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SHORT COMMUNICATION

The Black-necked Grebe (*Podiceps nigricollis*): an expanding species in the Middle Atlas wetlands, Morocco

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Abstract The present study investigates the population trends of Black-necked Grebe *Podiceps nigricollis* (Podicipedidae: Podicidae) over 5 years (2009–2013) in three Middle Atlas wetlands (Aguelmam Afennourir, Dayet Aoua and Dayet Ifrah). Using generalized linear models with a Poisson distribution, we demonstrated that the number of Black-necked Grebe breeding pairs has varied significantly and positively over the 5 years and between the three study wetlands. The annual population growth rate of the three colonies was 0.48 (±0.01). This positive trend is consistent with the current Least Concern conservation status of the IUCN Red List. Further more detailed studies are, however, needed to improve our understanding on the mechanisms driving the population increase in this part of North Africa. This remains a prerequisite for proper population conservation and management.

Keywords *Podiceps nigricollis* · Black-necked Grebe · Western Middle Atlas · GLM · Positive trend · Least concern

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Introduction

The Black-necked Grebe *Podiceps nigricollis* is gregarious species which occurs widely from the Western Palearctic to North America. Its main concentration is in the ecotones between steppe/prairie zones and woodland zones (O'Donnel and Fjeldså 1997). This monogamous species breeds colonially in natural freshwater lakes, usually shallow and well vegetated (Thévenot et al. 2003). The most recent Black-necked Grebe's fact sheet (Birdlife international 2012), that summarized the main findings of this species, suggests that this diving waterbird is threatened by several factors, including oil pollution (Ogilvie and Rose 2003), avian cholera (Ogilvie and Rose 2003, Friend 2006) and human disturbance (del Hoyo et al. 1992). Because the species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion, the current population status of the Black-necked Grebe is of a Least Concern in the IUCN Red List (O'Donnel and Fjeldså 1997; Birdlife international 2012, IUCN 2012).

In North Africa, the species is present in Algeria (Isenmann and Moali 2000), in Morocco (Thévenot et al. 2003), and in Tunisia (Isenmann et al. 2005). Nevertheless, there has been little research on the Black-necked Grebe populations in these countries. In Morocco, this species is a winter visitor and a resident breeder (Thévenot et al. 2003). The most important area for Black-necked Grebes remains the Western Middle Atlas (Thévenot et al. 2003). Furthermore, the population sizes remain poorly known, despite the importance of such information for understanding the long-term dynamics of this species at different spatial scales from within Morocco to the entire Mediterranean basin.

To assess the conservation status of wildlife species, it is important or even necessary to know trends in populations. Such knowledge is often used by several international organisations like the International Union for Conservation of Nature (IUCN), the Birdlife International, and the Living Planet Index (Loh et al. 2005; Couturier et al. 2013). These informations would allow wetland managers to develop sustainable ecological practices. It is with such concern that we examine, in the present study, the spatial and temporal variation in Black-necked Grebe numbers in the Western Middle Atlas. The purpose of the present study was to present trends of breeding Black-necked Grebes population in this region. We attempted to answer to the following questions. (1) Are the numbers of Black-necked Grebe breeding pairs varied spatially and temporally? (2) If so, how? (3) Does the Black-necked Grebe Middle Atlas population trend reinforce the current conservation status?

Methods

Study areas

The Black-necked Grebe populations investigated were at three Middle Atlas mountain wetlands: the Ramsar site of Aguelmam Afennourir and two sites of biological and ecological interest, Dayet Aoua and Dayet Ifreh (Fig. 1; Table 1). The Aguelmam Afennourir wetland is the furthest from the two others: 63.5 km from Dayet Aoua and 65.3 km from Dayet Ifrah. These two latters are spaced of 16 km. All the three wetlands occur within the Ifrane National Park.

Data collection

Adult Black-necked Grebe and broods were counted each year (2009–2013) in May at the peak of breeding activity when birds are most in nests (both egg-laying and rearing activities) (Cherkaoui et al. 2013). Counts at the three lacks were made between sunrise and midday, and nearly always in good weather, ensuring that detection conditions were relatively homogeneous.

The number of counting points depends of the wetland surfaces and of their shapes. Counts were carried out from accessible vantage points that cumulatively allowed total surveys of each site. Hence, we established 03 point count stations that were at least 300 m apart in Aguelmam Afennourir, 03 at Dayet Aoua and 01 at Dayet Ifrah (this wetland is located in the hollow of a hill). To standardize the counts, Black-necked Grebes were counted from the same points on every annual visit, the points being visited in the same order. To reduce the possibility of missing birds or counting them twice, we based on Woollhead's (1987) method. Behavioural breeding activities [adults frequently swimming together, synchronous preening, nuptial display (pivoting with necks, bouncy posture, performing the ghostly penguin posture), copulation, incubation, prey delivery to chicks on the back of one of the adults, etc.] were used to locate and determine numbers of reproductive pairs within each site. According to weather conditions, visits to a site generally lasted a minimum of 1 day. Observations were made using a Bushnell and Minox spotting scope (30X by 60 mm) and telescopes KOWA (60X) and Swarovski (60X). Precipitation data were obtained from the Agrarian Works Center of Azrou (2012) located into the hills of the Middle Atlas Mountains.

Statistical analysis

Statistical analyses were done in R software, version R2.12.2 (R Core Development Team 2009). We fitted generalized linear models (GLMs) considering a Poisson distribution and a log link function (McCullagh and Nelder 1989). The ratio of residual deviance to residual degrees of freedom after the dependant variable was fitted in the model was close to 1, indicating that the data were not overdispersed (Dean 1992; Smith and Heitjan 1993). We developed an all-inclusive set of candidate GLMs by using multi-model

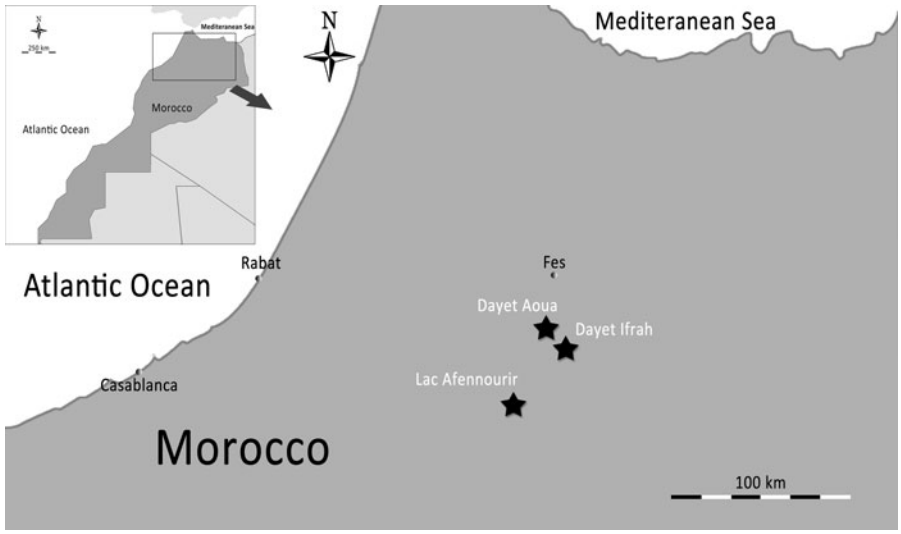

Fig. 1 Map showing the location of the three Black-necked Grebe study sites in the Middle Atlas, Morocco

Table 1 Morphometric characters of the three studied wetlands in the Western Middle Atlas, Morocco

	Wetlands		
	Aguelmam Afennourir	Dayet Aoua	Dayet Ifrah
Latitude (N)	33°16′50″	33°64′98″	33°55′82″
Longitude (W)	05°15′	05°03′	04°92′
Altitude (m)	1,796	1,460	1,650
Area (ha)	300	140	250
Depth (m)	2	5	8
Bioclimate	Humid	Subhumid	Subhumid
Status[a]	1 + IBA + SBEI + RS	3 + IBA + SBEI	3 + IBA + SBEI

IBA important bird area, *SBEI* site of biological and ecological interest, *RS* ramsar site

[a] The numbers 1 and 3 indicate the priority of protection (urgent and medium-term)

inference (Burnham and Anderson 2002). The explanatory variable (site and year) were thus tested alone, in addition and in interaction. For each model, Akaike Information Criteria (AICs) were calculated from the general formula AIC = –2 (log likelihood) + 2 K, where K is the number of parameters. The model with the lowest AIC was selected as the best fitting model. We corrected AIC for small sample size using AICc (Burnham and Anderson 2002). To test whether the residuals of the best model are normally distributed, and thus acceptable, the goodness-of-fit (GOF) test was performed.

In order to assess the possible effect of precipitations (for each year monthly data were pooled from September to August) on the number of Black-necked Grebe breeding pairs, and because precipitation data were only available per province (Ifrane) and not per study site, we performed the non parametric Spearman's rank/order correlation (5-year study) between precipitation data and the number of breeding pairs for each study site and for the three combined sites (data for the three sites were pooled annually).

For each site, the annual population growth rate (r) was calculated by using the parameter estimates of the best model. The discrete population growth (λ) was then calculated as $e^{(\text{growth rate})}$ and percent change per year was calculated as $(e^{(\text{growth rate})} - 1) \times 100$.

We compared the number of breeding pairs between sites (without taking into account the effect of year) using a one-way ANOVA (followed by a HSD

Tukey post hoc test). Data are expressed as mean ± 1SE.

Results

The best model selection clearly supported the model with combined additive effects of site and year ($\Delta AIC > 2$, AIC weight = 0.79; $R^2 = 0.58$). The goodness-of-fit ($z = -1.21$, $P = 0.11$) supported the fit of this model. The model explained 79 % of the deviance in the Black-necked Grebe numbers and 58 % of their variance. The best model (Table 1: numbers of breeding pairs ~ year + site) showed that the number of Black-necked Grebe breeding pairs varied significantly over the 5 years ($P < 0.001$) and between the three sites ($P < 0.001$) (Fig. 2). Because this model is additive, the annual growth rate was the same for the three sites ($r = 0.48$; Table 2). The population growth rate was thus of 1.62 (a growing population), and the overall increase of the three colonies was 61.6 %.

With regards to precipitations, they were not significantly correlation with the number of breeding pairs respectively at Aguelmam Afennourir ($r_s = 0.30$, $P = 0.624$), Dayet Aoua ($r_s = 0.31$, $P = 0.617$) and Dayet Ifrah ($r_s = 0.10$, $P = 0.870$). The same result was also recorded for the total number of breeding pairs ($r_s = 0.5$, $P = 0.591$).

Although the growth pattern was similar across sites, there was significant variation in the number of breeding pairs between sites. The maximum of breeding pairs was recorded at Aguelmam Afennourir (354.20 ± 112.9) and the minimum at Dayet Ifrah (8.60 ± 4.28) ($F_{2,12} = 9.372$, $P = 0.004$).

Discussion

To our knowledge, this is the first study that determines the breeding Black-necked Grebe trends in North Africa. The Black-necked Grebe colonies have increased substantially from 2009 to 2013. During this 5 year period, statistical analysis indicated a yearly rate of increase of 62 %. This positive trend is globally consistent with those recorded in Western and Central Europe (1960–1990, O'Donnel and Fjeldså 1997), in United Kingdom (1973–2004, Martin and Smith 2007) and in Spain (Martí and Del Moral 2003; Palomino and Molina, 2009). In France, however, the breeding populations are stable or slightly in increase (I. Kayser pers. com.).

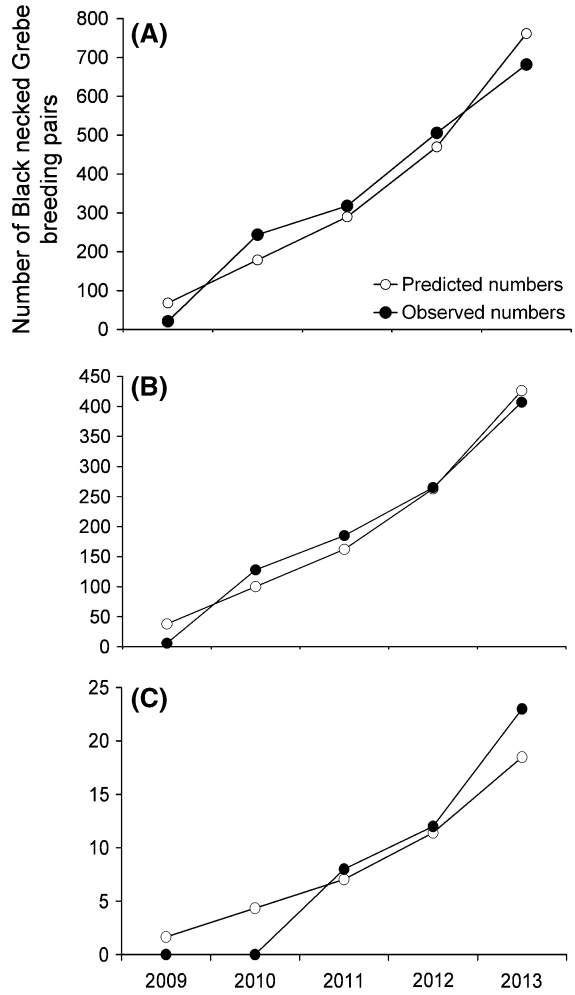

Fig. 2 Predicted values from the best model (*white dots*) and observed numbers of Black-necked Grebe breeding pairs (*black dots*) in each study wetland (*A* Aguelmam Afennourir, *B* Dayet Aoua, *C* Dayet Ifrah) from 2009 to 2013, Morocco

Although the overall pattern was of increase, there was an obvious variation in the number of breeding pairs between the three study sites. This is a characteristic in Black-necked Grebe breeding populations (O'Donnel and Fjeldså 1997). Indeed, it was only by 2011 that the first Black necked Grebe breeding pairs were recorded in Dayet Ifrah, whereas we had to wait 2013 to see eight breeding pairs at the Ramsar site of Aguelmame Sidi Ali. Those recent observations reinforced the hypothesis of an expansion of Black-necked Grebe breeding populations in the western

Table 2 Parameter estimates of the best model GLM (Poisson-distribution and a log link-function) fitted on the data set of the number of Black-necked Grebe *Podiceps nigriicollis* breeding pairs in the three study wetlands from 2009 to 2013, Morocco

Effect	Estimate ± SE	z value	Pr(>|z|)
Numbers of breeding pairs ~ year + site			
Intercept	−965.60 ± 29.96	−32.22	<0.001
Year	0.48 ± 0.01	32.43	<0.001
Dayet Aoua	−0.58 ± 0.03	−14.63	<0.001
Dayet Ifrah	−3.72 ± 0.15	−24.09	<0.001
Residual deviance	18.96		
df	11		
Goodness-of-fit	$P = 0.11$		

Middle Atlas. This is all the more true that this species was known to breed, since 1994, almost exclusively at Aguelmam afennourir [130 nests (Thévenot et al. 2003) vs. 303 in 2013 (present study)].

On the other hand, our results showed that precipitations were not correlated with the number of breeding pairs. It likely seems that local conditions do not affect the abundance of breeding Black-necked Grebes as previously reported by O'Donnell and Fjeldså (1997).

The significant and spectacular rise in the number of Black-necked Grebe breeding pairs recorded in the Western Middle Atlas (from 372 breeding pairs in 2009 to 1,100 in 2013) could be a part of a wider increase concerning many waterbird species including other grebe species breeding in the country namely the Great grebe (*Podiceps major*) and Little Grebe (*Tachybaptus ruficollis*). Indeed, a 10 year survey of breeding Anatidae at the Ramsar lake of Sidi Boughaba has clearly show the increase of breeding populations of four duck species: Red-crested Pochard (*Netta rufina*), Common Pochard (*Aythya ferina*), Ferruginous Duck (*Aythya nyroca*) and White-Headed Duck (*Oxyura leucocephala*) (Cherkaoui et al. 2013). This positive trend is also recorded in the most of the country. As evidenced, for instance, the recent withdrawal of White-headed Duck from the list of species subject to homologation in Morocco (decision of Moroccan Rare Bird Committee on June, 25th 2013).

Nonetheless, we can not exclude the hypothesis that the population increase of Black-necked Grebes on Western Middle Atlas would be in relation with intrinsic estimates of productivity, and adult and juvenile survival. It is also likely that immigration fuelled the population increase.

It is therefore necessary to initiate further studies to improve our understanding on the mechanisms driving the population increase in this mountain region. The part of each formulate hypothesis could only be known after having determined the Black-necked Grebe's breeding success (number of hatchling and number of young fledged per breeding pair) as well as its ecological determinants (weather conditions, water level and chemistry, habitat, density-dependent, predation level and human disturbance). The long-term trends in the number of breeding pairs remain also important and determinant.

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