

# Bird re-introduction and analogue options on the oceanic islands of the western Indian Ocean

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**Abstract:** The Mascarene Islands (Mauritius, Réunion, Rodrigues), and to a lesser extent the Seychelles, have suffered numerous anthropogenic extinctions. Although many of the lost bird species, such as the Dodo, were high-order endemics and thus irreplaceable, others survive on neighbouring islands, or ecologically similar congeners do. This poster matches avian extinctions with species potentially available for translocation, including possible ecological analogues (but excludes exchanges within the granitic Seychelles and within the Aldabra group). Similar data could also be tabulated for reptiles (lizards & tortoises) and mammals (bats).

## Key to codes in lists:

**Status codes:** Yellow = totally extinct, species in endemic genera; grey = totally extinct (genera not endemic); uncoloured = locally extinct; green = available for reintroduction; blue = available for analogue introduction

**Conservation priority codes:** ●●● translocation important for species survival, ●● translocation desirable for species survival and replacing lost equivalent elsewhere, ● translocation to old range could benefit declining species

**(Re-)introduction codes:** >> could be translocated to, << could translocate birds from; uncoloured = same species, blue = analogue species (with extinct species to replace in brackets; + indicates extinct).

## Mauritius:

*extinct species and those available for reintroduction or as analogues:*

### Landbirds

Reed Cormorant *Phalacrocorax africanus* << Madagascar [may be impossible due to mongoose]

Mauritius Night-heron *N.mauritianus* << Madagascar (*N.nycticorax*)

Dimorphic Egret *Egretta dimorpha* << Madagascar

Greater Flamingo *Phoenicopterus ruber* << Madagascar, East Africa [habitat now very limited]

Mauritius Sheldgoose *A.mauritianus* << Madagascar (*A.aegyptiacus*) [feral population already exists]

Mascarene Teal *Anas theodori* << Madagascar (*A.bernieri* ●●●) [may be impossible due to mongoose]

Réunion Harrier *Circus maillardi* << Réunion

[Mauritius Kestrel *F.punctatus*] ●● 3 [ >> Réunion (*F.duboisii*) ]

Sauzier's Wood Rail *Dryolimnas* sp.[not described] << Madagascar, Aldabra (*D.cuvieri*) [Aldabra only to IAA 4]

Mauritius Red Hen *Aphanapteryx bonasia* (B)

Mascarene Coot *Fulica newtoni* << Madagascar (*F.cristata*) [habitat now very limited]

Dodo *Raphus cucullatus* (A)

Pigeon Hollandais *A.nitidissima* << Madagascar, Comoros, Seychelles (*Alectroenas* spp.)

[Mauritius Pink Pigeon *N.mayeri*] ●●● >> Réunion (*N.duboisii* +)

Malagasy Turtle Dove *N.picturata* >> Rodrigues

Raven Parrot *Lophopsittacus mauritianus* (C)

Echo Parakeet *Psittacula eques/echo* ●●● >> Réunion

Thirioux's Grey Parrot *P.benoni* << India/Sri Lanka (*P.eupatria*)

Commerson's Lizard-owl *Mascarenotus sauzieri* (D)

[Mauritius Merle *Hypsipetes olivaceus*] >> [Rodrigues (*H. sp.* + {unnamed})]

[Mauritius Fody *Foudia rubra*] ●● >> [Réunion (*F.delloni* +)]

### Seabirds

Tropical Shearwater *Puffinus bailloni* << Réunion [on offshore islet, or mongoose-proof mainland site]

Abbott's Booby *Papasula abbotti* << Christmas Island ●●● [formerly on mainland, would now need safe islet, ? IAA 4]

Great Frigate-bird *Fregata minor* << Aldabra/Amirantes [formerly in south, but northern islets now have more seabirds]

Lesser Frigate-bird *F.ariel* << Aldabra/Amirantes [formerly in south, but northern islets now have more seabirds]

## Réunion:

extinct species and those available for reintroduction or as analogues:

### Landbirds

- Reed Cormorant *Phalacrocorax africanus* << Madagascar  
Réunion Night-heron *Nycticorax duboisi* << Madagascar (*N.nycticorax*)  
Dimorphic Egret *Egretta dimorpha* << Madagascar  
Réunion Solitaire (Ibis) *Threskiornis solitarius* << Madagascar (*T.(s.) bernieri*)  
Greater Flamingo *Phoenicopterus ruber* << Madagascar [habitat now very limited]  
Réunion Sheldgoose *Alopochen kervazoi* << Madagascar (*A.aegyptiacus*) [habitat now very limited]  
Mascarene Teal *Anas theodori* << Madagascar (*A.bernieri* ●●●) [habitat now very limited]  
pochard *Aythya* (cf. *innotata*) << Madagascar [habitat now very limited]  
Réunion Harrier *Circus maillardi* ● >> Mauritius  
Réunion Kestrel *Falco duboisi* 3 << Madagascar (*F.newtoni*), [Seychelles (*F.araea*)]  
Dubois's Wood Rail *Dryolimnas augusti* << Madagascar (*D.cuvieri*)  
'oiseau bleu' ?*Porphyrio* sp. (F) [identity not confirmed]  
Mascarene Coot *Fulica newtoni* << Madagascar (*F.cristata*) [habitat now very limited]  
[slaty pigeon] ?*Alectroenas* sp. [genus uncertain, no subfossils found]  
Réunion Pink Pigeon *Nesoenas duboisi* << Mauritius (*N.mayeri* ●●●)  
Malagasy Turtle Dove *N.picturata* >> Rodrigues  
Dubois's Parrot '*Psittacula*' (?) *borbonicus* [genus uncertain, no subfossils found]  
Mascarin Parrot *Mascarinus mascarinus* (E)  
Echo Parakeet *Psittacula eques/echo* << Mauritius ●●●  
Thirioux's Grey Parrot *P.benoni* << India/Sri Lanka (*P.eupatria*)  
Réunion Lizard-owl *Mascarenotus grucheti* (D)  
Réunion Merle *Hypsipetes borbonicus* >> [Rodrigues (*H. sp. + {unnamed}*)]  
Réunion Fody *Foudia delloni* << Comoros (*F.eminentissima*), Madagascar (*F.omissa*), [Mauritius  
*F.rubra* ●●]

Hoopoe Starling *Fregilupus varius* 1 << India (Grey-headed Starling *Sturnus (Temenuchus) malabarica*)

### Seabirds

- Tropical Shearwater *Puffinus bailloni* >> Mauritius [may be impossible due to mongoose]  
Réunion Black Petrel *Pseudobulweria aterrima* ●●● >> [Rodrigues; now lacks safe nesting habitat]

## Rodrigues: extinct species

### Landbirds

- Rodrigues Night-heron *Nycticorax megacephalus* << Madagascar (*N.nycticorax*) [but now lacks safe habitat]  
Leguat's Rail *Erythromachus leguati* (B)  
blue pigeon *Alectroenas* sp. [undescribed; unpublished data from Julian Hume] << Madagascar, Comoros, Seychelles  
(*Alectroenas* spp.) [but now lacks safe habitat;]  
Rodrigues Dove [? *Nesoenas*] *rodericana* [genus under study by Julian Hume]  
Malagasy Turtle Dove *N.picturata* << Mauritius, Réunion, Madagascar  
Rodrigues Solitaire *Pezophaps solitarius* (A)  
Leguat's Parrot *Necropsittacus rodricanus* (C)  
Rodrigues Parakeet *Psittacula exsul* << India/Sri Lanka (*P.eupatria*) [but now lacks safe habitat]  
Tafforet's Lizard-owl *Mascarenotus murivorus* (D)  
Rodrigues Merle *Hypsipetes* sp. [undescribed] << Madagascar (*H.madagascariensis*), [Mascarenes, Seychelles]  
Rodrigues 'Babbler' [undescribed] [identity unconfirmed, only 1 bone]  
Rodrigues Starling *Necropsar rodricanus* 1 << Andamans (*Sturnus (Temenuchus) erythropgia*)

### Seabirds

- Rodrigues Petrel *Pterodroma*. sp. [undescribed]  
Réunion Black Petrel *Pseudobulweria aterrima* << Réunion [but now lacks safe nesting habitat]  
Abbott's Booby *Papasula abbotti* << Christmas Island ●●● [further islet habitat restoration needed first]  
Red-footed Booby *Sula sula* << Aldabra [further islet habitat restoration needed first]  
Great Frigate-bird *Fregata minor* << Aldabra [requires boobies to be solidly re-established first]  
Lesser Frigate-bird *F.ariel* << Aldabra [requires boobies to be solidly re-established first]

## Seychelles (granitic islands):

extinct species and those available  
for re-introduction or as analogues:

### Landbirds

[Seychelles Kestrel *Falco araea*] 3 >> [Réunion (*F.duboisii* +)]

'poule bleu' ? *Porphyrio porphyrio* (*sens.lat.*) << Madagascar

[Seychelles Blue Pigeon *Alectroenas pulcherrima*] >> [Mauritius (*A.nitidissima* +)]

Seychelles Parakeet *Psittacula wardi* << India/Sri Lanka (*P.eupatria*)

Seychelles Black Bulbul (Merle) *Hypsipetes crassirostris* >> [Rodrigues (*H. sp.* + {unnamed})]

Seychelles Yellow White-eye *Zosterops semiflava* 2

[Seychelles Fody *Foudia sechellarum*] ●● [too vulnerable to rats to use as analogue on main islands]

## Seychelles (Aldabra Islands & Amirantes):

extinct species and those available for re-introduction or as analogues:

### Landbirds

[Madagascar Kestrel *Falco newtoni*] [probably better to use birds from Madagascar]

[White-throated Rail *Dryolimnas (cuvieri) aldabrensis*] >> Mauritius (*D. sp.* + {unnamed}) [only to cat-free islets]

Aldabra Brush-warbler *Nesillas aldabranus* << Madagascar (*N.typica*), Comoros (*N.mariae*, *N.brevicaudata*)

[Aldabra Fody *Foudia (eminentissima) aldabrana*] [too vulnerable to rats to use as analogue on main islands]

### Seabirds

Abbott's Booby *Papasula abbotti* << Christmas Island [formerly on Assumption, but might now be better on Cosmoledo]

Red-footed Booby *Sula sula* ●● >> Rodrigues [further islet habitat restoration needed first]

Great Frigate-bird *Fregata minor* ●● >> Rodrigues [requires boobies to be solidly re-established first]

Lesser Frigate-bird *F.ariel* ●● >> Rodrigues [requires boobies to be solidly re-established first]

Pink-backed Pelican *Pelecanus rufescens* << East Africa [was formerly on St.Joseph, Amirantes]

## Madagascar:

species available for introduction & as analogues:

Reed Cormorant *Phalacrocorax africanus* >> Mauritius, Réunion

Black-crowned Night Heron *Nycticorax nycticorax* >> Mauritius, Réunion (*N.mauritianus* +, *N.duboisii* +)

Dimorphic Egret *Egretta dimorpha* ● >> Mauritius, Réunion

Madagascar Sacred Ibis *Threskiornis (sacra) bernieri* >> Réunion (*T.solitarius* +)

Greater Flamingo *Phoenicopterus ruber* >> Mauritius, Réunion

Egyptian Goose *Alopochen aegyptiacus* >> Mauritius, Réunion (*A.mauritianus* +, *A.kervazoi* +)

Bernier's Teal *Anas bernieri* ●●● >> Mauritius, Réunion (*A.theodori* +)

Madagascar Pochard *Aythya innotata* ●●● >> Réunion

Madagascar Kestrel *Falco newtoni* 3 >> Réunion (*F.duboisii* +)

Red-knobbed Coot *Fulica cristata* >> Mauritius, Réunion (*F.newtoni* +)

White-throated Rail *Dryolimnas cuvieri* >> Mauritius, Réunion (*D. sp.* + {unnamed}, *D.augusti* +)

Purple Swamphen *Porphyrio (porphyrio) madagascariensis* >> Seychelles

Madagascar Blue Pigeon *Alectroenas madagascariensis* >> Mauritius (*A.nitidissima* +)

Malagasy Turtle Dove *Nesoenas picturata* >> Rodrigues

Malagasy Black Bulbul *Hypsipetes madagascariensis* >> Rodrigues (*H. sp.* + {unnamed})

Malagasy Brush Warbler *Nesillas typica* >> Aldabra (*N.aldabranus* +)

Forest Fody *Foudia omissa* >> Réunion (*F.delloni* +)

## Comoro Islands:

species available for analogue introduction (no known avian extinctions):

Comoro Blue Pigeon *Alectroenas sganzi* >> Mauritius (*A.nitidissima* +)

Malagasy Black Bulbul *Hypsipetes madagascariensis* >> Rodrigues (*H. sp.* + {unnamed})

Moheli Black Bulbul/Merle *H.moheliensis* >> Rodrigues (*H. sp.* + {unnamed})

Grand Comore Black Bulbul/Merle *H.parvirostris* >> Rodrigues (*H. sp.* + {unnamed})

Malagasy Brush Warbler *Nesillas typica* >> Aldabra (*N.aldabranus* +)

Grand Comoro Brush Warbler *N.brevicaudata* >> Aldabra (*N.aldabranus* +)

Moheli Brush Warbler *N.mariae* >> Aldabra (*N.aldabranus* +)

Comoro Fody *Foudia eminentissima* >> Réunion (*F.delloni* +)

## Africa:

*species available as analogues:*

Pink-backed Pelican *Pelecanus rufescens* >> St. Joseph, Amirantes  
[also extinct in Madagascar]

## India/Sri Lanka (Ceylon):

*species available as analogues:*

Alexandrine parakeet *Psittacula eupatria* >> Mauritius, Réunion (*P. bensoni* +), Rodrigues (*P. exsul* +)  
Seychelles (*P. wardi* +)

Grey-headed Starling *Sturnus (Temenuchus) malabarica* >> Réunion (*Fregilupus varius* +)

## Andamans & Nicobars:

*species available as analogues:*

Nicobar Pigeon *Caloenas nicobarica* (A) [also found on Indonesian islands]

White-headed Starling *Sturnus (Temenuchus) erythroptgia* >> Rodrigues (*Necropsar leguati* +)

## Christmas Island:

*species available for re-introduction:*

Abbott's Booby *Papasa abbotti* ●●● >> Mauritius, Rodrigues [offshore islets only]

## General comment on analogues

The Mascarenes and the Seychelles (granitics and Aldabras) originally lacked terrestrial mammals and the birds evolved without having to contend with rats, cats, monkeys and mongooses. Since some or all of these are now present, it would probably be prudent where possible to introduce predator-adapted analogues (e.g. from Madagascar) rather than predator-naïve species from other oceanic islands. Fodies *Foudia* spp. are typically very vulnerable to rats (and monkeys), so while the Réunion Fody was very similar to the Mauritius species (Cheke & Hume 2008), the forest fodies from Madagascar or the Comores Fody might make better analogues as more likely to survive [the granivorous Cardinal fody *F. madagascariensis* is already present through introductions on almost all the islands, but is not an ecological analogue to the endemic species (Garrett *et al.* 2007)]. Similar arguments could be advanced for blue pigeons *Alectroenas*, rails *Dryolimnas* and to a lesser extent merles *Hypsipetes* - especially introducing the first of these to Mauritius, where there are also predatory monkeys *Macaca fascicularis* - adaptation to lemurs in Madagascar might give an advantage to *A. madagascariensis*. However the rodent- and monkey-free offshore islets of Mauritius could support the flightless Aldabra race of *Dryolimnas cuvieri*. Potentially vulnerable analogues are included in the lists in square brackets.

Some low islands (atolls and banks) in the Indian Ocean, without endemics, but which have adequate forest cover, could be used to provide additional populations of certain species - especially where former coconut plantations have reverted to pantropical coastal forest, and some predators (e.g. cats) are absent (most, but not all, have rats). The islands of the Chagos (excluding Diego Garcia), Agalega\*, some of the Amirantes and Farquhars would be suitable to provide, perhaps temporarily, 'rescue zones' for such species as the Mauritius Olive White-eye *Zosterops chloronothus*, the Mauritius race of the Mascarene Paradise flycatcher *Terpsiphone bourbonnensis*, the Rodrigues endemics *Foudia flavicans* and *Acrocephalus rodericanus*, and possibly some scarce Malagasy and Comorian species, whose survival is precarious on their home island, but which cannot be introduced to neighbouring islands due to the presence of equivalent endemics or no known former presence of related taxa.

\*Agalega has no endemic birds, but has a unique small island population of Glossy Ibis *Plegadis falcinellus* (Cheke, A.S. & Lawley, J.C. 1983 *Atoll Res. Bull.* 273: 65-107). Apart from the Aldabra group, no other low islands had confirmed native landbirds, apart from cosmopolitan herons, the Malagasy Turtle Dove and, in the Chagos, White-breasted Waterhens (Skerrett *et al.* 2001).

## Possible analogues for high-order endemics

**A)** The Dodo's nearest relative is the Nicobar Pigeon *Caloenas nicobarica* (Shapiro et al 2002), which, although much smaller, is like the Dodo is a ground-feeder with a specialised seed-crushing gizzard (Cheke & Hume 2008), and would probably be the best analogue for the Dodo's role in the Mauritian ecosystem.

There is at present too little habitat left in Rodrigues to support the same analogue as substitute for the Rodrigues Solitaire, but it should be considered as restoration proceeds.

**B)** The Red Hen (Mauritius) appears to have been a snail specialist (Cheke & Hume 2008), though no doubt, like most large rails, it will also have opportunistically taken other invertebrates, small vertebrates and fruit/seeds. In appearance it resembled the extinct Hawkins's Rail *Diophorapteryx hawkinsi* from the Chatham Islands (NZ; Tennyson & Martinson 2006), but the surviving rail with the closest habitat and food profile, and equally flightless, appears to be the endangered Okinawa Rail *Gallirallus okinawae*, but several other large rails live in tropical forest and eat snails as well as other food (e.g. Lord Howe Rail *G.sylvestris* [Lord Howe Is., endangered], Grey-necked Wood Rail *Aramides cajanea* [S.America], Bare-eyed Rail *Gymnocrex plumbeiventris* [New Guinea & nearby islands]; data from Taylor & Perlo 1998). Unfortunately the Mauritian endemic snail fauna has been decimated (Griffiths & Florens 2006).

Leguat's Rail is known to have taken bird and turtle eggs - the Lord Howe Rail might be a better analogue here, as it a generalist liking open lowland forest; however, as for the Solitaire, there is very little remaining habitat.

**C)** The food of the large extinct Mascarene parrots, the Raven Parrot on Mauritius, and Leguat's Parrot on Rodrigues, was not recorded. It has been suggested that Raven Parrots may have followed tortoises for discarded/voided seeds in the way *Anodorhynchus* macaws followed extinct megafauna (and now cattle) in S.America (Cheke & Hume 2008). If so, with the tortoises extinct, this interaction cannot be replicated until they are also reintroduced (as analogues, the endemic *Cylindraspis* spp. are extinct). However there are large seeds uneaten and undistributed in Mauritian forests, and (predators permitting) a large parrot capable of feeding on the ground might help fill the missing niche (e.g. an *Anodorhynchus*, *Probosciger*, *Cacatua* or *Eclectus*, but potential impact on the surviving Echo Parakeet would have to be assessed and nest holes provided).

**D)** The long-legged *Mascarenotus* owls, presumed to be lizard specialists, could be replaced, in principle, by similar island owls from elsewhere, the best candidate perhaps being the Cuban *Gymnoglaux lawrencii*, of similar structure and habits (Garrido & Kirkconnel 2000). However the originally abundant terrestrial lizards have long since succumbed to introduced predators, so the niche has presumably disappeared, and there is no prospect of restoring lizard abundance on the main islands given the abundance of rats - unless rat-adapted analogue lizards are used instead of the endemic species that still survive on offshore islets.

**E)** The Mascarin Parrot was evidently easy to keep in captivity and was presumably a generalist frugivore; its affinities appear to be with the *Tanygnathus* group of Psittaculine parrots from Wallacea/New Guinea, but the lowland habitat on Réunion it probably inhabited has been long since destroyed.

**F)** The 'oiseau bleu' was apparently a *Porphyrio*, but its preferred habitat of grassy heath above the tree-line is unlike that of existing swamphens in the genus, though perhaps the giant flightless Takahe *Porphyrio hochstetteri* of New Zealand comes closest.

### Notes:

1. The two starlings, although in endemic genera, are close to the (sub-)genus *Temenuchus* (or *Sturnia*) related to *Sturnus* and *Acridotheres* (Zuccon 2006, Lovette et al 2008), hence suitable species from this (sub-)genus might be used as analogues; the plumage of the Nicobar race of *Sturnus/Temenuchus eythropterygia* is a perfect match for the extinct Rodriguan *Necropsar rodericanus* (Feare & Craig 1998), and *erythropterygia*, *malabaricus* and *albofrontata* (Ceylon) are all primarily frugivorous like *Fregilupus varius* of Réunion. However the potential analogues are more arboreal than either of the extinct endemics (Feare & Craig 1998).

2. The Seychelles Chestnut-flanked White-eye was a basal relic of the earliest white-eye radiation in the Indian Ocean, from Asia (Warren et al. 2006), but nothing is known of how it partitioned the habitat with the surviving *Z.modestus*, from which it may have been geographically separated. Since *modestus* has recently been

translocated to Praslin Group islands (*Oryx* 42:7, 2008), there is little to be gained by trying to add a replacement for *semiflava*.

3. The Réunion Kestrel was, from its bones (Mourer *et al.* 1999), less specialised than the Mauritius Kestrel (which feeds almost exclusively on arboreal day-geckos *Phelsuma* spp.), and either the Seychelles or Madagascar Kestrels, somewhat more generalist, might be better analogues, as the geckos are relatively scarce in Réunion.

4. IAA = Isle aux Aigrettes, the only forested rat and cat-free islet, similar to native habitat of flightless Aldabra rails and has suitable nesting trees for Abbott's Booby.

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# Western Indian Ocean



