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## Half a world apart meaning

Half a world away, another father has been given the opportunity to grieve. Clinton, even half a world away, was asked about the Lewinsky scandal. Mom gave me some answers, but the rest was half a world away. Some highbrow in Chicago, half a world away from the Asian region. Half a world away, Bush said those responsible would be tracked down. They were done almost half a world away in Wellington, New Zealand.Half a world away, the apartment of Kuwait's national team coach rocked. This time the problem is half a world away in Japan.Cossard also enjoys respect in academia, half a world away. The goal was scored half a world away, on the outskirts of Moscow.It's hard to see half a world away in a sentence. The country was torn apart by a misguided war half a world away. Wattman is half the world away for Kao executives. Television received by satellite dish from a broadcast site half a world away. They come from half a world and they've heard a lot about us. The excitement of a regular-season game was really half a world away. The country was deep in a bloody, pointless war. An urge, deep and strong, prompted him to travel half a world away. But half a world away, it was a different story. But his music can easily send away listeners who live half a world. Thursday, that dream came true, half a world away. This has become a topic of discussion between my group of friends. If someone was half a world away from Los Angeles, that's 6 hours away (like Brasilia, Brazil), which is half the distance between the two planetary axes, or it's 12 hours away (like Brisbane, Australia), which is half the total planetary circumference. Debated between here or r/trancecirclejerk, but actually just looking for the majority answer ty. Page 2 29 comments Open Access Peer-reviewed Distant populations of animals may share their non-breeding grounds or migrate to different areas, and this may have important consequences for population differentiation and dynamics. Small burrowing seabirds offer a suitable case study, as they are often limited to safe breeding grounds on islands, resulting in a patchy breeding distribution. For example, Thin-billed prions *Pachyptila belcheri* have two large breeding colonies more than 8,000 km apart, on the Falkland Islands in the southwest Atlantic and in the Kerguelen Archipelago in the Indian Ocean. We used geocators and stable isotopes to compare sea movements and trophic levels of these two populations during their non-breeding season, and applied ecological niche models to compare environmental conditions in the habitat. In three winters, birds breeding in the Atlantic showed a high consistency in their migration routes. most individuals migrated more than 3000 km to the east, while very few remained on the Patagonian Shelf. All birds from the Indian Ocean, on the other hand, migrated to the west, resulting in an overlapping non-breeding area in the eastern Atlantic sector of Southern Ocean. Geologists and isotope signature of feathers indicated that prions from the Falkland Islands have slightly higher latitudes than those of Kerguelen Islands. All birds fed low trophic prey, probably crustaceans. Phenology differed in particular between the two populations. Falkland birds returned to the Patagonian Shelf after 2-3 months, while Kerguelen birds remained in the non-breeding area for seven months, before returning to breeding grounds very synchronously and at high speed. Habitat models identified sea surface temperature and chlorophyll concentration as important environmental parameters. In summary, we show that although the two very distant populations migrate to roughly the same area for moulting, they have different wintering strategies: They had significantly different realized niches and timing that could contribute to spatial niche partitioning. Quote: Quillfeldt P, Cherel Y, Masello JF, Delord K, McGill RAR, Furness RW, et al. (2015) Half a World Apart? Overlap in non-livestock distributions of Atlantic and Indian Ocean Thin-Billed Prions. PLoS ONE 10(5): e0125007. Editor: Ken Yoda, Nagoya University, JAPANReceived: December 22, 2014; Accepted: 19 March 2015; Published: 27 May 2015Copyright: © 2015 Quillfeldt et al This is an open access article distributed under the terms of the Creative Commons Attribution License, which allows unlimited use, distribution and reproduction in any medium, provided that the original author and source are creditedData Availability: Prions, New Island, South Atlantic, (Quillfeldt): studies.path=study63293601. Prions and petrels, Indian Ocean (Weimerskirch and Quillfeldt) studies.path=study60577066.Funding: Grants were provided by the German Science Foundation DFG (Qu 148/5). Fieldwork at Kerguelen was supported by IPEV (Programme 109 to HW). RWF was supported by NERC Grant NE/I02237X/1. The funders had no role in the design of the study, collecting and analyzing data, the decision to publish the manuscript. Competing interests: The authors have stated that there are no competing interests. Migratory species regularly undertake seasonal movements to and from non-breeding areas, so parts of the year are spent on wide-ranging and ecologically diverse environments. Migration behaviour is particularly widespread in birds (e.g. [1]), which show a high variability in migration connectivity. In species with high migratory connectivity, individuals from different breeding areas mix during the non-nursery season and vice versa. Other species, on the other hand, have populations that use well-defined, non-overlapping breeding and low migratory connectivity (assessed by [2]). The degree of migration connectivity can explain the transfer of effects from one season to another, as well as differences in selective pressure [2], and thus have implications for the ecology, evolution and conservation of migratory species (e.g. [3]). Migration in seabirds, it is often characterized by long distance movements [4-7]. For seabirds, oceans offer large feeding habitats, interspersed with relatively few breeding grounds on islands, resulting in a patchy breeding arrangement. Procellariiformes (petrels, shearwaters and albatrosses) are the most pelagic of seabirds, and almost all species migrate to some extent [8]. However, definitive information on their migration routes, travel distances, staging points and non-breeding areas is only known to a small minority (e.g. [9]). Migration routes of albatrosses and large petrels cover enormous distances (e.g. 64,000 km in sooty waters *Puffinus griseus* Gmelin, 1789; [4]). The few species studied in detail show preserved temporal and general movement patterns, combined with significant variability in the use of specific wintering areas within and in individuals. For example, the soot sweeper in New Zealand traveled across the equator to the North Pacific [4]. Sooty shearwaters from the Falkland Islands also migrated to the North Atlantic [10]. The timing of the movement trajectory between the southern hemisphere breeding sites and the northern hemisphere wintering areas was very similar in pacific and Atlantic breeding colonies, but the two populations showed contrasting patterns of migratory connectivity. Birds from the Falkland Islands showed high migratory connectivity: they settled in one area in the northwest Atlantic for most of the Austral winter [10]. By contrast, sooty shearwaters in the Pacific ocean showed low migratory content: birds from two breeding colonies mixed and used three separate non-breeding areas (near Japan, Alaska and California, [4]). While populations of some procellariiform species may migrate to separate non-breeding areas, populations of other species may share non-breeding areas entirely or partially under conspecifics. It has been suggested that migration behaviour can profoundly affect the genetic structure of the population: almost all seabird species with two or more population-specific non-breeding areas were phylogeographically structured [11], while other species were not. Migration behaviour can therefore be an important determining factor for the taxonomic and conservation status of seabird populations, as threats in breeding and wintering areas and along migration routes can determine the persistence of the population. Miniaturized geolocators or Global Location Sensor (GLS) loggers now allow researchers to track the movements at sea of medium to small petrels (for example [12-14]), prions *Pachyptila belcheri* (Mathews, 1912) have two major breeding colonies, more than 8,000 km apart in the Atlantic ocean and in the Indian Ocean. In a previous study that the non-breeding movements of thin-billed prions breed on the Islands (Atlantic Ocean) nineteen of the 20 birds migrated to an area >3,000 km east of their breeding colony [15]. However, it was not known whether this population consistently used the same non-breeding areas from one year to the next. In addition, the migration routes of thin-billed prions from other colonies, including the important breeding ground in Kerguelen in the Indian Ocean, were unknown. Using stable isotopes of adult feathers, Cherel et al. [16, 17] derived a moulting area in Antarctic waters from consistently very negative carbon stable isotopes ratios of Kerguelen birds, which are very similar to the values observed among Falkland birds [18]. As the Falklands birds migrated east to the Indian Ocean sector, this may indicate a common wintering area, or, alternatively, that thin-billed prions breeding on Kerguelen spend their winters at similar latitudes, but in different areas. To clarify these patterns, which may be relevant to both populations of genetic and conservation, we (1) compared year-on-year thinly-billed prions from the Falkland Islands over three winters and (2) a comparison between the population of migration movements of thin-billed prions from each of the two main breeding sites. Using geolocation loggers, we specifically sought to detect: (i) migration routes and the timing of migratory movements of breeding birds in the Atlantic and Indian Ocean, (ii) possible overlaps in the wintering areas used by the two main colonies of the species, and (iii) to investigate the annual variation in timing and destinations of migratory movements. The isotope niche of the two populations during moulting was examined to provide additional information on nutrition during the non-breeding period. Feathers reflect the diet at the time they were grown because keratin is inert after synthesis [19, 20]. In thin-billed prions, adults do not moult while attending the breeding ground and birds return to the colony in the spring with moulting completed. The adult moult is believed to occur after completion of the breeding cycle, mainly from March to May [21]; hence feathers stable isotope values are likely to reflect the autumn foraging ecology of the species. Thin-billed prions breed on islands off The Coast of South America and in the Indian Ocean; there are several million birds in the islands Falkland and Kerguelen, a smaller population on Isla Noir (southern Chile) and a very small number (10-20 pairs) on the Crozet Islands [21]. They show the typical procellariiform pattern of a single-egg clutch and slow chick development. Thin-billed prions feed mainly on crustaceans during the breeding season and show some in diet within and between years [16, 17, 22]. To investigate spatial movements, we have attached small leg breeding focators (MK10, developed by British Antarctic Survey, Cambridge, UK) to breeding adult thin-billed prions over three years on New Island, Falkland/Malvinas Islands (51°43'S, 61°18'W) and a year on Île Île Kerguelen (49°28's, 69°57'E, for sample sizes, see Table 1). All animal work has been carried out in accordance with relevant national and international guidelines. All sampling procedures and manipulations were reviewed or specifically approved as part of the field permit. Access to private land, field procedures and animal manipulations was approved by the New Island Conservation Trust, the Falklands Government (Environmental Planning Office), the Committee for Animal Ethics of the Institut Polaire Français Paul Emile Victor) and by the Pr  fet des Terres and Antarctiques Françaises. Nests were selected based on accessibility, and on New Island, the presence of individuals known from previous years, to maximize the chances of recapture. The birds were caught by hand on marked nests during incubation. Geolocators weighed 1 g (<1.1% of the average body mass-130 g of thin-billed prions) and were attached to plastic leg bands. Tagged persons were marked with numbered steel rings on the other leg. A blood sample for sex determination was taken from the wing vein and stored on Whatman FTA Classic cards. Caves were revisited and devices retrieved during incubation in the following season (Table 1). In the current analysis, we included data from one winter period for each individual. Because several loggers stopped recording several months before the device's recovery, the final samples for tracks were smaller year-round than for recovered datasets. In addition, some return trips could not be determined because they were affected by equinox uncertainties. As previously described [15], the return of Falklands birds to the breeding area was variable, with 5 to 177 days (median = 13 days), because while most birds returned between April and June, others visited an intermediate non-nursery for variable time periods (range = 50-145 days), and a small number remained until early September. So, for the comparison with return flights of Kerguelen birds, we recorded all the birds with a clearly directed, roughly linear retreat. A detailed study found no evidence of a significant impact of geolocators on thin-billed prions: breeding performance was unaffected in the season of attachment or after recovery: eco-physiological measurements suggested that adults were adapting to the higher load; and the similarity in stable isotope ratios in blood and feathers of insite adults and controls indicated that the general diet and distribution were unaffected [23]. Geolocators offer two positions per day based on light levels, with an accuracy of approximately 186 ± 114 km [24]. Light data was analysed using the BASTrak software suite (British Antarctic Survey, Cambridge, UK). TransEdit was used to on integrity of light curves and to determine dawn and twilight times, and Locator to estimate latitude of day length and length from the time of local afternoon versus Greenwich Mean Time. We were going out of a sun. Sun. angle of -3.5°, based on known positions obtained during the pre- and post-implementation calibration of the loggers in the colony. All estimated locations were visually examined in a geographical information system (GIS) and any unrealistic positions — either associated with interference with light curves at sunrise or sunset, or in the temporary proximity of equinoxes when latitudes are unreliable — were excluded from further analyses. This leads to a reduced number of observations for the periods around the equinoxes. We also preserved the unfiltered data, and these were used to obtain information about longitudinal movements during equinox times, for example, to define the timing of return migration that partially overlapped with equinox times. The timing of the migration was determined by targeted longitudinal movements that ended up on or outside the breeding colony longitudinal (S1 Fig). The migration timing was clearly distinguished in all migrant individuals, while return migration was determined only in those who showed a typical, distinct migration pattern (2010:16 out of 19, 2011: 9 out of

9, 2012: 12 out of 15, 2013: 5 out of 6). Centroid distribution positions in the non-growers period were examined using kernel analysis of filtered locations [24], using the locations between round and return migration. The non-parametric solid kernel density estimator was used to determine density contours. Kernel densities do not require serial independence from observations when estimating foraging ranges [25]. Kernel analyses were conducted in a Lambert equal-area azimuthal map projection centered on the South Pole using ArcGIS 9.3 (ESRI, Redlands, CA, USA) and the Hawth tool [26] (settings: scaling factor 106, single parameter smoothing factor: 105 grid, cell size 5000). The distance travelled during round-trip travel was calculated in the same projection. The sex of each bird in this study was molecularly determined by PCR using primers 2550 and 2718 that reinforce sections of the sex-connected chromo-helicase-DNA-bound (CHD) gene according to [27]. DNA was extracted from 50 µl of blood using a Qiagen DNAeasy purification kit (Qiagen, Hilden, Germany). Each response was performed in 25 µl, with 10 ng template DNA, 1 × PCR buffer, 0.1 mM DNTPs, 2.5 mM MgCl<sub>2</sub>, 0.2 µM of each primer and 0.1 U Taq polymerase (Firepol, Solis Biodyne, Tartu). Thermocycling consisted of a first denaturation step of 2 min at 94°C, followed by 35 cycles denaturation at 94°C for 30 s, annealing at 54°C for 30 s, extension at 72°C for 1 min, and ended with two expansion steps of 42°C for 1 min and 72°C for 10 min. PCR products were visualized on a 2% agarose gel, with a single band at ~650 bp indicating male, and two tires at ~450 and ~650 bp indicating a female. Statistical analyses were carried out using SigmaStat 3.5 and R [28]. We tested for normality with kolmogorov-Smirnov tests and by checking plots of data. Resources were with their standard deviations. We found no significant difference in timing, location, distances or speed of travel between men and women in data visualizations or general linear models, including site and sex as factors (all p>0.05), therefore, data from both sexes were aggregated. The realized niches of the unfolded habitat of the two populations were modeled and extrapolated using the Bio-ORACLE dataset [29], ETPO2v2g badymetry data (National Geophysical Data Center: and MAXENT 3.3.3k (maximum entropy), as previously described [15]. We used eight non-superfluous variables: 'bathymetry' (depth, m), 'Mean chlorophyll' (chlorophyll a mean, mg/m3), 'Min chlorophyll' (chlorophyll a minimum, mg/m3), 'Minus cloud cover' (minimum cloud cover, salinity (salinity average, PSU (practical salinity units)), 'SST Fronts' (sea surface temperature, range in °C above 3 × 3 grid cells), 'Mean SST' (sea surface temperature average, °C) and 'Min sea ice' (presence/absence of sea ice during annual minimum size in February, categorical). The MAXENT programme was implemented with the eight non-redundant variables for three datasets: (1) non-breeding area of Kerguelen birds, (2) non-breeding area of Falklands birds, (3) non-edding area of all thinly billed prions combined. MAXENT models were executed using the following settings: logistical output classification, resulting in values between 0 and 1 for each grid cell, with higher values indicating more similar climatic conditions and 50 replicating versions of random (bootrap) subsamples with a random test percentage of 30%. The results were summarized as the average of the 50 models, and the area below the receiver operational characteristic curve (AUC) was used for model evaluation. For projected suitable habitat maps, values below the logistics threshold for 10th percentile training were removed. The isotope method has already been applied in the Southern Ocean, with δ13C values of seabirds indicating their latitudinal foraging habitats [18, 31] and their δ15N values increasing at trophic levels [31]. Stable isotope values of feathers grown in the non-rearing area (lower back/hull feathers in Kerguelen birds, a small segment of the inner barge of the inner primary in Falklands) were collected during the retrieval of the geolocators. Becker et al. [32] found a small but significant difference in δ13C values (0.6‰). The (dark) primary feathers were slightly depleted in δ13C, compared to the (white) breast feathers, and 0.6‰ is a typical difference when comparing black and white feathers [33]. However, the difference observed by Becker et al. was much smaller than the difference observed here (1.8‰), and we also used pigmented feathers (grey lower back/ hull feathers and slightly pigmented parts of the primaries) in both cases, which in both cases should result in no or minimal differences caused by pigmentation. For Kerguelen birds, a body feather was of each individual surface lipids and contaminants using a 2:1 chloroform:methanol solution for two minutes, followed by two consecutive methanol rinses. Feathers were then air dried and homogenized by cutting them into small fragments. Tissue subsamples were weighed (~0.4 mg) with a microbalance, packed in canned packaging, and nitrogen and carbon isotope ratios were then determined by a continuous flow mass spectrometer (Micromass Isoprime) linked to a basic analyser (Euro Vector EA 3024) in the LIENs laboratory at the University of La Rochelle, France. Replicating measurements of internal laboratory standards (acetanilide) indicated measurement errors <math>\pm 0.15 \leq</math> for both δ13C and 15N values. Carbon and nitrogen isotopes analyses of Falkland Island birds were conducted at the Scottish Universities Environmental Research Centre as previously described [34] at 0.65-0.7 mg spring aliquots, weighed in tin cups. The ratios of carbon and nitrogen isotopes were measured simultaneously by continuous flow isotope ratio mass spectrometry (CF-IRMS) using a Costech Elemental Analyser (EA) linked to a Thermo Finnigan Delta Plus XP Mass Spectrometer. For every 10 unknown samples, two laboratory standards were analyzed, which allowed each instrument drive to be corrected over a typical 14-hour run. Based on internal standards (tryptophan), analytical precision ( $\pm 1$  SD) was estimated at  $\pm 0.17 \leq$  and  $\pm 0.18 \leq$  for δ13C and δ15N respectively. All stable isotope ratios are expressed in  $\delta$  notation as parts per thousand (‰) deviation from the international standards Vienna-Pee Dee Belemnite (carbon) and AIR (nitrogen). A total of 48 of the 50 thin-billed prions migrated away from their breeding area (i.e. the area used during the breeding season). The two exceptions were observed in Falklands birds in 2010 and 2011 that remained above the Patagonian shelf during the non-breeding season. The outgoing migration took place immediately after a failed breeding attempt or after the chick was a full-fledged, resulting in two migration peaks. For successful breeders, the migration was 5 days earlier from Kerguelen Islands (average February 18, range February 5 to 27) than the Falkland Islands (average February 23, range February 14-28, Table 2). The duration, distance and speed of travel of the migration outwards were comparable for the two populations (Table 2). Kerguelen birds moved west along the Antarctic continent where they encountered easterly tail winds. Both populations migrated to a previously described non-rough area, located between 30°W and 30°W, and 50°S and 65°S (Fig. 1). The areas (95% kernel) used by individual birds in the non-breeding area (i.e. between outward and return migration) were extensive and their size did not differ between birds from Kerguelen falkland islands (Table 2). The centroids were located further northeast for birds from Kerguelen (Table 2). The average distance between the non-breeding area centroids and the breeding colony was 700 km further away for birds from the (Table 2). Download: PowerPoint scrolls larger image original image Fig 1. Migration of thin-billed prions from the Falkland and Kerguelen Islands, tracked using geolocators. In the top map, small dots indicate positions registered in the non-breeding area, while large symbols represent the breeding colonies (squares without black margins) and the centroid positions of 95% kernels for each individual. The bottom map shows round-trip naels. populations showed a characteristic seasonal pattern of latitudinal distribution (fig 2), with the lowest latitudes reached in March, i.e. during the early post-reproduction period and the onset of the assumed moulting period. Although Kerguelen birds had similar patterns, they continued further north in March-April and showed a lesser degree of variability in their latitudinal range (fig 2). MAXENT models achieved AUC values that indicated a good model assembly (Table 3). Sea surface temperature (SST) and average chlorophyll concentration were the most important parameters, and were very important in all three models after the permutation tests. Other important parameters were minimal cloud cover (only for the non-growing area of birds form Kerguelen) and salinity (S2 Fig). The most suitable habitat during the non-breeding season was found only south of the Arctic Front (PF) for birds from the Falkland Islands, while during the non-breeding period more northern areas were predicted for thinly billed prions from Kerguelen (fig 3). When thresholds were applied (Table 3), the potential distribution of non-breeding season included areas in the Pacific and Indian Oceans. Download: PowerPoint scrolls larger image original image Fig 3. Habitat suitability models of thin-billed prions of the Falkland and Kerguelen Islands.Habitat values maxent models of the non-shaped distribution of thin-billed prions from the Falkland and Kerguelen Islands. Values below the logistics threshold for the presence of 10 percentile training (see Table 1) were omitted. Most Falkland birds remained in the non-breeding area for 2-3 months, while birds from Kerguelen spent almost 7 months there (Table 2). Falklands birds returned 5 months earlier (May 5, range April 14 to June 16) to the area around their breeding grounds than Kerguelen birds (mean October 7, range September 29 to October 10, Table 2). The return of Kerguelen birds was very synchronous (starting within 12 days), short and fast, while the Falkland birds took twice as much time and travelled at half the speed (Table 2), probably because Kerguelen birds moved east on their return, taking advantage of westerly tail winds while birds flew against the general westerlies stream. Among the thinly-billed prions of the Falkland Islands, we found no annual differences in outbound migration or the position of the target area (Table 4). The birds also started return migration on comparable dates per year and spent a similar number of days on return migration. Slight differences between the turn of the year were observed in the return migration speed and the length of the track (Table 4), indicating that birds varied in their straightness of the journey. With regard to the feathers grown in the non-breeding season, a thinly billed prion of the Falkland Islands that spent the winter on the Patagonian shelf that was clearly separated from other studies birds had high (relatively enriched) stable isotope values (δ13C = -16.0 ‰, δ15N = 13.8 ‰, fig 4). Of the remaining birds, all of which had migrated, Kerguelen's had higher δ13C values (-23.1 ± 1.4 ‰) than birds from the Falkland Islands (-24.9 ± 0.8 ‰, t = 4.6, d.f. 37, P<0.001, fig 4). The values of the spring δ15N also differed between the two populations (Kerguelen: 8.6 ± 0.4 ‰, Falkland Islands: 8.0 ± 0.7 ‰, t = 3.4, d.f. 37, P = 0.002, fig 4). With an isotope estimate of the Arctic Front at -21.2 ‰ for feathers [30], all but one bird from the Falkland Islands and all but one bird from Kerguelen Islands diamond on the Arctic front and further south, with most prions renewing their feathers in high Antarctic waters. Download: PowerPoint scrolls larger image original image Fig 4. Stable isotope analyses of thinly billed prions from the Falklands and Kerguelen Islands.Feather δ13C and δ15N values of thinly billed prions from the Falkland Islands (green) and Kerguelen Islands (red) grown in the non-growing area in 2010 and 2012, respectively (N = 20 per year). Note a thin-billed prion of the Falkland Islands with very high stable isotope values (marked as an outlier). This bird did not migrate, but spent the entire non-nursery season on the Patagonian Shelf. The signature of cape petrel chick feathers (CP) and snowy bird (SP) from Adélie Land illustrates the δ13C values of species known to fetsih in high Antarctic waters, where they feed primarily on crustaceans and fish, respectively [53], unpublished data from authors); the signature of chick down from black-browed albatross of New Island refers to a species that foraging over the Patagonian shelf and feeds on high trophic level prey [54, 55]. We used geocators to compare the distribution of thin-billed prions of the two largest populations of the species, namely in the Falkland and Kerguelen Islands. We found that the two populations located more than 8,000 km apart used common moulting grounds located in Antarctic waters halfway between the two sites. These common lands were reached by most individuals in the fall just after breeding. We have similar migration patterns and phenologies data collection for Falklands birds for 3 years. Furthermore, we found a species-specific latitudinal pattern, albeit with a preference for slightly more southern latitudes during moulting in thinly-billed prions of the Falkland Islands. The most striking differences between the two populations were the length of stay in the eastern Atlantic Ocean of the Southern Ocean, and thus the timing of homeward migration. The outbound migration of both populations was relatively straight and immediately after the breeding season or failed breeding attempt. While Kerguelen birds remained in the same broad sector until winter, Falklands birds moved back across the Atlantic to winter close to the breeding grounds above the Patagonian shelf, indicating that the two populations have contrasting wintering strategies (Table 2, fig 2 lower panel). Most of the thin-billed prions of the Falkland Islands spent on average just over 80 days in the eastern Atlantic sector of the Southern Ocean. The δ13C values of the first primaries indicated that birds moult there and thus the primary purpose of the trap movements of Falklands birds is to migrate to high Antarctic waters for moulting. In an earlier study, data on the series of primaries 1 to 10 indicated that most thin-billed prions of the Falkland Islands spent the entire spring moulting time in a latitudinal area, only one of the five birds had increasing δ13C values indicating movement to lower latitudes during moult [35]. Unlike Falkland birds, thin-billed prions from Kerguelen remained in the eastern Atlantic sector of the Southern Ocean for more than 200 days, on average. This extended period includes the moulting period, which takes place during the 2-4 months following the breeding season [36], and the rest of the non-breeding period in the winter. Then, at the beginning of the courtship period, in October, the birds return to the breeding ground. Previous studies on seabird migration have focused mainly on species-specific migration strategies. For example, thin-billed prions and closely related Antarctic Prions (*Pachyptila desolata*, Gmelin 1789) from the southwest Atlantic have divergent patterns of migration, resulting in almost complete spatial segregation [15]. In another example of related species, eastern and northern rockhopper penguins (*Eudyptes chrysocome filiholi* Forster, 1781 and *E. moseleyi* Mathews &amp; Iradale, 1921) overlapped in their spatial distribution in the Indian Ocean, but avoided significant overlap by a temporary delay of two months [37]. However, some studies have also compared migration strategies between different populations of the same seabird species. North Atlantic and Mediterranean populations of Cory's shearwaters *Calonectris diomedea* (Scopoli, 1769) used three common wintering areas, associated with up-welling systems of the tropical and southern Atlantic Oceans [5]. Together with the current study, this suggests that the use of wintering areas by different populations, found at great distances from the breeding colonies, may also occur in other pelagic seabirds. The current study is mainly because the two populations arrive at the common breeding grounds from the opposite direction. The routes of Kerguelen birds appear to have been selected, so birds use favourable winds on both the outwards Return. They first traveled west along the Antarctic continent where they use the prevailing easterly winds, and then travelled further north on their return journey using the westerly wind current. Other petrels are also known to select favorable wind conditions on their migration [38, 39]. On the other hand, the routes of Falklands birds do not seem so optimal, indicating that the location of common moulting grounds has led to contrasting migratory strategies for the separated colonies. The simultaneous use of GLS and SI enabled us to investigate the spatio-temporal location of the occurrence of seabird moulting, and suggests that the falkland and Kerguelen thin-billed prion wintering areas overlapped only in a small part of the moulting areas, and that the two populations had different distributions with different habitat characteristics. Similarly, neighbouring populations of diving seabird species avoid overlap in winter areas (e.g. eastern rockhopper penguins [37], southern rockhopper penguins [40]). This highlights the need for resource distribution at the level of the population of seabirds, even in winter, as has been demonstrated for the breeding season when chick supply of seabirds is more restricted by foraging at the central site [41]. In addition to the population differences, we also saw individual migration differences (fig 5). Two Falkland individuals did not move to the eastern Atlantic to moult, but remained over the Patagonian Shelf. For example, the Falklands population shows migration morphism within the population similar to partial migration, with resident and migrant individuals. This has also been proposed using stable isotope analysis [18]. However, stable isotope data also indicated that while most individuals repeated their choice of winter area, individuals can also switch from year to year between the two strategies [35], demonstrating phenotypic plasticity rather than genetically fixed strategies. Download: PowerPoint scrolls larger image original image Fig 5. Individual variability of year-round longitudinal positions of thin-billed prions. Birds were followed using geolocators, from Kerguelen (top panel, in red) and the Falkland Islands (lower panel). Birds that exhibit unusual migration timing are marked with arrows. variability in winter fenology was further underlined by the large dispersion in exchange times in both populations (fig 5). For example, a Falkland bird in 2010 remained in the eastern Atlantic sector of the Southern Ocean until early September (Fig 5, marked with an arrow). An exception to the general pattern of movement was also seen in one of the 15 Kerguelen birds. This bird first emigrated to the but had migrated back to waters south of Kerguelen from 4 to 10 June, and from there to the northeast, to a easternmost point at 105°E, 41°S on 5 July 2012. The bird remained east during the end August, before entering the waters around Kerguelen in September (Fig 5, marked with an arrow). It has been suggested that various factors, such as resource competition, predation risk and intraspecific niche diversity, may work synergistically to create complex patterns of migratory polymorphism within populations [42]. A degree of phenotypic plasticity in phenology and the location choice of bird migration is crucial for the ability of organisms to respond to naturally occurring environmental variability and climate change. The selection can therefore give preference to highly plastic individual migration fenologies in variable or changing environmental conditions [43]. This should become even clearer in long-lived birds, such as thin-billed prions. Most Falklands spend the first part of winter in the eastern Atlantic and we can conclude from the stable isotope data that primary moulting occurs in this area (see also , for example,[35]). The moulting areas found in the current study are also used by other types of Procellariiformes for moulting, such as Light thrifed soot albatrosses *Phoebastria palpebrata* Forster, 1785 (HW unpublished), suggesting that this sector of the southeast Atlantic ocean could be an important place for several southern ocean species. This is an open water area of 2000-4000 m depth. Why it is used during moulting by populations arriving from the western Atlantic and Indian Ocean is not known, but it is likely that prey concentrations play an important role, especially during this energetically demanding period. Thin-billed prions feed mainly on zooplankton during the breeding season [16, 17, 22], and ventral isotope values indicated that low trophic levels are maintained during moulting (Fig 4). Thin-billed prions feed mainly on zooplankton in the size range of 8-15 mm (mainly euphausiids and amphipods). Although the Southern Ocean is dominated by zooplankton of two sizes, i.e. <math>\leq 10</math> mm (e.g. oesopod lobsters) and 20-50 mm (e.g. Antarctic krill *Euphausia superba*, Dana, 1850, [44]), the 4-28 mm large hyperiid amphipod *Themisto gaudichaudii* (Guérin-Ménéville, 1825) is an abundant zooplankton in the intermediate size class, and turned out to be the main prey item for billing prions of both the Falkland and Kerguelen Islands [16, 17]. Themisto gaudichaudii is a cold water species spread in the southern hemisphere and has been described as a voracious carnivore that often occurs in huge swarms. In the Southern Ocean it can be found in the West Wind Drift of 39 °S-63°S, including the southern Patagonian and Kerguelen waters [45, 46]. In the Discovery Investigations (1925-1951), Themisto gaudichaudii was particularly present in December and March, when they were concentrated in two high-density belts south and north of the Antarctic Arctic Front, centered at 46-47°S and 53°S [47]. This corresponds to the winter distribution of the thin-billed prions, especially those of Kerguelen (e.g. Fig. 2), 2). In recent decades, the westernies of the southern hemisphere have shifted poleward and increased in intensity [48], leading a southward shift of the Arctic Front [49], while Kane [47] recorded the Arctic Front south of South Africa at 49-50°S, it was given at 52°S in [50]. Therefore, the distribution of zooplankton can also be shifted, and thin-billed prions of the Falkland Islands with their more southern distribution can also feed mainly on Themisto gaudichaudii. Alternatively, krill and oarfish can be brought further south [44]. During breeding, thin-billed prions of Falkland can use copepods as a replacement when amphipods and krill are scarce [22], and the Birds of Kerguelen prey on Antarctic krill when performing long voyages [16]. Comparisons of recent and historical feathers suggested that both populations of thin-billed prions exhibited a latitudinal change in the moulting grounds to more polar waters over the last decades [17, 18]. This can be explained by the results of this study, because both populations moult within the same area. The fact that both populations exhibit similar latitudinal movements in winter (fig 2) also suggests that both populations respond to similar signals or movements of their prey. Finally, the question of why Kerguelen birds remain in the same broad sector until winter, while Falklands birds do not, can be explained by differences in abundance of prey. For the breeding season, better foraging conditions around the Falkland Islands than around Kerguelen were already proposed, based on higher chick facilities [16, 51]. If these differences persist in winter, we would expect Kerguelen birds to stay in their winter enclosures for as long as possible. Falklands birds, on the other hand, can benefit from winter spending over the Patagonian Shelf, which offers a range of abundant prey in waters above the vast shelf area and shelf slope, and the extensive and highly productive confluence zone of the Brazilian stream with the Falkland/Malvinas Stream. In addition to these boundary flows, the size of the Patagonian shelf makes the development of mesoscale fronts [52], including a number of tidal fronts throughout the year, such as the Bahía Grande Front and the Valdés Front, which supports, among other things, zooplankton populations of the favorite prey Themisto gaudichaudii. In addition, the presence in winter may allow thin prions from the Falkland Islands to better adapt the timing of reproduction to the prevailing conditions in this highly seasonal ecosystem. The results presented here show remarkable similarities and differences in migration strategies of two spatially separated populations of a small pelagic seabird. Reach from opposite directions in autumn a common moulting ground, where during the moulting season (March/May) they show some spatial segregation. In the winter (June/September) Falklands birds leave this area and so the spatial segregation is complete, except except few individuals who differ in their phenology from the rest of the population (e.g. the outlier in fig 4). Together with other studies, the behavior of these individuals suggests selection for high phenotypic plasticity, in order to cope with the variability of oceanographic conditions and thus the distribution of prey. While opposing migration directions may occur to promote population differentiation and possibly speciation, this process can be offset by phenotypic plastic individuals whose irregular distribution can lead to a successful exchange and gene flow between populations. Top panel: Year-round positions, used to reflect the main phases of the annual cycle. All longitudinal values (blue dots; lon\_all) were overlaid with filtered longitudinal values (red dots; lon\_filtered), excluding unrealistic positions — either associated with interference with light curves at sunrise or dusk, or in temporal proximity to equinoxes. Lower panel: Focused on return migration from the same person. The timing of the migration was determined by targeted longitudinal movements that ended up at or outside the breeding colony length. These were clearly distinguished in all individuals. 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