 Livestock Farming & Ranching			
	<input type="checkbox"/> 2.4 Marine & Freshwater Aquaculture			
<input type="checkbox"/> 3. Energy Production & Mining	<input type="checkbox"/> 3.1 Oil & Gas Drilling			
	<input type="checkbox"/> 3.2 Mining & Quarrying			
	<input type="checkbox"/> 3.3 Renewable Energy			
<input type="checkbox"/> 4. Transportation & Service Corridors	<input type="checkbox"/> 4.1 Roads & Railroads			
	<input type="checkbox"/> 4.2 Utility & Service Lines			
	<input type="checkbox"/> 4.3 Shipping Lanes			
	<input type="checkbox"/> 4.4 Flight Paths			
<input type="checkbox"/> 5. Biological Resource Use	<input type="checkbox"/> 5.1 Hunting & Collecting Terrestrial Animals			
	<input type="checkbox"/> 5.2 Gathering Terrestrial Plants			
	<input type="checkbox"/> 5.3 Logging & Wood Harvesting			
	<input type="checkbox"/> 5.4 Fishing & Harvesting			

		Aquatic Resources			
<input type="checkbox"/> 6. Human Intrusion & Disturbance	<input type="checkbox"/>	6.1 Recreational Activities			
	<input type="checkbox"/>	6.2 War, Civil Unrest & Military Exercises			
	<input type="checkbox"/>	6.3 Work & Other Activities			
<input type="checkbox"/> 7. Natural Systems Modifications	<input type="checkbox"/>	7.1 Fire & Fire Suppression			
	<input type="checkbox"/>	7.2 Dams & Water Management/Use			
	<input type="checkbox"/>	7.3 Other Ecosystem Modifications			
<input type="checkbox"/> 8. Invasive & Other Problematic Species, Genes & Diseases	<input type="checkbox"/>	8.1 Invasive Non-Native/Alien Species/Diseases			
	<input type="checkbox"/>	8.2 Problematic Native Species/Diseases			
	<input type="checkbox"/>	8.3 Introduced Genetic Material			
	<input type="checkbox"/>	8.4 Problematic Species/Diseases of Unknown Origin			
	<input type="checkbox"/>	8.5 Virus/Prion-induced Diseases			
	<input type="checkbox"/>	8.6 Diseases of Unknown Cause			
<input type="checkbox"/> 9. Pollution	<input type="checkbox"/>	9.1 Domestic & Urban Wastewater			
	<input type="checkbox"/>	9.2 Industrial & Military Effluents			
	<input type="checkbox"/>	9.3 Agricultural & Forestry Effluents			
	<input type="checkbox"/>	9.4 Garbage & Solid Waste			
	<input type="checkbox"/>	9.5 Air-borne Pollutants			
	<input type="checkbox"/>	9.6 Excess Energy			
<input type="checkbox"/>	10. Geological Events (Volcanoes, Earthquakes, Avalanches/Landslides)				
<input type="checkbox"/> 11. Climate Change & Severe Weather	<input type="checkbox"/>	11.1 Habitat Shifting & Alteration			
	<input type="checkbox"/>	11.2 Droughts			
	<input type="checkbox"/>	11.3 Temperature Extremes			

	<input type="checkbox"/> 11.4 Storms & Flooding			
	<input type="checkbox"/> 11.5 Other Impacts			
<input type="checkbox"/> 12. Other Threats:				

Appendix 2: Impact scoring guide

Impact Scoring Guide

Timing impact scores

Description	Score
Only in the past (and unlikely to return)	-
Only in the past (no direct affect but limiting)	0
Now suspended (could come back in the long term)	1
Now suspended (could come back in the short term)	2
Continuing	3
Only in the future (could happen in the short term)	2
Only in the future (could happen in the long term)	1
Unknown	U

Scope impact scores

Description	Score
Affects the whole (>90%) population	3
Affects the majority (50%-90%) of the population	2
Affects the minority (<50%) of the population	1
Affects a negligible proportion of the population	0
Unknown	U

Severity impact scores

Description	Score
Causing or likely to cause very rapid declines (>30% over 10 years or three generations)	3
Causing or likely to cause rapid declines (20-30% over 10 years or three generations)	2
Causing or likely to cause relatively slow, but significant, declines (<20% over 10 years or three generations)	1
Causing or likely to cause fluctuations	1
Causing or likely to cause negligible declines	0
No decline	0
Unknown	U