Blue-eyed shags survived Ice Age in New Zealand

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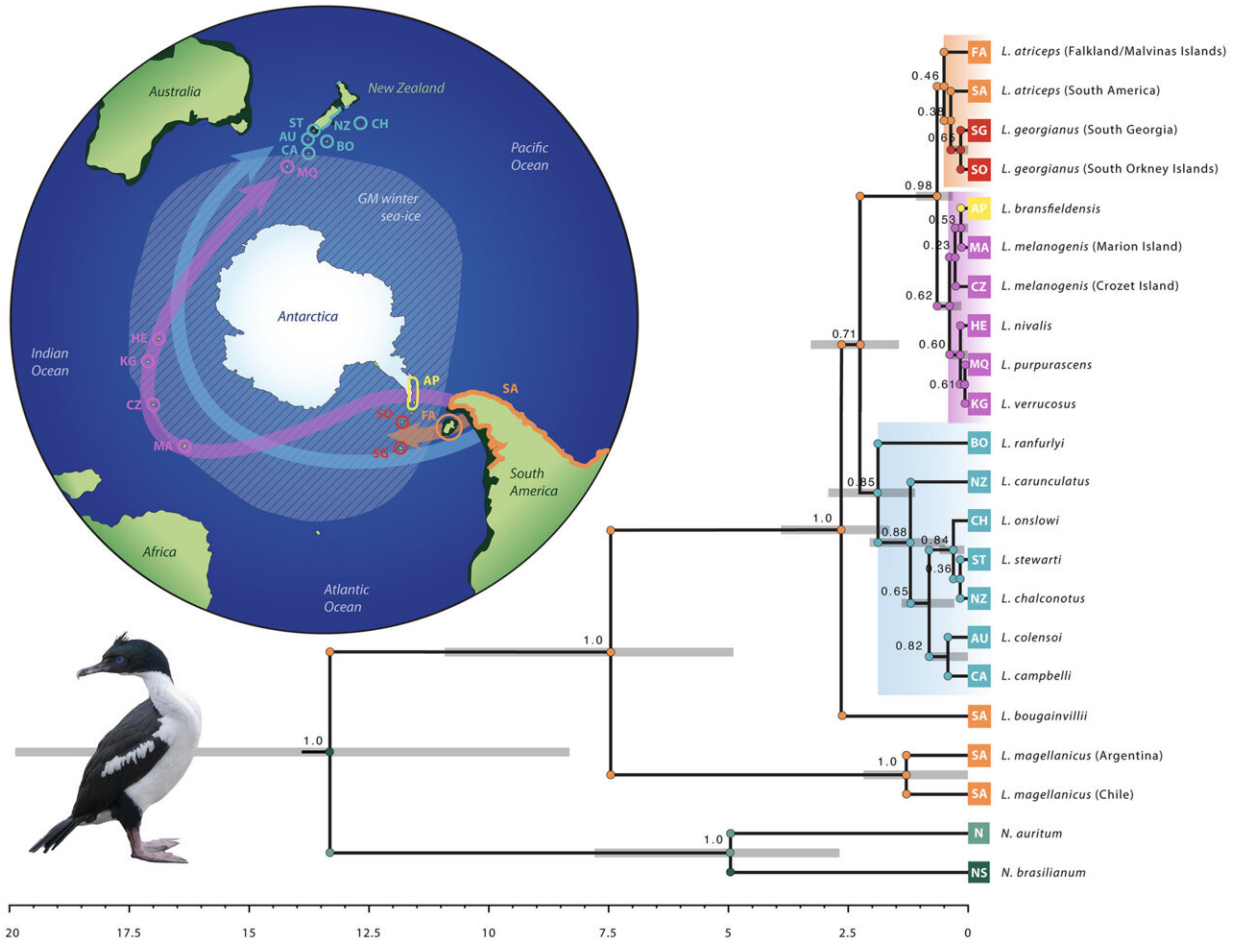

Evolutionary history of blue-eyed shags (Leucocarbo spp.) in the Southern Ocean. The map depicts inferred postglacial colonization routes (arrows) supported by the dominant westerly winds and eastward flow of the Antarctic Circumpolar Current. The extent of winter sea ice (cross-hatched pattern) and land area (dark green) during the Pleistocene Last Glacial Maximum 29–19 Kya

is indicated. Rapid circumpolar expansion and founder-speciation hypotheses are supported by temporal phylogenetic and ancestral biogeographic reconstructions. The time-calibrated species tree is derived from 8.2 kilobases of DNA sequence data (five mitochondrial and five nuclear genes) with Nannopterum as the outgroup. Node bars on the phylogeny are 95% HPD of divergence times as indicated on the scale bar (millions of years before present). Node values are Bayesian posterior probability support. Node circles show the ancestral state reconstruction of the geographic distribution based on the DEC + J model. Colors and abbreviations are as follows: Orange: South America; purple/red: High-latitude sub-Antarctic islands; yellow: Antarctic Peninsula; blue: New Zealand region; olive: North America; dark green: South America; FA: Falkland/Malvinas Islands; SA: South America; SG: South Georgia; SO: South Orkney Islands: AP: Antarctic Peninsula; MA: Marion Island; CZ: Crozet Island; HE: Heard Island; MQ: Macquarie Island; KG: Kerguelen Island; CA: Campbell Island; AU: Auckland Island; NZ: Mainland New Zealand; ST: Stewart Island; CH: Chatham Islands; BO: Bounty Islands; N: North America; NS: North and South America. Clade and arrow colors: Orange: South America, South Georgia, South Orkney Islands; purple: Antarctic Peninsula, high-latitude sub-Antarctic islands; blue: New Zealand region. Credit: *Journal of Biogeography* (2022). DOI: 10.1111/jbi.14360

The genetic whakapapa of New Zealand's blue-eyed shags stretches back millions of years—outliving their close relatives throughout the Ice Age—University of Otago research has found.

Their history has led lead author Dr. Nic Rawlence, of the Department of Zoology, to call the humble seabird, with 17 different species and subspecies, "the canary in the Southern Ocean coal mine" in relation to the susceptibility of blue-eyed shags to climate change and human disturbance.

"Their dynamic and rapid responses to past, and potentially future climate change should be a warning to us all about how fast ecosystems

can change," he says.

The DNA study, published in open access *Journal of Biogeography*, found New Zealand's blue-eyed shags, which include the extinct Kohatu shag, and among others the living King, Otago and Foveaux shags, originated in South America millions of years ago.

"Many New Zealand birds trace their ancestry to Australia, so to find linkages to other parts of the world is quite rare and fascinating."

The group expanded to Antarctica and then into the high-latitude sub-Antarctic Islands and the New Zealand region around 2.5 million years ago, surviving in New Zealand throughout the Ice Age.

"In contrast, any blue-eyed shags on the Antarctic Peninsula and sub-Antarctic islands outside the New Zealand region—like South Georgia, South Orkneys, Marion, Crozet, Kerguelen, Heard, and Macquarie—got knocked out repeatedly with each cold glacial cycle, followed by rapid recolonization from South America during each warm interglacial cycle," Dr. Rawlence says.

The researchers were surprised by how these extinction-recolonization processes played out across such a large area of ocean and the speed with which they occurred.

"While the first wave of blue-eyed shags out of South America survived in the New Zealand region, and their South American homeland throughout the Ice Age, those in the intervening areas were no doubt repeatedly knocked out with each glacial cycle by sea ice and ice/snow cover. The speed with which these high-latitude areas were recolonized surprised us all.

"While we know a lot about how animals responded to the Ice Age in the

Northern Hemisphere such as contracting into and expanding out of glacial refugia, it is great to now know how one group responded in the Southern Ocean.

"The distribution of different blue-eyed shags across the Southern Ocean makes them a great natural laboratory to study rapid evolution, much like the famous Darwin's finches in the Galapagos Islands."

With more of their history understood, and with increasing global temperatures, the future of these present-day populations in a changing world is unknown.

More information: Nicolas J. Rawlence et al, Rapid radiation of Southern Ocean shags in response to receding sea ice, *Journal of Biogeography* (2022). DOI: 10.1111/jbi.14360

Provided by University of Otago