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The impact of climate change on population trends of marine birds in Libya.

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Abstract

The coastline of Libyan is characterized by different wetlands that are used as roosting areas for many migratory marine birds. They provide shelter, food and nesting ground for many birds' species during their migration from their home to wintering grounds. Climate change considered as the greatest threat to natural communities in many the world's ecosystems. It is already affecting birds in different ways. Precipitation and moisture are critically important climate variables to birds. Marine (sea) birds are highly dependent on precipitation to sustain their wetland habitats. Data on wintering birds in Libya were collected through the years 2005 - 2010 and analyzed in order to investigate their relationships with some climatic factors. This study found that precipitation reductions and drought in critical stopover areas have negative implications for marine birds wintering in Libya. However, the decrease and increase in bird numbers were related to the rate of rainfall.

Keywords: Coastline, migratory, precipitation and wintering birds.

1. Introduction

Climate changes have obvious impacts on biodiversity. Predictable future changes are expected to result in changes in the species distribution and habitats, and overall biodiversity loss (Staudinger et al., 2012). The response of individual species is different, depending on their climate tolerances and the ability to disperse into a new site. However, species ranges and population dynamics are already responding to recent climate shifts (Heller and Zavaleta, 2009; Staudinger et al., 2012). Moreover, the species richness and composition are also influenced by the climatic changes (Lemoine et al., 2007). Many studies and observations and reported over the last decade provide undeniable evidence about the significant impact of climate change on the global biodiversity (Parmesan, 2006); and many studies have modelled different potential impacts on biodiversity over the rest of this century and expressed that widespread impacts can be expected to lead to species extinction (e.g. Hughes 2000; Walther et al. 2002; Parmesan and Yohe 2003; Root et al. 2003).

Significant changes in climates, including an increase in the average global temperature are due to the steady increases of greenhouse gases concentrations in the atmosphere. Furthermore, global temperatures increased during the 20th century about 0.6 °C; this increase is higher than in the pre-industrial era, and they may increase by a further 1.4–5.8°C over the next century (IPCC, 2007; The

World Bank, 2012). In addition, climate change is expected to cause increases in the frequency of extreme climatic events. For example in some areas hurricanes, heavy rains and floods may occur more often; while other regions may suffer from drought and desertification.

Birds are the most widely studied species on the planet; they provide an important indicator group for knowledge about the impact of climate changes (Şekercioğlu et al., 2012). Birds' phenologies in directions consistent are affected by human-caused climatic changes. Bird migration is a movement to the right place at the right time. Migratory birds' species are adapted to using the best sites for foraging, breeding and avoid harsh winter by moving to areas that are more suitable (Coppack and Both, 2002; Robinson et al., 2005; Lemoine et al., 2007).

The Libyan coastline in characterized by many different ecosystems that are used as stopover routes for many migratory and resident birds (Defos *et al*. 2001, Etayeb and Essghaier, 2007). They provide food, shelter and nesting ground for many avifaunas during their migration from their home to wintering grounds. However, Libya, with its relatively dry climate, is perceived as having few wetlands. It is also, ornithologically, the least known country of Mediterranean Africa (Smart *et al*. 2006). The diversity of habitats which characters the country provide refuge and food for many migrants which amounts to about 75% of avifauna of the country passing from western Palearctic region to the southern quarter. The majority numbers of wintering species individuals are belongs to the seabirds group. However, one of the most fields of research is how seabirds would be influenced by climatic changes, and how monitoring of seabirds could inform us about the impacts of climate change on coastal and marine environments. Therefore, the present paper investigated the population trend of sea birds species along the coast line of Libya and their response to the impact of some metrological factors.

2. Material and methods

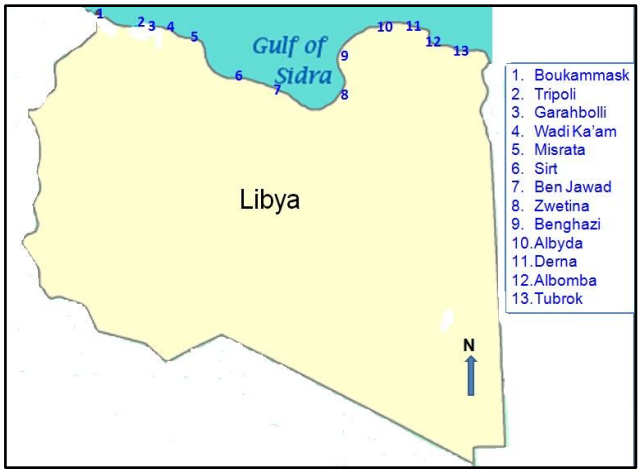

Figure 1: Map of Libya showing study sites.

2.1. Data collection

Data on the numbers of seabirds (Laridae and Sternidae species) were collected from the reports of Libyan wintering birds survey (2005 – 2010; table 1) and observations from some field visits in winter during the period from 2005 to 2010 (Azafzaf et al., 2005, 2006; Smart et al., 2006; Etayeb et al., 2007; Hamza et al., 2008; EGA–RAC/SPA Waterbird Census Team, 2012). Meteorological data were obtained from the Libyan National Meteorological Center for the sites that occupied by seabirds during winter season (fig. 1). Averages of temperature, humidity and precipitation for winter months

(December, January and February) were used to investigate their relation to the trend of seabird populations.

Table 1. Number of wintering Seabirds in some coastal sites during the period from 2005-2010.

Site name	Number of wintering Sea birds along the years						
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
Farwa/Ras-Jder	1734	2067	4618	3805	4390	8027	**24641**
Tripoli	0	168	108	529	13	0	**818**
Garhbolli	50	0	8	0	0	0	**58**
Wadi Ka'am	14	0	0	17	7	67	**105**
Misrata	184	6265	2096	0	2980	687	**12212**
Sirt	334	406	201	134	66	94	**1235**
Ben Jawad	0	3	0	0	96	2	**101**
Zwetina	114	37	0	0	2	0	**153**
Benghazi	16840	10033	15913	29710	17945	2240	**92681**
Al-Bayda	22	87	11	0	66	10	**196**
Derna	58	63	0	0	0	130	**251**
Bomba	96	569	0	0	0	0	**665**
Tobruk	329	0	0	0	0	35	**364**
Total	**19775**	**19698**	**22955**	**34195**	**25565**	**11292**	

2.2. Data analyses

In order to examine the population trend of sea birds wintering along the coastline of Libya through the years from 2005 to 2010, the Living Planet Index (LPI) was used. The use of LPI was started in 1997 by the World Wide Fund (WWF) to investigate the changes of global biodiversity over time, especially for measuring the average trends of vertebrate populations (Loh *et al*., 2005). In the present paper, the Chain method was used to calculate the index, where the logarithm of the ratio of the population of each pair of years was calculated using the formula:

$$\mathbf{d_t = \log(N_t/N_{t-1})}$$ where N= population size and t= years (time).

The specific values of d_t were generated for n_t as: $$\bar{d}_t = \frac{1}{n_t}\sum_{i=1}^{n_t} d_{it}.$$

Finally, the index for the sea birds population in a standard year *t* was calculated as:

$$I_t = I_{t-1}10^{\bar{d}_t}.$$

A linear regression model was fitted to investigate the impact of metrological factors (temperature, humidity and rainfall) on the population trend of seabirds wintering in Libyan coastline during the period from 2005 to 2010. Pearson correlation test was used to examine the correlation and independency between the meteorological variables. A significant correlation was found between rainfall rates and humidity (Pearson Cor. r = 0.84, p = 0.035); and therefore, the results dealt with precipitation and temperature as climatic factors.

3. Results and discussion

3.1. Population trends

Using the Chain method revealed that the population index of the wintering sea birds along the Libyan coastline has decreased by up to 57% during the period from 2005 to 2010, with a beak of up to more than 75% in winter 2008 (fig. 2). However, the results of this study indicate that there are some factors affecting Seabirds population during their winter migration or their habitats of stay in Libya. Although, a study of food abundance at the coastal wetlands is needed to investigate its relation with Seabirds numbers, but, the present study suggested to study the metrological factors which have a direct impact on water levels and drought.

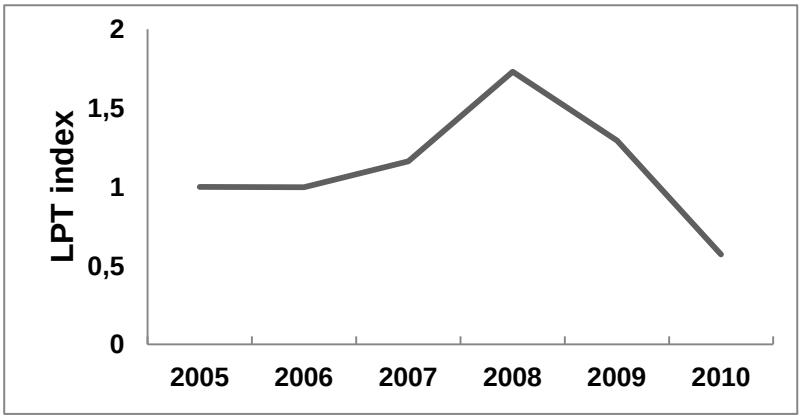

Figure 2: Population trend of Seabirds along the Libyan coastline.

3.2.The relationship between birds population trend and climatic factors:

Altered temperature, precipitation and humidity, a generally more variable climate, and more extreme weather are directly affect birds (Wormworth and Mallon, 2006). The present study found the tested metrological factors are clearly affecting the population trend of wintering Seabirds in Libya. There was a significant positive relationship between precipitation rates and Seabirds population (R^2 = 0.64, t = 2.70, p = 0.05; fig. 2a); as well as with the humidity (R^2 = 0.65, t = 2.73, p = 0.05; fig. 2b). The number of Seabirds decreased with the decrease of the rates of rainfall. This maybe because of coastal wetlands in Libya mostly represented in salt marshy areas relies on local winter rainfall to have a suitable water level for birds and other components such as unique vegetation and in-fauna species. However, if migratory birds experience increasingly severe food scarcities on their wintering areas due to decreased rainfall, this may affect non-breeding performance and also impact negatively on their time of departure for their breeding areas (Studds and Marra, 2007). Moreover, considerable evidence suggests that precipitation rates during the non-breeding season can have crucial consequences for migratory birds. Precipitation and temperature on the non-breeding grounds in Africa play a big role to influence first arrival dates, abundance and survival at breeding grounds in Europe (Gordo et al., 2005; Both et al., 2006; Saino et al., 2007).

The increase in temperature is the key predominant driver of climate change leading to habitat loss (Li et al., 2009; Şekercioğlu et al., 2012). Our study found that there was a significant negative relationship between the trend of Seabirds populations and temperature (R^2 = 0.71, t = -3.2, p = 0.03; fig. 2c). This result provides substantial evidence on the impact of temperature increase as a limiting factor on Seabirds abundance; which is in accordance with the results of Gordo et al. (2005) and Both et al. (2006). Comparatively high temperatures have an effect on proximate ecological factors (e.g. food abundance), that enables migratory species the ability to migrate (Saino et al., 2007). Temperature increase may be unfavorable for the birds because of the decline in the availability of their own preys (Durant et al., 2004). Moreover, Saino et al. (2007) mentioned that "variation in migration phenology

of 9 common species of trans-Saharan migratory birds at a Mediterranean island is related to temperature in the Sahel wintering areas and rainfall in North African passage areas".

Global temperature increase also affects the paths of many migratory birds and their annual migration time. Numerous of migratory birds change their routes, shorten or entirely cancel their journey as a consequence of changing temperatures (http://www.worldmigratorybirdday.org; Crick, 2004; Robinson et al., 2005).

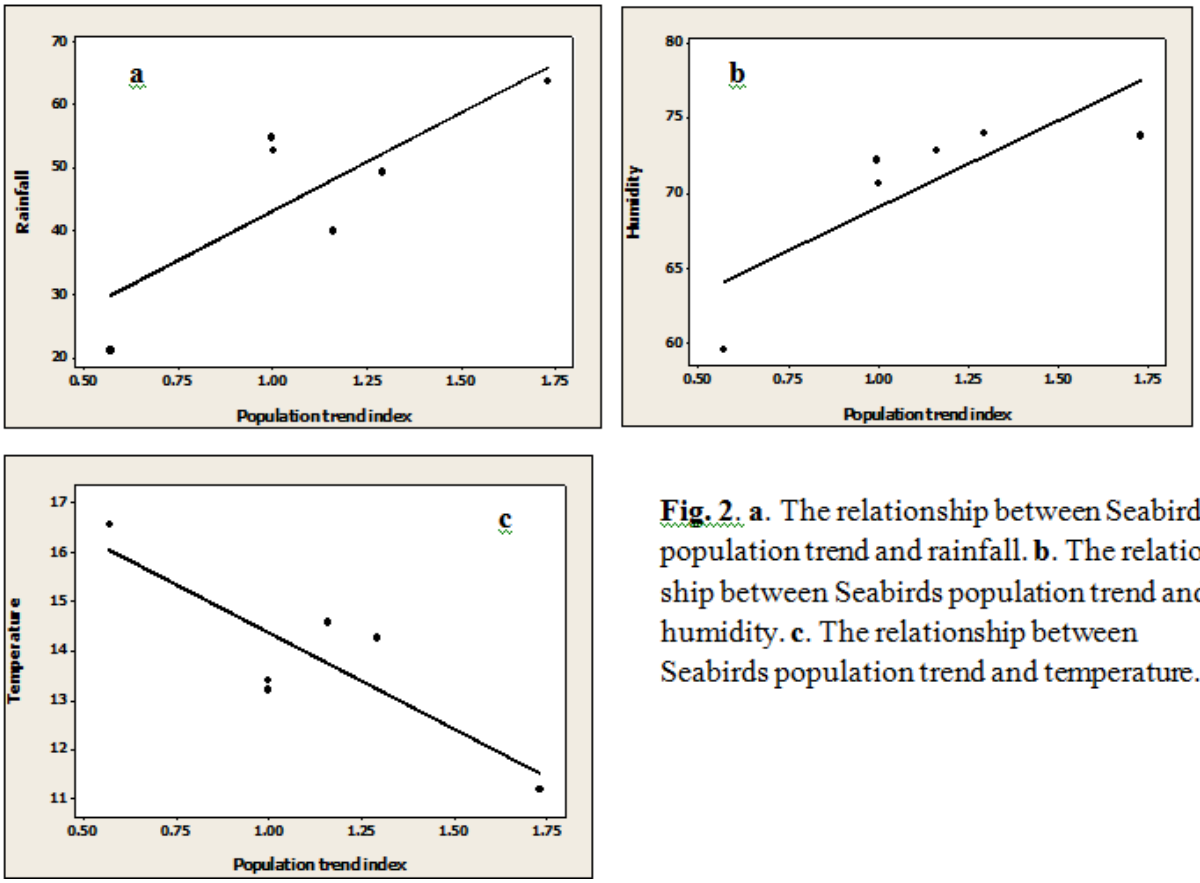

Fig. 2. a. The relationship between Seabirds population trend and rainfall. **b**. The relationship between Seabirds population trend and humidity. **c**. The relationship between Seabirds population trend and temperature.

4. Conclusion

Our results highlighted the impact of climatic changes on Seabirds population as a group of the most widely studied species on the planet. Human-induced global warming is happening at an accelerated speed and it is becoming increasingly difficult for many bird species. In addition, the changes in temperature and rainfall rates affecting the migratory bird species in both levels of habitat loss and migration rhythm.

Acknowledgements

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