Easternmost record of an Atlantic Puffin *Fratercula arctica* in the Mediterranean Sea on the coast of Israel

Annette L. Fayet[1*] and Paolo Becciu[2]

** Correspondence author. Email: annette.fayet@gmail.com*
[1] *Department of Zoology, University of Oxford, Oxford OX1 3PS, UK.*
[2] *Animal Flight Laboratory, Department of Evolutionary and Environmental Biology, University of Haifa, 199 Aba Khoushy Ave., 3498838 Haifa, Israel.*

Abstract
We report the finding of an Atlantic Puffin *Fratercula arctica* on the Mediterranean coast of Israel in September 2018. We use morphometrics and current knowledge of Puffin movements to infer that the bird is likely from the United Kingdom (UK) or Ireland. This record is over 1500 km further east than the easternmost recovery of a British or Irish ringed Atlantic Puffin in the Mediterranean Sea to date.

Introduction
The Atlantic Puffin *Fratercula arctica* (hereafter 'Puffin') is a key species of North Atlantic breeding seabirds, with colonies all around the North Atlantic, the largest located in Iceland and Norway. Ringing recoveries over several decades suggest that a minority of birds from the western shores of the UK and Ireland winter in the Mediterranean Sea (Wernham *et al*. 2002). More recently, advances in tracking technology have allowed scientists to study the non-breeding movements of the species in detail, first from single populations (Anker-Nilssen & Aarvak 2009; Harris *et al*. 2010; Guilford *et al*. 2011; Jessopp *et al*. 2013; Fayet *et al*. 2016) then across their entire range (Fayet *et al*. 2017). These studies reveal that birds winter across the North Atlantic and adjoining seas, with key hotspots south of Greenland, in the Labrador Sea and around Iceland, and confirm that a proportion of birds breeding in Wales (18%) and Ireland (13%) spend the second half of the winter (December to February) in the western Mediterranean Sea, along the Spanish and French coasts, and no further east than Corsica and Sardinia (Jessopp *et al*. 2013; Fayet *et al*. 2016). Based on these two populations alone, over 10,000 adult Puffins may visit the Mediterranean Sea each winter. Puffin ringing recoveries in the Mediterranean Sea remain, however, relatively rare and are confined to the western Mediterranean, with the easternmost recovery of a Puffin from the UK coming from Sicily (Harris 1984). Here we report the discovery of a long-dead Puffin on the Mediterranean coast of Israel in September 2018 and discuss its likely provenance based on morphometrics and current knowledge of Puffin distributions.

Description
An unringed dead Puffin was discovered on 15 September 2018 on the beach in Bustan Hagalil (32°57'N, 35°4'W), Israel (Figure 1a). The cause of death is unknown, but the bird did not appear oiled. Its state of desiccation suggested it had been on

the beach for several weeks or even months. Its beak, which still had the sheath, had two grooves (Figure 1b), and the bird appeared to be in full summer plumage with full-length primaries (i.e. was not in moult) (Figure 1c). Morphometrics measurements, made with a vernier calliper and ruler (with an accuracy of 1 mm), are provided in Table 1, along with average measurements from other countries for comparison. Due to the missing inner sheet and horny rim of the bird's upper mandible, our measurement of straight bill length is likely to be less accurate than that of the wing. The bird is now part of the collection of the Steinhardt Museum of Natural History at Tel-Aviv University (voucher number AV21909).

Discussion

The bird was found long after its death and it is therefore likely that its body shrunk and that our measurements are underestimates of its morphometrics at the time of death. However, average post-mortem shrinkage in Puffins over 48 months is less than the variability between distant populations (Harris 1980); < 1 mm for the bill and < 2 mm for the wing. Based on our measurements of wing length the bird is clearly in the lower size range of the species and is therefore likely to come from a southern colony such as those in Ireland or the UK. Bill straight length was also within the range of measurements from these locations. Such an origin is also supported by the fact that only birds from these locations were found to visit the Mediterranean Sea during the non-breeding season (Fayet *et al*. 2017) and that all other Puffin recoveries in the Mediterranean have been from what has been categorised as the smaller subspecies *Fratercula arctica grabae* (Carboneras 1988), to which this bird would also seem to belong.

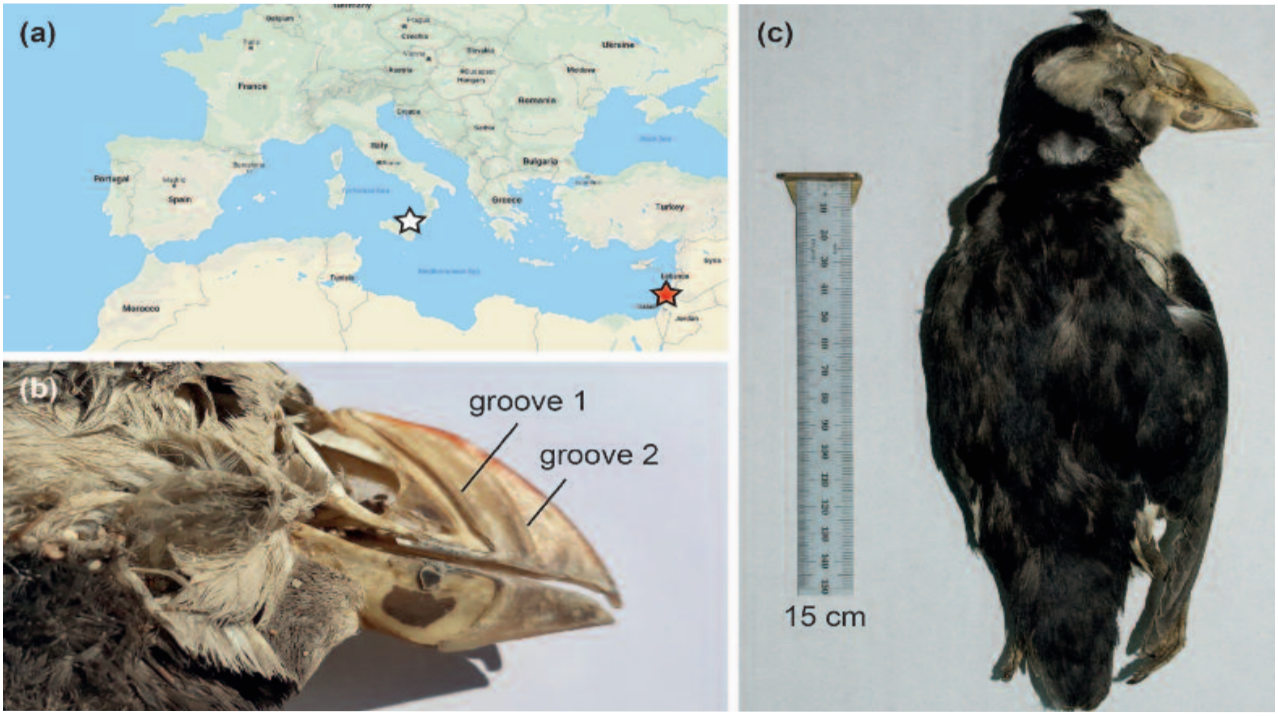

Figure 1. (a) Map showing the previous easternmost recovery of a British Atlantic Puffin *Fratercula arctica* in Sicily (white star) and the location of the new record from Israel (red star). **(b)** Bill of the Israeli Puffin, with two grooves. **(c)** Summer plumage of the Israeli Puffin, with primaries intact. Credits: (a) Google Maps, (b) Daniel Berkowic, (c) Paolo Becciu.

Table 1. Morphometrics measurements (in mm) of the recovered Atlantic Puffin *Fratercula arctica*, and mean [range] (with sample size) for adults from different locations (Harris & Wanless 2011).

	Wing length (mm)	Straight bill length (mm)
Recovered bird	155.0	30.5
Wales (Skomer)	159.3 [152–171] (200)	28.6 [25.2–31.4] (360)
W Scotland (St Kilda)	158.2 [144–170] (495)	28.2 [25.5–30.7] (276)
E Scotland (I. of May)	161.8 [149–176] (1615)	29.5 [27.1–32.0] (464)
Faeroe Islands	161.5 [152–171] (159)	28.6 [25.5–32.0] (159)
Iceland (Baer)	168.3 [169–173] (13)	30.8 [28.5–32.2] (13)
Norway (Runde)	169.5[157–179] (149)	30.5 [27.2–35.7] (130)
Spitsbergen	184.0 [178–187] (14)	31.9 [29.6–34.8] (14)

The Puffin had full summer plumage and had not started to moult its primary feathers. The number of grooves on a Puffin bill can be used to age the bird; here the two grooves suggest the bird was an adult old enough to be breeding (Harris 2014), yet when considering also the not totally smooth top ridge of the bill it was more likely a subadult bird, perhaps about four years of age (T. Anker-Nilssen, pers. comm.). It may have reached the Mediterranean Sea after the end of the breeding season (July–August), however tracking data show that breeding adults from Welsh and Irish colonies only visit the Mediterranean Sea between December and March and soon after breeding (Jessopp *et al*. 2013; Fayet *et al*. 2016). It is therefore more likely that the bird died before the start of the breeding season in spring, which is plausible given its advanced state of decomposition and the fact that its primaries were not heavily worn or bleached. Alternatively, this bird could have been a non-breeding immature (i.e. in its pre-breeding years). Very little is known about the movements of Puffins in their early years of life, but survey sightings in the western Mediterranean are highest between April and June (Carboneras 1988), when birds would be in summer plumage and when breeders would have already returned to their breeding colonies, suggesting that most Puffin sightings may be from non-breeding individuals. Considering all these indications, the timing of the discovery and the fact that three to four year old birds can also have two bill grooves (Harris 2014), we find it most likely that it was still a pre-breeding individual.

The striking aspect of this discovery is how far it was from any previous record, over 1,500 km further east than the closest British or Irish Puffin recovery in Sicily (BTO, pers. comm.). We found a single record of a Puffin sighting further east (from searches in the First Country Reports of the Handbook of the Birds of the World, E-bird, and online searches in English, French and Italian). A Puffin of unknown origin was sighted off the north-eastern coast of Italy in late May 2015 (http://www.riservamarinamiramare.it/stampa-intro/archivio-news/128-raro-avvistamento-pulcinella-di-mare-sotto-le-falesie-di-duino) — the timing here again suggests that the bird may have been an immature non-breeding bird — but this remains > 1,500km west of the Israeli coast. While it is possible that the Israeli bird was a breeder that got lost while undertaking its habitual migration to the western Mediterranean, an alternative explanation — especially if the bird was still in its pre-breeding years — is that it was exploring the Mediterranean Sea. The exploration-refinement theory, developed as an explanation for the dispersive migratory patterns and high individual route fidelity of

Welsh Puffins, speculates that Puffins may spend their early years exploring the ocean and gradually refining their migration route until they have developed a stereotypical route by the time they start to breed (Guilford *et al*. 2011). While tracking immature Puffins would be the best way to test this prediction, it currently remains very challenging, and so reporting findings of Puffins in unusual locations, such as this one, along with photographs of their bill to allow aging, will help understand the movements of the species during their early years of life.

Acknowledgements

We are grateful to the Steinhardt Museum of Natural History (SMNH) at Tel-Aviv University and particularly to Roi Dor, Amos Belmaker, and Daniel Berkowic, for letting us take measurements of the bird. We also thank the British Trust for Ornithology for providing information on previous recoveries of ringed Puffins, Mike Harris for his help aging the bird and improving the manuscript, Ela and Peleg Shilo who discovered the bird and reported it, and Graham Prescott for bringing the finding to our attention. A.L.F. is funded by The Queen's College, Oxford.

References

Anker-Nilssen, T. & Aarvak, T. 2009. Satellite telemetry reveals post-breeding movements of Atlantic puffins *Fratercula arctica* from Rost, North Norway. *Polar* Biology 32:1657–1664.

Carboneras, C. 1988. The auks in the western Mediterranean. *Ringing & Migration* 9: 18–26.

Fayet, A. L., Freeman, R., Anker-Nilssen, T., Diamond, A. W., Erikstad, K. E., Fifield, D. A., Fitzsimmons, M. G., Hansen, E. S., Harris, M. P., Jessopp, M. J., Kouwenberg, A. L., Kress, S., Mowat, S., Perrins, C. M., Petersen, A., Petersen, I. K., Reiertsen, T. K., Robertson, G. J., Shannon, P., Sigurðsson, I. A., Shoji, A., Wanless, S. & Guilford, T. 2017. Ocean-wide drivers of migration strategies and their influence on population breeding performance in a declining seabird. *Current Biology* 27:3871–3878.

Fayet, A. L., Freeman, R., Shoji, A., Boyle, D., Kirk, H. L., Dean, B. J., Perrins, C. M. & Guilford T. 2016. Drivers and fitness consequences of dispersive migration in a pelagic seabird. *Behavioral Ecology* 27: 1061–1072.

Guilford, T., Freeman, R., Boyle, D., Dean, B., Kirk, H. L., Phillips, R. A. & Perrins, C. M. 2011. A Dispersive Migration in the Atlantic Puffin and Its Implications for Migratory Navigation. *PLoS ONE* 6: e21336.

Harris, M. P. 1980. Post-mortem shrinkage of wing and bill of puffins. *Ringing & Migration* 3: 60–61.

Harris, M. P. 1984. Movements and mortality patterns of North-Atlantic Puffins as shown by ringing. *Bird Study* 31: 131–140.

Harris, M. P. 2014. Aging Atlantic Puffins *Fratercula arctica* in summer and winter. *Seabird* 27: 21–40.

Harris, M. P., Daunt, F., Newell, M., Phillips, R. A. & Wanless S. 2010. Wintering areas of adult Atlantic puffins *Fratercula arctica* from a North Sea colony as revealed by geolocation technology. *Marine Biology* 157: 827–836.

Harris, M. P. & Wanless S. 2011. *The Puffin*. T. & A. D. Poyser, London.

Jessopp, M. J., Cronin, M., Doyle, T.K., Wilson, M., McQuatters-Gollop, A., Newton, S. & Phillips, R. A. 2013. Transatlantic migration by post-breeding puffins: a strategy to exploit a temporarily abundant food resource? *Marine Biology* 160: 2755–2762.

Wernham, C. V., Toms, M. P., Clark, J. A., Siriwardena, G. M. & Baillie, S. R. (eds). 2002. *The Migration Atlas: movements of the birds of Britain and Ireland*. T. & A. D. Poyser, London.