European Journal of Wildlife Research (2022) 68:52
https://doi.org/10.1007/s10344-022-01601-x

ORIGINAL ARTICLE

Apparent survival, reproduction, and population growth estimation of a Kentish plover population in the Canary Islands

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Received: 28 January 2021 / Revised: 6 July 2022 / Accepted: 10 July 2022

Abstract
The increase of the tourism and urbanization of vast areas of dunes and beaches has been accompanied by an increase in the level of disturbances to many shorebirds, especially on those species which depend on such habitats to breed. The European Kentish plover (*Charadrius alexandrinus*) population is declining, also in the Canarian archipelago, one of the most important touristic destinations worldwide. Using data from an intense monitoring program on Lanzarote Island and the nearby La Graciosa islet (hereafter, both referred as Lanzarote), we aimed to (1) estimate the breeding output and survival and (2) use these parameter estimates to build a population model to assess the long-term growth rate of the population and evaluate, accordingly, its conservation status. Our studied population presents a relatively high breeding success although, thereafter, the first-year apparent survival is low. Even though adult apparent survival rates are reasonably high, these seem insufficient to compensate for the low survival rates of the first-year birds. In this sense, we found a negative growth rate according to a population model estimating an annual loss equivalent to 20% (95% confidence interval: 6–35%). Local studies to account for the effects of human disturbance caused by tourist industry on survival, breeding rates, and demography are required to develop precise conservation actions for the Kentish plover population in Lanzarote.

Keywords Biological conservation · *Charadrius alexandrinus* · Demography · Macaronesia · Shorebirds · Tourism · Waders

Introduction

Waders are one of the most threatened bird groups worldwide (Stroud et al. 2006). Apart from historical causes explaining past declines, like hunting and egg collection (e.g., Piersma and Wiersma 1996), nowadays, habitat loss and degradation are important factors driving wader population declines in many regions (Stroud et al. 2006; Bamford et al. 2008). The increase of tourism has been accompanied by an increase of the level of disturbances, as well as urbanization of vast areas of dunes and beaches, creating a severe impact on those waders that depend on such habitats to breed (Burger et al. 1997; Ruhlen et al. 2003; Davenport and Davenport 2006; Garcias and Tavecchia 2018). In this sense, Spain, one of the main touristic destinations worldwide, receiving more than 80 million tourists each year (Spanish National Institute of Statistics), suffers a huge pressure on its coast and beaches (Ivars i Baidal et al. 2013; Ferrer-Valero et al. 2017). Demographic analyses on bird populations that depend on this habitat type are crucial to identify conservation problems, detect key areas, and plan conservation/management measures (Ruhlen et al. 2003; Davenport and Davenport 2006; Navedo and Herrera 2012; Schlacher et al. 2013; Martín et al. 2014; Burger et al. 2017).

The Kentish plover (*Charadrius alexandrinus*) is a broadly distributed wader species, breeding across middle latitudes from western Europe and northern Africa to eastern Asia (Piersma and Wiersma 1996; Message and Taylor 2005). It is a chiefly coastal species, though it also breeds in mainland open flats near brackish/salty water bodies, in sand, silt, or dry mud (Piersma and Wiersma 1996). The European populations of Kentish plovers breed mostly in the Mediterranean and the Atlantic coasts, up to

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southern Scandinavia. The entire European population, of 21,500–34,800 adult breeding pairs, is decreasing (Staneva and Burfield 2017). The main threats for the species are habitat loss and disturbances caused by humans (e.g., Rocha et al. 2016), though predators can also have a role in some areas (Lorenzo and González 1993; Figuerola and Amat 2003). Oil spills have also impacted negatively some populations (Vidal and Domínguez 2015). In Spain, which hosts about 5000–6000 pairs (Amat 2012), the species has been recently declared as endangered (Gómez-Serrano et al. 2021). However, besides this adverse conservation status, the demography and dynamics of Spanish Kentish plover populations remain poorly known (Amat 2012). Indeed, only a recent work carried out in the Balearics addressed a demographic analysis including survival estimates and proposing a population model (Garcias and Tavecchia 2018).

Formerly, in the Canary Islands, Kentish plover breeding populations occupied the four central and eastern islands, but during the last decades, they have suffered severe declines in their numbers and are now extirpated from Tenerife, being also near to extinction on Gran Canaria (Lorenzo and Barone 2007). The last available census estimated ca. 400 breeding pairs for the whole archipelago (Palomino and Molina 2009), mostly concentrated in the two eastern-most main islands, i.e., Lanzarote (including La Graciosa islet) and Fuerteventura (including Lobos islet) (Lorenzo and Barone 2007). These populations are of conservation concern because of an incipient genetic and phenotypic differentiation with respect to mainland European birds (Küpper et al. 2012; Almalkl et al. 2016). The population dynamics (breeding output, survival, dispersal rate) of the Canarian population remains unknown, and although there are no quantitative studies, it seems to be threatened, as suggested by an alarming population decline and a reduction in the number of breeding localities in the last decades (Lorenzo and Barone 2007). This scenario contrasts with findings for the Balearic population, which seems to be stable or even slightly increasing (Garcias and Tavecchia 2018). The increasing amount of human use along the coast of the Canary Islands, together with an abandonment of historical saltworks, poses these islands with a challenging opportunity for the conservation of the Kentish plover (Lorenzo and González 1993; Tejera and Rodríguez 2014; Barone 2019).

Using data from an intense monitoring program conducted on the island of Lanzarote (and the nearby La Graciosa islet, hereafter considered as part of Lanzarote), here we aimed to (1) estimate the breeding output and survival of Kentish plovers in this island and (2) use these parameter estimates to build a population model to assess the long-term population growth rate of the population and evaluate, accordingly, its conservation status in Lanzarote. Previous research from a population in the Balearics showed that the population growth rate was especially sensitive to adult survival rates, followed by breeding success and first-year survival (Garcias and Tavecchia 2018). Thus, we expect that the observed population decline may respond to particularly low adult survival rates or, alternatively, to an also very low breeding output or low first-year survival rate.

Material and methods

Study area and data collection

This study was carried out in Lanzarote, situated in the easternmost extreme of the Canary Islands (Fig. 1). With an area of almost 846 km^2, it is a subtropical volcanic island with a landscape dominated by low and flat relief with scattered volcanic craters and related badlands with a poor vegetation cover (Reyes-Betancort et al. 2001). The coast is dominated by rocky intertidal areas and sandy beaches, and there are 27 coastal saltworks (Luengo and Martín 1994), of which only two are currently active. Saltmarsh habitat is lacking. The local human population is around 150,289 (in 2019), mainly concentrated on the southeast coast (source: ISTAC 2020; www.gobiernodecanarias.org/istac). Formerly, the economy was based on agriculture and fishing but, nowadays, it is highly dependent on tourism, attracted by unique landscapes (González et al. 2006). Around 2.7 million foreign tourists visited the island in 2019, a figure about 15 times larger than Lanzarote's resident population (ISTAC 2020). Tourism has led to a very fast growth of urbanized areas especially along the coast.

The Kentish plover breeding population in Lanzarote is estimated at 23–136 pairs (Lorenzo and Barone 2007). They mainly occupy coastal rocky flat habitats, sandy beaches, and saltworks, including sites close to human settlements (Tejera and Rodríguez 2014).

Field procedures

Kentish plovers were ringed as either chicks or adults in several beaches in three main areas of Lanzarote (Fig. 1): Arrecife (central south-coast), Janubio (eastern north-coast), northern (western north-coast, from Famara area to Punta Prieta, and also including La Graciosa island). Ringing was carried out during the breeding seasons of 2013 to 2017, mostly comprising from March to June, using an official metal ring and a combination of color rings for individual identification at distance. We ringed both chicks of different ages (from recently hatched to almost fledged) and adults (captured, respectively, by hand or with a quadrangular spring trap in the nest). In parallel, the breeding places were inspected to look for the presence of ringed individuals. In addition, sightings from birdwatchers and wildlife photographers were collated. From 2013 to 2017, therefore, our data set consisted of chicks and adults ringed every year, together

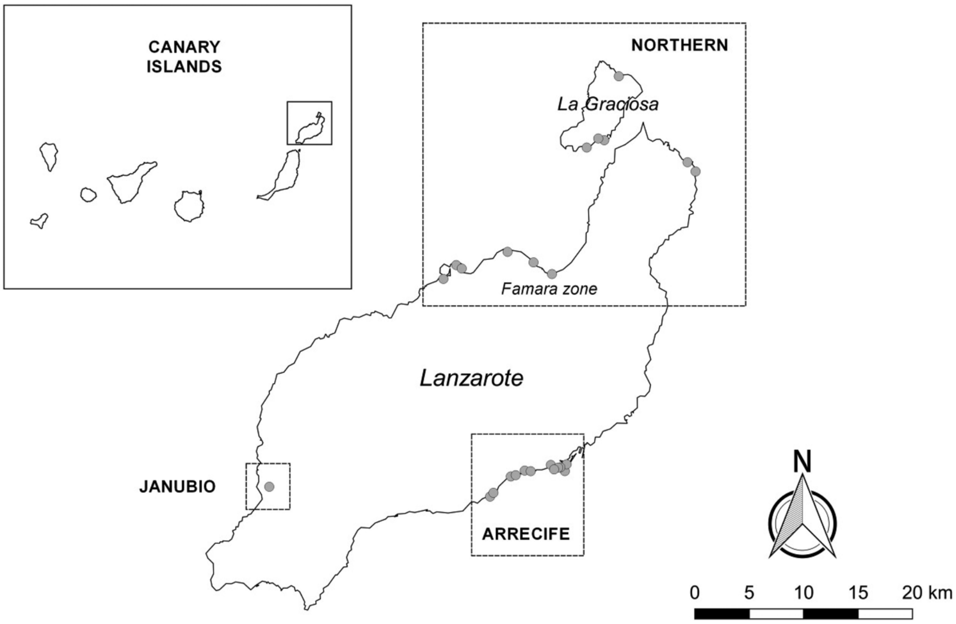

Fig. 1 Location of the three study zones (dashed squares) within the island of Lanzarote, Canary Islands. Dots in Lanzarote/La Graciosa show sampling localities

with recaptures at nests and sightings of birds that had been ringed previously.

To estimate breeding parameters each year, we searched nests using binoculars (10×) and a fieldscope (20×60) from vantage points and observing adults' behavior. We recorded clutch size (number of eggs in the nests) and the number of eggs hatched. For that, every nest was visited at least two times to record its fate, thus allowing us to estimate breeding success as the percentage of successful nests (i.e., nests from which at least one egg hatched). To calculate nest success, we used the Mayfields' equation (Johnson 1979), considering a mean incubation period of 27 days (Amat 2012).

Statistical analyses

Only a minority ($n=4$, 1.6% of total ringed birds) of the birds was found in subsequent years in areas outside the one where they were ringed, a priori indicating a very modest flow among the three sampling zones considered in this work. Accordingly, we used single-site Cormack-Jolly-Seber (CJS)–related models (Lebreton et al. 2009) in MARK (White and Burnham 1999) to estimate the following two population parameters: (1) apparent annual survival, φ; probability of surviving from year t to year $t+1$; (2) encounter rate, p; probability of detecting a bird that is alive. Alternative multi-state recapture models that estimate transition rates among sites are not justified given the too small observed flow among the three sampling sites where the ringing was carried out (i.e., even though we originally differentiated three sampling sites, all the data were pooled for the analyses and considered using a single-site approach).

The matrix used in MARK was built using the captures (or recaptures) obtained from 2013 to 2017, with a sample size of 243 individuals. Overall, therefore, our matrix had 243 rows by 5 columns. Before starting a selection process including different alternative models, we tested for the fit of the data to CJS assumptions, for which the U-CARE software was run (Choquet et al. 2009). A global goodness of fit test showed that the data set, overall, fits to the assumptions ($\chi^2=15.35$, $df=13$, $P=0.286$). Both a specific test to detect transients ($Z=1.32$, $P=0.186$) and another one to detect trap-dependence ($Z=2.81$, $P=0.999$) were non-significant. Our basic model from which to start to build alternative, more complex models was φ(t), p(t) (i.e., time-dependence for the two parameter estimates). Additionally, we also tested for age-dependence on φ, considering two age classes: first-year birds and adults. In these models, birds ringed as adults were considered to have constant φ, while those ringed as chicks were considered to have as first φ value (relative to their first year of life, where φ is assumed to be lower), and another one for the subsequent years, which would be the same than φ in those birds ringed as adults. All possible models were ranked in relation to their small-sample size Akaike values (AICc), and then the models differing in less than 2 AICc units were considered to fit to the data equally well (Burnham and Anderson 1998). Model averaging was carried out to obtain parameter estimates weighed for the models that differed in less than 2 AICc units (Arnold 2010).

We ran Generalized Linear Models (GLM) to test for the effect of year and zone on breeding success and clutch size. For breeding success, we used a negative binomial errors distribution with a logit-link function, and for clutch size, a

Table 1 Summary data of the captures and recaptures (or resightings) of Kentish plovers ringed in Lanzarote (Canary Islands) during a 5-year period. For each year and age category, we indicate the number of captures and, in parenthesis, how many of those individual birds were seen at least once after the year of capture in any of the study zones

Year	Chicks Captured (recaptured)	Adults Captured (recaptured)
2013	25 (6)	14 (11)
2014	28 (2)	31 (14)
2015	48 (2)	18 (12)
2016	35 (2)	21 (7)
2017	18 (-)	5 (-)

Gaussian distribution. We used in both models the "lmerTest" (Kuznetsova et al. 2017) package for R (R Core Team 2014).

To estimate a long-term population growth rate, we ran the same methodological approach used by Garcias and Tavecchia (2018), by building a 2 × 2 population prebreeding model (Eq. 1) (Caswell 2001).

$$\begin{bmatrix} FS_{FY} & FS_{FY} \\ S_{AD} & S_{AD} \end{bmatrix} \tag{1}$$

where S_{FY} and S_{AD} are the apparent survival rate of first-year birds and adults, respectively; F is the mean number of females fledged in relation to each breeding female (it is assessed as half of mean clutch size) (Que et al. 2019) multiplied by breeding success (Hiraldo et al. 1996). In this work, we considered $F = 0.966$; this value comes from the breeding parameter estimates obtained in this work (for details, see the "Results" section: $(2.8/2) \times 0.69$). The population growth rate was calculated using models assuming a stochastic approach in survival and breeding success. As in Garcias and Tavecchia (2018), we made 1000 simulations, each with a random value of survival (mean: 0.66; *SD* = 0.07; truncation within a range from 0 to 1) and breeding success (mean: 0.70; *SD* = 0.07; truncation within a range from 0.54 to 0.86), and then we calculated the mean and variance for the population growth rate. Values from survival and breeding success directly come from our own data (for details, see the "Results" section). These models were done with the package "popbio" (Stubben and Milligan 2007).

Results

Survival

From 2013 to 2017, we ringed 243 Kentish plovers overall; of them, 154 were ringed as chicks and 89 as adults (Table 1). Overall, 12 (7.8%) plovers ringed as chicks and 44 (49.4%) ringed as adults were subsequently sighted.

Overall, there were four models that fitted to the data equally well (Table 2). All of them considered that survival varied between birds in their first year of life and adults but, additionally, some models also considered that survival varied in relation to year, either for both or one of the two age categories considered. However, the fact that the models assuming this temporal effect did not differ from the one assuming constant survival for each age category must indeed be interpreted as a weak, marginal effect of year on survival, likely due to the high over-dispersion of data. Overall, we obtain a φ_{FY} estimate varying between 0.07 and 0.21 (mean value in model 1: 0.12 ± 0.04). The average estimate for φ_{AD} was 0.68 (95% *CI*: 0.54–0.78). "Recapture" probability varied in relation to year in some of the top-ranked models (including the first one), but not in others. Thus, mean annual p values ranged from 0.40 (95% *CI*: 0.22–0.62) to 0.92 (0.62–0.98) (Fig. 2).

Table 2 Ranking of the Cormack-Jolly-Seber models built to estimate the survival (φ) and recapture/resighting probability (*p*) in a Kentish plover population breeding in Lanzarote

Model	AICc	ΔAICc	AICc weight	Num. Par.	Deviance
φ_{FY}, φ_{AD}, p (year)	334.34	0.00	0.317	6	40.92
φ_{FY} (year), φ_{AD} (year), p	335.22	0.88	0.205	9	35.44
φ_{FY}, φ_{AD} (year), p	335.52	1.17	0.176	6	42.10
φ_{FY} (year), φ_{AD}, p (year)	335.71	1.37	0.160	9	35.93
φ_{FY} (year), φ_{AD}, p	337.56	3.22	0.063	6	44.14
φ_{FY} (year), φ_{AD} (year), p (year)	338.15	3.80	0.047	11	34.06
φ_{FY}, φ_{AD} (year), p (year)	339.05	4.706	0.030	9	39.27
φ_{FY}, φ_{AD}, p_{FY}, p_{AD}	339.69	5.353	0.021	4	50.43
φ, p (year)	391.25	56.91	0.000	5	99.92
φ (year), p	392.36	58.02	0.000	5	101.02
φ, p	392.94	58.60	0.000	2	107.78
φ (year), p (year)	394.77	60.43	0.000	7	99.25

AICc small sample size–corrected Akaike value, *ΔAICc* difference of AICc in relation to the first model, *Num.Par.* number of parameters, *FY* first-years (the parameter may have a specific value for the first-year birds, concretely for the interval spanning from the pre-fledging period to the next year), *AD* adults, year, the parameter may vary among years

Breeding parameters and population growth estimation

The breeding success and the clutch size did not vary statistically in relation to zone and year (Table 3). Therefore, the population had an average breeding success of 68.9 ± 7.0% (range: 53.5% in 2014 to 86.4% in 2016). The Mayfields' approach of nest success provided similar estimates, with a global mean of 58% (range: 42.8 in 2014 to 82.2% in 2016). The mean clutch size was 2.8 ± 0.1 eggs (mode: 3 eggs; $n = 126$ nests, success = 65.1%). Our stochastic population model provided a growth rate of 0.80 (95% confidence interval: 0.66–0.94), i.e., the population was declining at an annual rate of 20%.

Discussion

Population parameters

This is the first study that investigates the demography of a Canarian Kentish plover population. The observed return rate of chicks after their natal year was 7.8%, a value higher than the rate detected in a population in Turkey (Sandercock et al. 2005). For adults, a half of them were detected at least once after the year when they were ringed. Note, however, that all these observed means depend on three factors: emigration, survival, and recapture/resighting probability. According to our analytical approach, we were unable to separate true survival from apparent survival, this last assuming both the true survival and emigration (i.e., the model has no way to separate deaths from birds that decide to leave the focal area where the birds are being surveyed to breed in other sites). However, we must notice that the flow among breeding sites situated nearby within the Lanzarote island was seemingly low (only 4% as assessed from observed data), which would indicate a high philopatry to breeding/natal sites. As high as this philopatry is, the assessed apparent survival may be closer to true survival.

Table 3 Beta parameter estimates from the models used to estimate the role of year and zone on two breeding parameters

Factor	Beta ± SE (beta)	*P*
Breeding success: Overdispersion: 1.05		
Intercept	+ 1.79 ± 299.94	0.995
zona1	+ 2.24 ± 458.17	0.996
zona2	− 0.55 ± 299.94	0.999
year1	− 6.67 ± 640.19	0.992
year2	− 1.99 ± 299.94	0.995
year3	+ 3.73 ± 412.23	0.993
zona1:year1	+ 2.92 ± 727.87	0.997
zona2:year1	+ 7.08 ± 640.19	0.991
zona1:year2	− 2.37 ± 458.17	0.996
zona2:year2	+ 1.18 ± 299.94	0.997
zona1:year3	− 8.16 ± 538.41	0.988
zona2:year3	− 4.57 ± 412.23	0.991
Clutch size: Overdispersion: 0.31		
Intercept	+ 2.78 ± 0.08	< 0.001
zona1	− 0.03 ± 0.13	0.825
zona2	+ 0.09 ± 0.09	0.347
year1	− 0.31 ± 0.16	0.058
year2	+ 0.08 ± 0.12	0.500
year3	+ 0.02 ± 0.13	0.869
zona1:year1	+ 0.13 ± 0.20	0.512
zona2:year1	+ 0.28 ± 0.17	0.105
zona1:year2	+ 0.00 ± 0.17	1.000
zona2:year2	− 0.20 ± 0.13	0.143
zona1:year3	− 0.17 ± 0.19	0.361
zona2:year3	− 0.09 ± 0.15	0.565

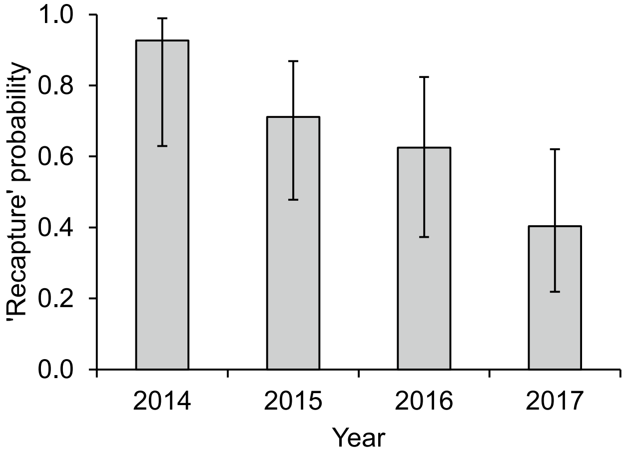

Fig. 2 "Recapture" probability (annual mean ± 95% confidence interval) of ringed Kentish plovers in Lanzarote

As expected, mean survival was much lower in first-year birds (0.12) than in adult birds (0.68). Much of this difference between age classes must be attributed to the relatively still high rates of mortality in the pre-fledging period and, maybe, the first days/weeks after fledging (Newton 1998, 2013). Note that we ringed opportunistically chicks from hatching to fledging, so our survival estimate for this age category included this period as a whole (with normally low survival) and the period from fledging to the breeding season of the next year when the first breeding event (potentially) occurs (with a higher survival rate) (Stenzel et al. 2007). To be meaningful, a comparison with other works should take into account the age at which the chicks were ringed, since survival rates between the two periods (pre- and post-fledging) are different and, therefore, odd demographic conclusions might arise if this is ignored. Our first-year survival estimation is below the value of 0.476 provided in a population from southern Iberia, obtained from direct observations of resighting data of chicks ringed at a time from hatching to fledging (Fraga and Amat 1996). However, our estimation was within the range found for a population from Turkey (Sandercock et al. 2005). In this population, the mean apparent survival of first-year birds from hatching to the next year was 0.09, 0.15 if we only consider survival from fledging to the next year (Sandercock et al. 2005). In California (USA), mean survival from hatching to fledging for the Snowy Plover *Charadrius nivosus* was 0.38 and from fledging to the next year, it was 0.46. So, the mean annual survival was estimated to be 0.18 (Stenzel et al. 2007), a value that is within the range found for the plovers from the Canary islands. Note, however, that as in our study many chicks in all age ranges were marked at a time closer to fledging than in other studies, we were likely subestimating the mortality from hatching to fledging (Colwell et al. 2007). Therefore, our estimation may be conceptually closer to the 0.46 value given by Stenzel et al. (2007) for the post-fledging period of the Snowy Plover in California. Overall, therefore, it can be concluded that first-year survival in our population had a low value but still within the range found in other plover populations.

Causes underlying such a low first-year survival rates are still unknown. Part of this result undoubtedly should be attributed to pre-fledging mortality (Stenzel et al. 2007), which would be caused by both depredation and disturbance of human-origin. In this line, the number of tourists in Lanzarote increased 37% throughout our sampling period, from 2,294,000 in 2013 to 3,146,000 in 2017 (source: Cabildo de Lanzarote). Moreover, both humans and dogs are known to cause mortality in Kentish plover chicks (Ruhlen et al. 2003; Gómez-Serrano 2021). In this context, according to our experience, the majority of the sites where the Kentish plover breeds in Lanzarote suffer an intense use by people and dogs, especially if the sites are situated close to human settlements (Tejera and Rodríguez 2014). Due to these causes, the species may be displaced to suboptimal areas to breed and feed, further reducing the survival (Kosztolányi et al. 2007; Kober and Bairlein 2009).

The overall nest success was ca. 60% (after Mayfields' approach). In other areas, the breeding success ranges between 22 (United Arabic Emirates; Kosztolányi et al. 2009) and 65% (NE Spain, Portugal; Ballesteros and Torre 1993; Ferreira-Rodríguez and Pombal 2018). Overall, we expected higher survival estimates on islands due to their reduced predator guilds (George 1987; Blumstein and Daniel 2005; Covas 2012), and in this context, Lanzarote seems to fit the role. In Lanzarote, the list of potential natural predators of either eggs or chicks is small, including the Atlantic Lizard (*Gallotia atlantica*), the Common Kestrel (*Falco tinnunculus*), the Barbary Falcon (*Falco peregrinus pelegrinoides*), the Eleonora's Falcon (*Falco eleonorae*), the Common Raven (*Corvus corax*), the Yellow-legged Gull (*Larus michahellis*), and the Grey shrike (*Lanius excubitor koenigi*) (G. Tejera, pers. obs.). Introduced species like feral cats (*Felis catus*) and rats (Rattus sp.) are potential predators (Lorenzo and Barone 2007). In addition to effects as direct predators, introduced mammals might also cause a negative impact on breeding success because of disturbance effects (Woinarski et al. 2017; Greenwell et al. 2019; Kays et al. 2020).

Regarding adults, our estimation (with a 95% *CI* of 0.54–0.78) was within the survival range found for other populations of Kentish/Snowy plovers (0.58–0.88 in Utah; Paton 1994, 0.64 in Turkey; Sandercock et al. 2005, 0.70 in California; Stenzel et al. 2007, 0.76 in Mallorca, Spain; Garcias and Tavecchia 2018). This suggest that, generally, adult survival rates seem to be fairly homogeneous among populations, supporting the conclusion that it is nesting success and first-year survival, but not adult survival rates, the parameters with a higher demographic weight (i.e., a higher effect on population growth rate) on Kentish plover populations (Garcias and Tavecchia 2018).

The mean clutch size observed in Lanzarote (2.8 eggs) is within the range of studied populations, such as, for example, 2.3 eggs in Morocco (El Malki et al. 2018), 2.5 eggs in Arabia (AlRashidi 2016), 2.7 eggs in Italy and Algeria (Pietrelli and Biondi 2012; Bouakkaz et al. 2017), or 2.9 eggs in Spain and Morocco (Hanane 2011; Vidal and Domínguez 2015).

Population trend

We estimated a negative population growth rate, with an annual loss of 20% (range: 6–35%). Even though the population was not properly, systematically censused from 2013 to 2017, we assessed a population size (number of adult breeding pairs) of ca. 70 pairs in 2013, but only 55 in 2017, thus implying a decrease of 21.4% (G. Tejera, unpubl. data), which gives rise to an annual decrease of 6%. The predicted figure would result in a population of 12 (70×0.65^4) to 55 $(70 \times 0.94)^4$ pairs for the period 2013–2017, a range which falls within the observed decrease. Future work should concentrate in developing a robust yearly monitoring program to obtain a fine assessment of the population size and check the possible mismatch (if any) between real estimates and predictions. Finer (with lower associated error) parameter estimates, feasible with larger data sets, will contribute to develop more precise models. Exploring the causes underlying such a possible mismatch is crucial to detect some important demographic processes (Colwell 2010). For instance, a certain rate of immigration from nearby source population (e.g., from Fuerteventura) could help to soften the negative trend that would be obtained if the Lanzarote's breeding population would only depend on its own. Almalkl et al. (2016) did not find genetic similarity between the population in northern Africa with the one in the Canary Islands, which makes unlikely mainland African populations to be a source for breeding Kentish plovers in Lanzarote.

Conservation implications

In the Canary Islands, the Kentish Plover should be of special conservation concern given its morphological and genetic differences with mainland populations (Küpper et al. 2012; Almalkl et al. 2016). The negative growth rate assessed in our study may be exacerbated by an annual increase in tourist pressure (Gómez-Serrano et al. 2021). As stated by Colwell (2010), human activity has the potential to negatively affect the productivity and survival of waders and consequently their population dynamics. Our results highlighted the low survival of first-year birds in Lanzarote, so conservation measures must be focused first in understanding its proximate causes and then in minimizing their effects. By sure, in the Canary Islands, human activities are constraining long-term conservation of Kentish Plover as the species has disappeared from several sites following increases in tourism's development (Lorenzo and Barone 2007), and since dense human populations occur there and local economy is based on tourism's industry, those related to recreational use must be of concern. Kentish Plovers can tolerate relatively intense human disturbances in their breeding sites (Tejera and Rodríguez 2014); however, a negative impact on its long-term population trend could arise as several studies have demonstrated that tourism pressure could affect both habitat availability, chick survival and productivity of beach-nesting plovers by producing soil and vegetation changes and intensifying human disturbance (Ruhlen et al. 2003; Montalvo and Figuerola 2006; Yasué and Dearden 2006). Moreover, breeding Kentish Plovers are more sensitive to the presence of walkers when they are accompanied by dogs (Gómez-Serrano 2021). In our study areas, the presence of people accompanied by dogs seems to be increasing during the last years, and although in Arrecife local authorities have tried to regulate the recreational use of some beach sectors, the Janubio salt pans are becoming a popular site for dog walking, even using the lake as a training site where several nests were destroyed (pers. obs.). Contrary to Lanzarote, the Kentish plover population in Mallorca island, also a popular tourist destination, is increasing, which may be due to the fact that in such island, the plovers breed not only in sandy beaches frequented by people, but also in salt marshes where the chicks may not experience so many disturbances (Garcias and Tavecchia 2018).

In summary, precise local studies addressing the effects of human disturbance on survival, breeding rates, and demography are required to assess and predict human impacts, and hence to develop precise conservation actions in Lanzarote. It would be also highly recommended to consider the Kentish plover population in Fuerteventura together with the Lanzarote population, as there is a likely interchange of individuals between both islands (as shown by some ring-recovery data, G. Tejera, unpubl. data). The conclusions from other studies where breeding plovers face similar threats suggest that minimizing human disturbances could help to improve chicks' survival (Dowling and Weston 1999; Colwell et al. 2007). For management actions to be effective, it is required that the more critical areas for plovers' survival are identified and effectively protected. As the majority of important areas for Kentish Plovers are within the Canarian Network of Natural Protected Areas, the Kentish plover could act as an umbrella species, so that the proposed measures would help to improve the conservation status of other species in these fragile and endangered ecosystems.

Acknowledgements Many thanks to the people who helped in the fieldwork, especially to C. Armas, D. Miranda, and I. Tejera. Also to R. Toledo, for her support during this study. This research was authorized by the Canary Island Government and other local Administration. Two referees provided valuable comments that contributed to improve an earlier version of this work. G. Tavecchia helped us with handling stochastic population models.

Funding During manuscript preparation, JAA was funded by grant CGL2017-83518-P from Ministerio de Economía, Industria y Competitividad, Spain, with EU-ERDF financial support.

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