



Short communication

When immigration mask threats: The rescue effect of a Scopoli's shearwater colony in the Western Mediterranean as a case study



Ana Sanz-Aguilar*, José Manuel Igual, Giacomo Tavecchia, Meritxell Genovart, Daniel Oro

Population Ecology Group, Instituto Mediterráneo de Estudios Avanzados, IMEDEA (CSIC-UIB), Miquel Marqués 21, E-07190 Esporles, Islas Baleares, Spain

ARTICLE INFO

Article history:

Received 19 October 2015
 Received in revised form 27 January 2016
 Accepted 29 March 2016
 Available online 12 April 2016

Keywords:

Recruitment
 Survival
 Demography
 Dispersal
 Sink
 PVA

ABSTRACT

Populations of long-lived species are highly sensitive to increases in mortality, but a loss of breeders can be compensated for by recruitment of local individuals or immigrants. Populations maintained through immigration can be sinks, jeopardizing the viability of the metapopulation in the long term when additive mortality from anthropogenic impacts occurs. Thus, the correct identification of whether a breeding population is maintained by local recruitment or by immigration is of special importance for conservation purposes. We developed robust population models to disentangle the importance of local recruitment and immigration in the dynamics of a Western Mediterranean population of Scopoli's shearwater *Calonectris diomedea* showing low adult survival but stable breeding numbers. Our results show that the shearwater population is not self-maintained but rescued by immigration: yearly immigrants recruiting in the population represents ~10–12% of total population size. We believe that this situation may be common to other Western Mediterranean populations, currently acting as sinks. We recommend urgent demographic studies at large core colonies to evaluate the global conservation status of the species.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Survival, reproduction and dispersal processes (emigration and immigration) drive population dynamics and viability (Hanski, 1999; Morris and Doak, 2002). Whereas local survival and recruitment (accession to reproduction) determine the intrinsic viability of a local population (Oro, 2013; Sanz-Aguilar et al., 2009, 2014, 2015), dispersal is the key process driving the dynamics of spatially structured populations and metapopulations (Hanski, 1999; Hill et al., 2002). Demographic differences among local populations can arise from heterogeneous habitat quality, in which populations inhabiting sub-optimal habitats or threatened differently by anthropogenic factors may not be able to balance local mortality by reproduction, being sinks (Pulliam, 1988; Dias, 1996). Source-sinks dynamics seem common in nature, but additive impacts from the global change can alter those dynamics and exacerbate extinction probabilities at sinks, posing a challenge for the conservation of endangered populations (Liu et al., 2011). Population viability of long-lived species is highly sensitive to changes in adult survival (Sæther and Bakke, 2000). However, populations can compensate for adult mortality by density-dependent changes in other demographic parameters, such as fecundity and/or recruitment (Boyce et al., 1999; Gaillard et al., 1998). Recruitment has been identified as a key factor

responsible for population fluctuations (or stability) in several long-lived species (Servanty et al., 2011; Tenan et al., 2014; Votier et al., 2008). For example, populations of wild boar *Sus scrofa*, common guillemots *Uria aalge* or kittiwakes *Rissa tridactyla* subject to high adult mortality, buffered the loss of breeders by recruiting at earlier ages or increasing recruitment rates (Porter and Coulson, 1987; Servanty et al., 2011; Votier et al., 2008). However, sometimes, reproduction and local recruitment alone cannot buffer the loss of breeders and immigration is needed to maintain a local population (Lieury et al., 2015; Sanz-Aguilar et al., 2014). Dispersal from source populations with demographic excess permits the maintenance of sink populations (Fernández-Chacón et al., 2013), which although unviable alone, they contribute to increase metapopulation size and time to extinction (Pulliam, 1988; Howe et al., 1991; Liu et al., 2011). The correct identification of whether a breeding population is maintained by local recruitment (demographic stability or excess) or by immigration (demographic deficit) is of special importance to identify source and sink populations and design adequate conservation actions (Howe et al., 1991; Dias, 1996; Liu et al., 2011; Oro, 2013). Identifying source and sink populations is a complicated task because it requires long-term demographic studies for estimating dispersal between patches and also because sinks can become sources (and vice-versa) if environmental conditions change (Dias, 1996; Liu et al., 2011).

In a recent study, Tenan et al. (2014) showed that the stability of a Scopoli's shearwater *Calonectris diomedea* colony in the western Mediterranean (Pantaleu colony, Balearic Archipelago, 39°34'N, 2°21'E) was achieved through recruitment processes buffering the loss of

* Corresponding author.

E-mail addresses: a.sanz@imedea.uib-csic.es (A. Sanz-Aguilar), jm.igual@uib.es (J.M. Igual), g.tavecchia@uib.es (G. Tavecchia), m.genovart@uib.es (M. Genovart), d.oro@uib.es (D. Oro).

adult individuals by mortality. However, whether those recruits maintaining the population are local or foreign individuals dispersing from other populations remains unknown. The Scopoli's shearwater is a long-lived bird with low fecundity, delayed recruitment and high adult survival, largely affected by oceanographic processes (SOI index) and fisheries bycatch (Genovart et al., 2013a; Igual et al., 2009; Jenouvrier et al., 2009; Ramos et al., 2012). Unlike other seabirds like gulls, in which natal and breeding dispersal are very common (Fernández-Chacón et al., 2013; Sanz-Aguilar et al., 2014), petrels and shearwaters behave faithfully to their breeding sites (Igual et al., 2007; Sanz-Aguilar et al., 2011) and local individuals mostly recruit very close to their natal site (Bonadonna and Sanz-Aguilar, 2012; Gómez-Díaz et al., 2009) but see (Martínez-Abraín et al., 2002). The importance of dispersal in these species is, however, very difficult to evaluate due to their hypogeous breeding habits and because only a very small proportion of birds are ringed, and in a reduced number of colonies (typically in small ones). In fact, genetic studies pointed to a non-negligible role of dispersal in the Scopoli's shearwater (Genovart et al., 2013b; Ramírez et al., 2013).

Exhaustive nest and individual monitoring during a long-term program (2001–2014) at Pantaleu, facilitated by the relatively small size of the islet, 2.5 Ha, allowed a robust estimate of local demographic parameters (Genovart et al., 2013a; Sanz-Aguilar et al., 2011, 2016) and provided reliable data on temporal variation in breeding numbers (Tenan et al., 2014). Here, we developed robust population models and integrated census and demographic data to disentangle the importance of local recruitment and immigration in the dynamics of the population. In particular, we compared the observed breeding numbers over the study period with the breeding numbers projected under different scenarios of immigration combined with the local estimates of survival, recruitment, breeding propensity (sabbatical) and breeding success. This comparison allowed the quantification of the reproductive potential of the population to balance local mortality, and thus its identification as a sink or source.

2. Methods

We calculated the observed mean population growth rate λ_{obs} as the geometric mean of the annual observed growth rate (No. nests occupied $t + 1$ /No. nests occupied t) (Morris and Doak, 2002).

Age-stage structured deterministic and stochastic matrix population models were built to forecast deterministic and stochastic population dynamics for the studied population (Caswell, 2001; Morris and Doak, 2002) using the package POPBIO in the software R (Stubben and Milligan, 2007; Team, 2005). The model followed a pre-breeding census format, and only the female population was modeled, assuming equal survival between sexes and monogamy (Genovart et al., 2013a). Given previous results, we defined 8 age classes and 3 stages (pre-breeder, breeder and breeder in sabbatical) (Fig. A1.1. Appendix 1). Estimates of age-dependent recruitment (π), survival (ϕ), and sabbatical were obtained from previous studies (Sanz-Aguilar et al., 2011, 2016) (Table A1.1 Appendix 1). Mean survival of resident breeders of unknown age was estimated using capture-recapture data on 363 breeding adults from 2001 to 2014 to update a previous estimate (model $(\phi_1, \phi_2, \pi_t + m)$ in (Pradel and Sanz-Aguilar, 2012)). We used this survival estimate for the oldest breeder's age class ($\phi_{\geq 8}$). Fecundity (f) was defined as the number of females produced by a breeding female (breeding success * sex ratio). We assumed that sex ratio at birth was 0.5 (Genovart et al., 2005). Mean breeding success was calculated using data on nest monitoring from 2001 to 2014 (see details in Genovart et al., 2013a).

Deterministic projection was used to estimate the asymptotic population growth rate (λ), the stable age distribution, the reproductive value of each age-stage class, and the sensitivity (the change in λ associated with a change in a demographic parameter) (Caswell, 2001) (Appendix 2). Stochastic matrix population models (Appendix 3) were

used to estimate the expected number of breeders in the study population during the study period under different scenarios of immigration (see below). The initial population size for each age-stage class was calculated by combining the stable age distribution obtained by the deterministic model (Appendix 2) with the observed number of breeding pairs at the beginning of the study (183 in 2001). Projections included parameter uncertainty in all demographic parameters (Table A1.1 Appendix 1) by randomly selecting parameter values from a beta-distribution (Fieberg and Ellner, 2001; Morris and Doak, 2002). Demographic stochasticity in fecundity and survival was modeled using binomial distributions. We ran 10,000 stochastic population model simulations over 1 to 13 year periods (i.e., up to the end of the study, 2014).

The first scenario assumed a closed population (i.e., absence of immigration) and alternative scenarios simulated different numbers of immigrants (ranging from 1 to 25) entering annually into the population (in proportional numbers to age-dependent probabilities of recruitment; Sanz-Aguilar et al., 2016). We compared the number of breeders simulated for each year by each scenario with the observed annual breeding population size.

3. Results

The breeding population of Scopoli's shearwater at the Pantaleu colony was almost stable during the study period, $\lambda_{\text{obs}} = 0.989$ (Fig. 1), whereas the deterministic population model not considering immigration predicted a sharp decline ($\lambda = 0.907$, ~10% annual decrease). The stable age distribution indicated that the population should be primarily composed of breeders older than 8 years (32.4%; Fig. A1.2. Appendix 1), which are the individuals with the highest reproductive value (10.7%; Fig. A1.3. Appendix 1). Individuals breeding at 5 years (youngest breeders) showed the lowest reproductive value (0.2%; Fig. A1.3. Appendix 1). The asymptotic population growth rate (λ) was especially sensitive to survival (Fig. A.1.4–5 Appendix 1), and negatively influenced by sabbatical and early recruitment (Fig. A.1.4,6–7 Appendix 1).

Under current conditions but in the absence of immigration, the stochastic population model projected an average decline of 70% in the breeding population at the end of the study (i.e., 54 breeding pairs in 2014), not matching with the observed breeding pairs (Fig. 1) even when accounting for uncertainty (Fig. A.1.8. Appendix 1). Population projections suggested that the number of immigrants varied annually during the study period, increasing in the last years (Fig. 1, Table A1.2 and Figs. A.1.8–13. Appendix 1). Projections with less than 10 female immigrants by year were not supported (Figs. A.1.8–10. Appendix 1). By considering an annual number of 18 to 20 female immigrants, the model showed the best match (i.e., the smaller mean differences in mean breeding numbers) to the observed breeding pairs from 2001 to 2014 (Fig. 1, Table 1A1.2, Appendix 1).

4. Discussion

Mediterranean populations of Scopoli's shearwater and Atlantic populations of Cory's shearwater (*C. borealis*) are similarly affected by large scale oceanographic variables during wintering (Genovart et al., 2013a; Jenouvrier et al., 2009; Ramos et al., 2012). Additionally, the species is severely affected by important local threats in foraging areas during the breeding season, such as bycatch in longline fisheries (Barcelona et al., 2010; Belda and Sanchez, 2001; Laneri et al., 2010; Ramos et al., 2012). During the last decades, the industrialization of fisheries has dramatically increased their impact on seabird populations (Wagner and Boersma, 2011) and recent bycatch estimates reported ca. 200,000 seabirds killed annually in European Union (EU) waters. In particular, the western part of the Mediterranean sea is subjected to one of the highest pelagic longline fishing efforts in the world (Lewison et al., 2014). Shearwaters of several western Mediterranean colonies share foraging areas (Arcos et al., 2009) and may thus be subjected to common

Download English Version:

<https://daneshyari.com/en/article/4385029>

Download Persian Version:

<https://daneshyari.com/article/4385029>

[Daneshyari.com](https://daneshyari.com)