Will vagrancy rates in the movement of migratory bird species increase with human induced environmental changes?

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Paper: Migratory bird species trade off the hazards of migration for favourable environmental conditions at their "breeding" and "wintering grounds". The extent of the migration ranges from short hops for altitudinal migrants to 15,000+ kilometre epics for trans-equatorial migrants. While some of the long distance migrants can fly direct from start of finish, others need to break their journey to rest and refuel.

While migratory birds are good navigators and tend to follow set routes, some individuals do get off-route. This typically happens when they get confused (and fly in the wrong direction) or they are forced off course by adverse weather conditions. Birds that are well out of their normal range are termed vagrants, and birds that turn up on the wrong continent tend to get birdwatchers excited (and be intensively observed once discovered).

While all four of these shorebirds are trans-equatorial migrants, the Lesser Yellowlegs on the left would normally winter in South America

While migratory shorebirds to be quite specific in their destinations, other long distance travellers are quite dispersive away from their breeding grounds. Many seabird species, for example, become foraging vagrants when they are not breeding. Do the origin-destination species have sufficient plasticity in their natures to alter their migration patterns in response to environmental changes?

This question is becoming increasingly relevant as human induced environmental changes are progressively increasing the pressure on migratory species. On the one hand, anthropogenic habitat change (e.g. environmental contamination, vegetation clearance and coastal land reclamation etc) is reducing the space and resources available – not only at the breeding and wintering grounds, but also at the refuelling spots along the way (e.g. Kay 2015, Keenan 2015). On the other hand, climate change is not only affecting the timing of the environmental conditions that motivate migration (e.g. peak food supply during the breeding season) but also the sea level at key transit points and the meteorological challenges the birds face in transit (e.g. Gill 2014, Iwamura et.al. 2013). In addition, human persecution (hunting pressure) has increased in some regions, such as the Mediterranean (e.g. Birdlife International 2015).

As is the case with the high profile Monarch Butterflies in North America, the cumulative impact of these environmental pressures is seriously threatening the survival of a number of migratory species. While people in one part of a migratory species range can take action to improve its prospects in their area, there are limits to what they can have in other areas where the population has different priorities. The survival of some species may depend on their capacity to adapt to these environmental challenges, and hence, on changes to their patterns of movement.

In Europe, the changing climatic conditions are motivating changes in the winter destinations of some populations, with some opting for locations closer to their breeding grounds. Indeed, some species that now have year round access to food sources in their breeding ranges (e.g. refuse tips) have growing subgroups that are becoming sedentary (e.g. Lehikoinen et.al 2013, de la Casa-Resino 2015).

What might happen in the case of trans-equatorial migrants? While some immature and other non-breeding individuals might "sit out" a migration cycle and stay in the non-breeding range (where winter conditions are milder) for a year, it would seem very unlikely that they might "settle down" and breed there.

How might the consequences of environmental pressures on migratory species manifest in Australia? Clearly, there have been declines in the numbers of birds observed in the areas where they are expected to be. Perhaps there might be an increase in the number (or proportion) of birds overwintering in Australia. Might there also be an increase in the number of birds observed in areas where they aren't expected to be? Could such a change in vagrancy presage changes in migration patterns?

Addressing that question is beyond the scope of this paper. At this stage the focus is on developing a baseline picture of avian vagrancy in Australia.

Australia is a big region relative to the number and distribution of competent bird observers resident in the country. There is plenty of scope for vagrants to turn up in places away from the regular haunts of birdwatchers and go unnoticed.

The dataset this paper draws on is the list of records of rare or rarely reported species accepted (or under review) by the BirdLife Australia Rarities Committee (BARC). The committee is made up of panel of experienced ornithologists who vet observations of birds within Australia's territory to the boundary of its exclusive economic zone. This includes distant locations such as Ashmore Reef, and Christmas, Cocos-Keeling, Norfolk and Macquarie Islands. BARC maintains a list of rare birds recorded in Australian territory that feeds into the official BirdLife Australia Working List of Australian Birds.

BARC also maintains a review list of species (http://birdlife.org.au/documents/BARC_Review_List_v2015Jul.xls). These are typically species that have less than five documented occurrences in any five year period. It also includes rare species observed away from their regular breeding colonies (such as the Abbott's Booby), as well as any species newly observed in Australian Territory.

Abbott's Booby is a rare species that is reportable away from its breeding colony on Christmas Island.

BARC was formed in 1975. It has assessed over 800 observations, including a small number of historical records (such as an 1893 record of a Corncrake in Sydney). As of July 2015, observations of more than 190 species have either been accepted or are currently under review. While not perfect, the BARC Index of Cases is a workable compilation of avian vagrants in Australia.

Before discussing data, it is important to note that there has been a substantial increase in ornithological capacity since BARC began its work. Simply put, there are more and better informed birders with better recording equipment and communication capacity making observations across a broader geographical range now than there were in 1975. In summary:

- The ornithological literature is far more detailed and accurate. Birders have access to detailed reference books and field guides with an increasing amount of audiovisual information available via mobile IT.
- Ongoing developments in photographic and audio recording technology with linked spatial and temporal metadata are increasing the capacity of birders to provide conclusive records.
- The birding community is linked via IT enhancing the dissemination and corroboration of observations.
- There are increased rates of "birding patrols" to places where rarely seen birds are likely to occur – these include regular/monthly pelagic birdwatching trips from ports around Australia as well as regular visits to remote locations, such as Ashmore Reef and Christmas and the Cocos-Keeling Islands.

Ultimately, there are fewer "zen birds": vagrants that turn up that no one records.

An Asian Brown Flycatcher observed on a birding patrol to Ashmore Reef.

The changing pattern of observations

Looking at the data arising from the deliberations of BARC (Table 1), there was a step up on the frequency of reports submitted to BARC in the mid 1970s, followed by a second step up at the turn of the century. (The average frequency of submissions increased from 2 per year during 1966-75 to 11 per year during 1976-85 to 28 per year during 1996-2005.) These increases reflect increases in birding (observer) activity and the use of digital cameras.

Table 1: Outcome of Observations Reviewed by BARC up to July 2015

Year of occurrence	Number of occurrences accepted	Number of occurrences not accepted	Number of species accepted for the first time	Proportion of first occurrences observed on the "mainland"
Before 1961	7	3	7	60%
1961-65	2	0	2	100%
1966-70	3	1	1	100%
1971-75	7	8	6	83%
1976-80	29	22	15	100%
1981-85	36	11	20	100%
1986-90	40	3	15	80%
1991-95	52	22	21	81%
1996-00	78	25	23	70%
2001-05	142	39	29	45%
2006-10	279 (+1)	37	35	53%
2011-15	133 (+35)	17	13 (+7)	54% (+29%)

Bracketed figures are submissions under review. (Further observations of birds sighted during 2011-15 are yet to be submitted.)

Data source http://birdlife.org.au/documents/BARC_Index_of_Cases_v2015Jul.xls

Another factor that emerges from the data is that quality of the submitted observations to BARC has improved over time. Only 53% of observations made during 1966-75 were accepted by BARC. In comparison, 66% of the observations made during 1976-85, 78% of the observations made during 1986-2005 and 89% of observations made since 2005 have been accepted by BARC.

A third factor is the addition of species to the list of birds observed in Australian territory. Column 4 of Table 1 lists the number of species occurrences that accepted for the first time by BARC by year of observation. Many of these occurrences would be the first reliable observations of those species in Australia. As such, the list of birds observed in Australian territory has increased, with the number of accepted first occurrences rising

from an average of 3.6 species per year during 1976-95 to an average of 6.4 species per year during 2001-10.

A fourth factor is the number of first occurrences that were observed away from continental ("mainland") Australia. Whereas 90% of the first accepted occurrences during 1961-95 were made on continental Australia, only 50% of the first accepted occurrences during 2001-2010 were made on continental Australia. Indeed, five of the seven species currently under review for the first time were observed on distant places such as Cocos-Keeling and Macquarie Islands.

Characteristics of the species observed

Roughly half (46%) of the accepted occurrences involved terrestrial species (Table 2). These are generally not noted swimmers. While these species typically occurred in Asia, ten were resident in New Guinea.

Table 2: Classification of rarities observed

Type of species	Number of species
Terrestrial	89
Pelagic	55
Shorebird	27
Coastal	14
Waterfowl	8

A further 29% of the accepted occurrences involved pelagic species. These are typically good swimmers. Indeed eleven of these species were penguins.

Shorebirds made up 14% of the accepted occurrences. Many shorebird species are capable of long distance fights. Interestingly one-third of the shorebird species normally commuted between North and South America.

Coastal birds made up 7% of the accepted occurrences. These are mostly terns and gulls, and are good swimmers. A number of these species also occurred in the Americas.

This Laughing Gull is typical of the trans-equatorial coastal migrants from the Americas.

The overwhelming bulk of the occurrences involved mobile species (Table 3). Only one in ten would be classified as sedentary.

Table 3: Movements of rarities observed

Normal pattern of movement	Number of species
Trans-equatorial migrant	20
Long distance migrant	61
Dispersive	47
Regional migrant	37
Sedentary/local movements	19

Close to half the trans-equatorial migrants were shorebird species, a quarter were coastal species and a quarter were pelagic species. These species typically breed in the northern hemisphere and winter in the southern hemisphere.

In comparison, long distance migrants don't normally cross the equator. Many species breed in the northern parts of their ranges and winter in the tropics. Over half of these were terrestrial species, while close to a quarter were shorebirds.

Dispersive species don't have set migration routes, but range over large distances away from their breeding grounds. Close to 90% of these were pelagic species that typically ranged over the Pacific, Southern and Indian Oceans.

The remaining species were either sedentary, made local movements or migrated short distances. These were predominantly terrestrial species (89% of sedentary species and 62% of regional migrants.

Over two-thirds (69%) of species occurrences accepted by BARC were observed in mainland Australia (Table 4). Others were only observed on remote islands. For example, 14% were only seen on Christmas and the Cocos-Keeling Islands, while another 8% were only seen on Ashmore Reef.

Table 4: Location of rarity occurrences

Sighting zone	Number of species
Mainland Australia	133
Christmas & Cocos-Keeling Islands only	27
Ashmore Reef only	16
Torres Strait only	6
Macquarie Island only	4

Most of the species arriving at Christmas/Cocos-Keeling Islands (81%) and Ashmore Reef (88%) are terrestrial migrants. In contrast, the species only observed in the Torres Strait are all terrestrial residents, while the species only observed at Macquarie Island are all pelagic. While the onward trajectory of the birds arriving at Ashmore Reef and the Torres Strait might take them on to mainland Australia, the birds arriving at Christmas/Cocos-Keeling Islands would otherwise end up in the Indian Ocean. While Ashmore Reef is on a possible migration route to Australia, the Christmas/Cocos-Keeling Islands are not.

This Blue Rock-Thrush is typical of the terrestrial vagrants arriving on the Cocos-Keeling Islands.

Species removed from the BARC review list

Species with documented observation frequencies above the threshold are progressively removed from the BARC review list. Table 5 lists the species with occurrences accepted by BARC that are no longer on the review list.

Of the 22 species removed from the review list, nine are pelagic species, 5 are shorebirds, 5 are terrestrial species, 2 are coastal species and 1 is a waterfowl. Proportionally, 19% of the shorebirds, 16% of the pelagics, 14% of the coastal species, 13% of the waterfowl and 6% of the terrestrial species have been delisted.

While the delisting of some of the shorebirds may have been a consequence of birders being better able to distinguish them from visually similar species (Little Stints vs Red-necked Stints), and some of pelagics may have been delisted because more birders are going out to sea, it is possible that some are turning up in Australian territory more often than before.

Certainly, it appears that the rate at which species are removed from the list is increasing. Of the species that have accepted observations but are now not on the list, two were last accepted during 1971-80, five were last accepted in 1981-90, six were last accepted in 1991-2000 and eight were last accepted in 2001-10.

Ultimately, the delisting of a species from the review list might portent a change in the distribution of that species.

Table 5: Species removed from the BARC review list

Species	Type of bird	Pattern of movements	Year of last acceptance
Providence Petrel	pelagic	dispersive	1983
Bulwer's Petrel	pelagic	dispersive	1993
Light-mantled Albatross	pelagic	dispersive	1993
Grey Noddy	pelagic	dispersive	1995
Grey Petrel	pelagic	dispersive	1995
Kermadec Petrel	pelagic	dispersive	2000
Cooks Petrel	pelagic	dispersive	2009
Matsudaira's Storm Petrel	pelagic	long distance migrant	1996
Black Petrel	pelagic	long distance migrant	2010
Red-necked Phalarope	coastal	long distance migrant	1979
Franklin's Gull	coastal	trans equatorial migrant	2015
Common Redshank	shorebird	long distance migrant	1983
Asian Dowitcher	shorebird	long distance migrant	1985
Little Ringed Plover	shorebird	long distance migrant	2003
Pin-tailed Snipe	shorebird	long distance migrant	2005
Little Stint	shorebird	long distance migrant	2010
Garganey	waterfowl	long distance migrant	1989
Eastern Yellow Wagtail	terrestrial	long distance migrant	1984
Grey Wagtail	terrestrial	long distance migrant	2006
Oriental Reed Warbler	terrestrial	long distance migrant	2007
Red-rumped Swallow	terrestrial	sedentary/long distance migrant	2006
Barn Swallow	terrestrial	trans equatorial migrant	1974

Looking ahead

BARC's Index of Cases provides an historical transect of the arrival of vagrants in Australian territory over the last four decades. It provides a background picture for the analysis of vagrancy patterns in Australia.

The record shows that some species (such as American trans-equatorial migrants) are susceptible to very large navigational errors (possibly initiated by extreme weather events). It also shows the potential for range extension in the case of some species that normally show up in South-East Asia and New Guinea (such as Spotted Whistling ducks increasingly reported on Cape York Peninsula).

Previously there was limited observational data on the birds visiting Ashmore Reef, Christmas Island, and the Cocos-Keeling Islands. An ongoing increase in the number of

and variety of terrestrial vagrants arriving at these sites may be indicative of environmental pressures motivating changed migratory behaviour.

Overall it appears possible that vagrancy rates are increasing, but more time is needed before a clear signal is available in the BARC data. It might be another ten years or more before that occurs.

The South Island Oystercatcher (ex New Zealand) can be difficult to differentiate from Pied Oystercatchers. It is a species that might be removed from the review list in the next decade.

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