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The Endangered Pink Pigeon: An Exploration of the Ecology, Pathology, and Conservation Efforts

A veszélyeztetett rózsaszín galamb: Az ökológia, a patológia és a konzervációs erőfeszítések feltárása

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Abstract

The endangered pink pigeon (*Nesoenas mayeri*), a species native to the island of Mauritius, is among the rarest pigeon species in the world. This literature review explores the biology, genetic background, habitat, pathology, and conservation efforts of the pink pigeon, focusing on the factors that have contributed to its decline and the ongoing conservation efforts to bring this species back from the brink of extinction. The review highlights the unique ecological setting of the Mascarene Islands, where human-induced habitat destruction, the introduction of invasive species, and the extinction of native species have severely impacted the region's biodiversity. Historically, the pink pigeon faced significant challenges, including predation by introduced mammals, devastating losses to their natural habitats, and the emergence of diseases, notably avian trichomonosis and leucocytozoonosis. However, conservation efforts, such as captive breeding, supplementary feeding, habitat restoration, and legal protections, have resulted in a remarkable population recovery. The current population of pink pigeons, while still vulnerable, has increased to over 600 individuals as of 2023. This thesis examines the key factors driving the species' recovery while highlighting the importance of continued conservation strategies to ensure the species' long-term survival. By analysing the pink pigeon's ecological, genetic, and pathogenic challenges, this literature review contributes to a broader understanding of island endemism, species extinction, and conservation in isolated ecosystems.

Absztrakt

A Mauritius szigetén honos rózsaszín galamb (*Nesoenas mayeri*) a világ egyik legritkább galambfaja. Ez, a szakirodalmat áttekintő diplomamunka a rózsaszín galamb biológiáját, genetikai hátterét, élőhelyét, patológiáját és védelmi erőfeszítéseit tárja fel, összpontosítva azokra a tényezőkre, amelyek hozzájárultak a fajszám hanyatlásához, valamint azokra a folyamatos védelmi erőfeszítésekre, amelyek célja a faja kihalás széléről való kiemelése.

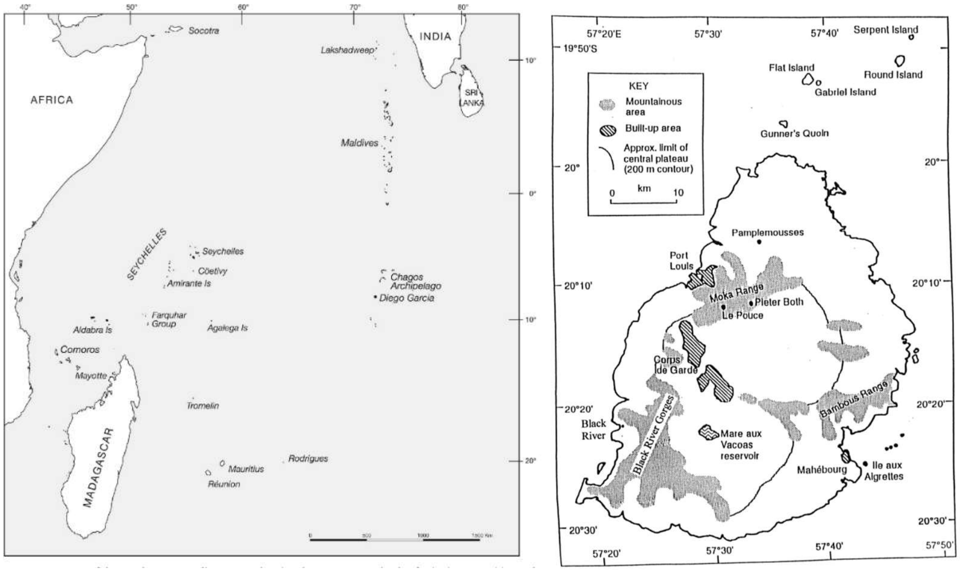
A diplomamunka kiemeli a Mascarene-szigetek egyedülálló ökológiai környezetét, ahol az ember által előidézett élőhelyek pusztulása, az invazív fajok betelepítése és az őshonos fajok kihalása súlyosan befolyásolta a régió biológiai sokféleségét. Történelmileg a rózsaszín galambnak jelentős kihívásokkal kellett szembenéznie, beleértve a betelepített emlősök által okozott ragadozást, természetes élőhelyeiket pusztító tevékenységeket és az újonnan megjelent betegségeket, nevezetesen a madarak trichomonosisának és leukocitozonózisának megjelenését. Azonban a védelmi erőfeszítések, mint például az *ex situ* tenyésztés, az élőhelyek helyreállítása és a jogi védelem figyelemre méltó populáció-helyreállást eredményeztek. A rózsaszín galamb jelenlegi populációja, bár még mindig sérülékeny, 2023-ra több mint 600 egyedre nőtt. Ez a dolgozat a faj regenerálódását elősegítő kulcsfontosságú tényezőket vizsgálja, miközben kiemeli a folyamatos védelmi stratégiák fontosságát a faj hosszú távú túlélése érdekében. A rózsaszín galamb ökológiai, genetikai és patogén kihívásainak elemzésével ez az áttekintés hozzájárul a sziget endemizmusának, a fajok kipusztulásának és az elszigetelt ökoszisztémák megőrzésének szélesebb körű megértéséhez.

Contents

1 Introduction

Islands are "global centers of endemism richness", hosting endemic species at levels 9.5 times higher than that of mainland areas, particularly pronounced among vertebrate species [1], reinforcing the unique ecological and evolutionary importance of island habitats. Endemism, a key concept in biogeography, describes the restriction or exclusive occurrence of a certain species in a specific geographic area or ecosystem, without natural occurrences outside that range [2, 3]. Endemic species are often highly adapted to specific local conditions, making them especially susceptible to environmental changes and human activities, such as habitat destruction, climate change, or the introduction of invasive species [3, 4].

The Mascarene Islands or Mascarenhas Archipelago, found in the southwestern part of the Indian Ocean, comprises of a group of three distinct islands: Mauritius, Reunion and Rodrigues, connected only by their volcanic origins and close proximity [5]. The Mascarenes and granitic Seychelles —sharing a similar history of human colonization, which has highly impacted their native habitats —host a globally significant angiosperm flora with high endemism, currently under severe threat primarily due to extensive past habitat destruction and ongoing impacts from invasive alien species [6].



[5]

Figure 1. Left: Map of the Southwestern Indian Ocean showing the Mascarene Islands of Réunion, Mauritius and Rodrigues [5]. Right: Map of Mauritius showing the Black River Gorges National Park and Ile Aux Aigrettes [7]

2 Mauritius

Mauritius (20.25°S, 57.5°E) is a small, tropical island in the southwestern Indian Ocean, covering 1,865 km² [8]. It is the oldest of the Mascarene Islands, with its formation dating to 10 million years ago. Due to its volcanic origin, Mauritius has always remained isolated from a continental landmass throughout its geological history, allowing unique ecosystems to develop through intermittent colonisation events via island "stepping stones" [5]. Around 14,000 years ago, rising sea levels submerged most linking islands, leaving Mauritius isolated until human arrival in 1598. Located 840 km east of Madagascar, Mauritius has varied topography, from low plains in the north and east to a 700-meter plateau in the southwest, featuring the Black River Gorges. A fringing reef encloses its lagoon and several small coralline islets (for example, the Ile Aux Aigrettes) [5, 8, 9].

2.1 Climate

The Mascarenes, including Mauritius, are influenced by southeasterly trade winds throughout the year, with distinct climate variations during the austral summer (January to March) when tropical cyclones and depressions occur due to the southern movement of the Intertropical Convergence Zone (ITCZ). Mauritius experiences two main seasons: a warm, humid summer from November to April and a cooler, dry winter from June to September, with transition periods in May and October. Average summer temperatures reach 24.7°C, peaking at 29.2°C in January and February, while winter averages 20.4°C, with lows of 16.4°C in July and August. The island's annual rainfall averages 2010 mm, primarily in the summer months (67% of annual precipitation), with February and March being the wettest months, and October the driest [10–12].

3 Pink Pigeon, *Nesoenas mayeri*

The pink pigeon (Prévost, 1843) is one of the rarest pigeons in the world [5], and the largest Mauritian *Nesoenas* species [13]. The pink pigeon, *Nesoenas mayeri*, endemic to the island of Mauritius, was named in recognition of Gustave Mayer, at that time based in Mauritius, who ostensibly sent the first specimen of the species to M. Marchal, and provided some preliminary observations on the bird's habits [13].

However, the pink pigeon is not the only pigeon to have inhabited the Mascarene archipelago. Paleontological records and contemporary accounts suggest that up to nine species of smaller Columbids, now extinct, once colonised the Mascarenes along with the still-surviving *Nesoenas mayeri* [13]. *Nesoenas duboisi* (Réunion pink pigeon) went extinct in c. 1700 (<1703) [14], *Nesoenas cicur* around 1715, and *Nesoenas rodericana* (Rodrigues pink pigeon) disappeared sometime between 1725 and 1761 [13]. Of at least 12 endemic pigeons and doves, *Nesoenas mayeri* is now the last surviving Mascarene pigeon [5, 13].

Early records from visitors to the Mascarene Islands, along with fossil findings, offer significant insights into the islands' historic avian diversity. In Mauritius, the first fossil evidence was uncovered in 1865 at Mare aux Songes (20°26'S 57°41'E), a marshy area in the island's southeast, and since then, fossils of *Nesoenas mayeri* are among the most frequently found in cave deposits across the island, although they are less commonly present in the Mare aux Songes site [10, 13].

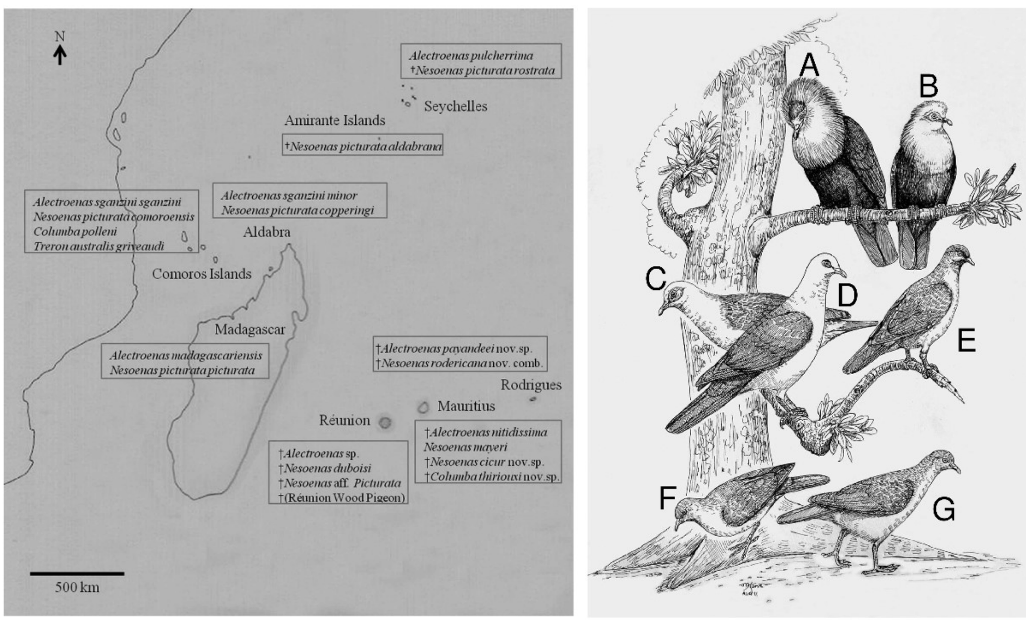


Figure 2. Left: distribution of Columbids in the Mascarene Islands with † indicating an extinct taxon. Right: Mascarene Columbids: Alectroenas nitidissima (A), Alectroenas payandeei (B), Nesoenas duboisi (C), Nesoenas mayeri (D), Columba thiriouxi (E), Nesoenas rodericana (F), and Nesoenas cicur (G), taken and modified from [13].

A medium-sized bird, the male pink pigeons average around 315 grams and the females weigh about 290 grams. It has a broad tail and short, rounded wings, with the legs and beak slightly elongated. The back and wings are primarily dark brown, with a long russet-coloured tail. Ventrally, the belly is pale pink, which lightens around the head and neck; males often have an almost white head [15].

Figure 3. A pink pigeon featured perching on a tree branch [16].

3.1 Taxonomy

In *Lost Land of the Dodo*, Cheke & Hume categorise endemic species of the Mascarene Islands (with related species globally) into four general groups: (1) those having affinities to Madagascar, (2) those with relatives in Asia (for e.g. the cave swiftlets) which are found throughout the Asia-Pacific, however absent in Madagascar and mainland Africa, (3) species related to Australasia, such as the flying-foxes, which are part of an extensive Indo-Australasian and Pacific lineage yet not present in Africa, and (4) seabirds with mixed or uncertain origins. Pink pigeons fall into the first category, connecting them to Madagascar, specifically within the subgroup of "Malagasy endemic genera with diverse or unknown origins" [5].

There seems to be much debate around the taxonomical classification of the pink pigeon where some believe that the pink pigeons are unique enough to have its own genus *Nesoenas*, while some are of the conviction that they have affinities with the *Columba* pigeons [15]. Traditionally, *Nesoenas* has been classified alongside Old World *Columba* species, while the Malagasy turtle dove is considered an atypical member of the *Streptopelia* genus [17].

One speculation is that the pink pigeon may be related to the white-headed pigeon (*Columba leucomela*) from Australia, given that both species share many similarities when it comes to breeding and ecology [15], thus providing a rationale to include pink pigeons in the *Columba* genus. On the other hand, the Mauritius pink pigeon (*N. mayeri*) and its extinct counterpart from Réunion (*N. duboisi*) are often classified within their own genus due to characteristics that are intermediate between those of the typical woodpigeons (*Columba*) and turtle doves (*Streptopelia*) [5]. These species, classified within the Indian Ocean endemic genus

Nesoenas, represent remnants of an early evolutionary radiation of ancestral stock related to woodpigeons and turtle doves. Genetic studies have identified three main clades of *Streptopelia*: (1) *S. chinesis* and *S. senegalensis*, (2) *S. picturata* (Malagasy turtle dove) and *Nesoenas mayeri*, and (3) all other species of *Streptopelia* [17]. While it remains uncertain whether these clades form a monophyletic group distinct from the Old-World *Columba*, several analyses have come to support this arrangement. The sister relationship between *Nesoenas mayeri* and *Stretopelia picturata* is obvious, given the islands, Mauritius and Madagascar, are in close proximity to each other; moreover, their phylogenetic relationship is further substantiated by similarities in vocal characteristics [17]. It is likely that the two pink pigeon species (*N. mayeri and N. duboisi*) reached the Mascarene Islands from Madagascar leading to their speciation, followed later by the arrival of the Malagasy turtle dove [17]. The mitochondrial gene divergence percentage between the pink pigeon and Malagasy turtle dove is only 3.0%, further supporting this evolutionary link, thus Johnson *et. al* (2009) proposed to move *Nesoenas mayeri* to the genus *Streptopelia* [17].

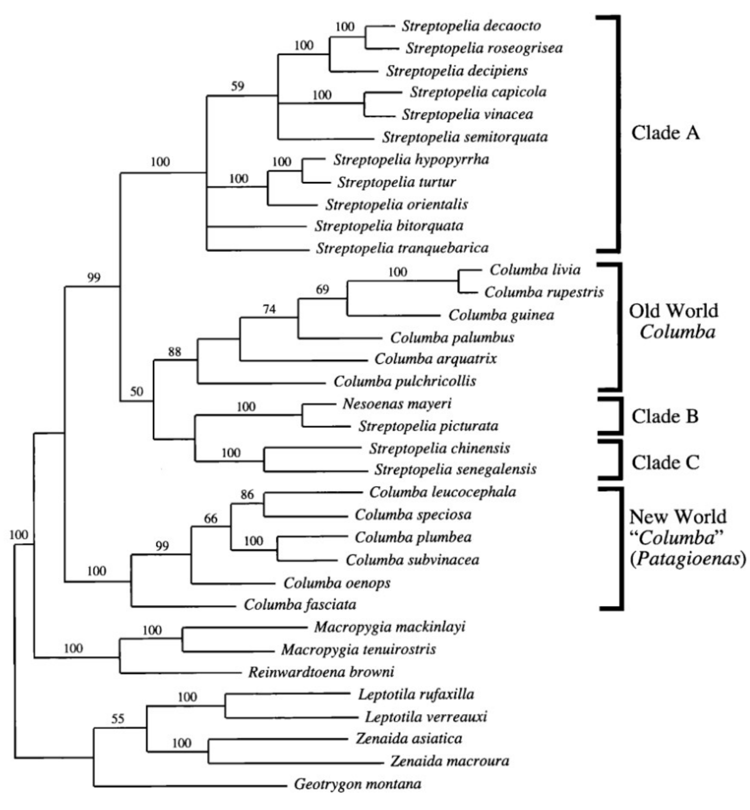


Figure 4. Phylogeny tree of Streptopelia, indicating where Nesoenas mayeri is found from unordered parsimony analysis of combined mitochondrial (cyt b, ND2, COO and nuclear (FIB7) genes [17].

Moreover, given that *Stigmatopelia* doves are found in India, this region may be the ancestral source of the *Nesoenas* lineage [5]. The estimated divergence time of 7 million years ago (mya) indicates that these birds likely did not utilise ancient hotspot island chains for their dispersal, nor is this timeframe consistent with the more recent island formations of the Ice Age. However, the ability of the Malagasy turtle dove to colonize low-lying coral islands suggests that its ancestors may have dispersed from Asia to Madagascar through a process of island-hopping across atolls [5, 17, 18].

3.2 Legislation

The protection of the pink pigeon is legislated under the Native Terrestrial Biodiversity and National Parks Act (Act 14 of 2015) [19], which oversees both fauna and flora endemic species conservation, habitat management, and preservation efforts on reserved lands designated as National Parks or Special Reserve. Part VII "Control of Wildlife" emphasizes the control and management of wildlife to protect endangered species and their habitats, whereby granting authority to regulate human interactions with native fauna. Under this legislation, the pink pigeon is protected (directly or indirectly) through stringent measures against habitat destruction and hunting, and populations are actively monitored and managed by organizations like the Mauritian Wildlife Foundation (MWF) and the National Parks and Conservation Service (NPCS). In Mauritius, the Ministry of Environment serves as the focal point for implementing conventions, while the NPCS functions as the National Executing Agency [20].

These efforts also align with international conservation goals and obligations under the Convention on International Trade in Endangered Species (CITES) of which Mauritius is a member since 1975 [21] as well as the African Convention for the Protection of Nature and Natural Resources (1968) [20], further ensuring that the species receives global protection from trade-related threats. In fact, Mauritius was the first country globally to ratify the Convention on Biological Diversity (CBD) in 1992 [20].

3.3 Habitat and distribution of pink pigeons

Prior to the colonisation of Mauritius and the subsequent change in the ecology of the island, the pink pigeon is thought to have frequented all vegetation types [15], but is now restricted to the 65.7 km^2 wide State-owned and protected reserve of Black River Gorges National Park [22]. They demonstrated a preference for the montane rainforest of Montagne Cocotte, Les Mares and Pigeon Wood (Plaine Paul) [15].

The region encompassing Plaine Champagne, Les Mares, and Montagne Cocotte are frequently shrouded in clouds enough to have fostered the development of a mossy forest ecosystem [23]. Les Mares, the swampy headwaters of the Black River and Rivière du Poste at the head of the Gorges, was characterized as a highly wet and swampy forest, with much of its vegetation growing on rocky islets surrounded by marshlands, or as screw-pines (*Pandanus*) emerging directly from the water [5]. This environment likely proved inhospitable for predators, and is now believed to have provided a level of protection for nesting birds similar to that currently observed in Pigeon Wood [15]. Les Mares was not only vital for sheltering the pink pigeons, but also crucial for their sustenance, with the area particularly rich in nectariferous plants [5, 24]. In fact, their close association to this 'dwarf' forest is how the pink pigeon came to be known as 'Pigeon des Mares'.

In the early 1970s, a work program cleared the remaining extensive areas of the forest, including the unique marshy forest of Les Mares which, in turn, exacerbated the already vulnerable condition of native bird populations [25]. Due to the increasing demand for wood in the mid-20th century, large swathes of the native forest were felled for the cultivation of economically valuable species such as pines and Japanese Cedar *Cryptomeria japonica*, and to accommodate temporary cash crop ventures, including tea cultivation in Mauritius [5].

Japanese Red Cedar was also being planted in "indigenous pole forests", later earning the moniker "Pigeon Wood" as it became the last known breeding site for the wild pink pigeons [26]. The trees provided excellent cover to the nests of pink pigeons due to its thick foliage, as well as additional protection from predation by rats and monkeys, who hated climbing about in these trees [5]. Pigeon Wood, now part of the protected Black River Gorges, thus became a vital nesting site for this then-critically endangered endemic bird.

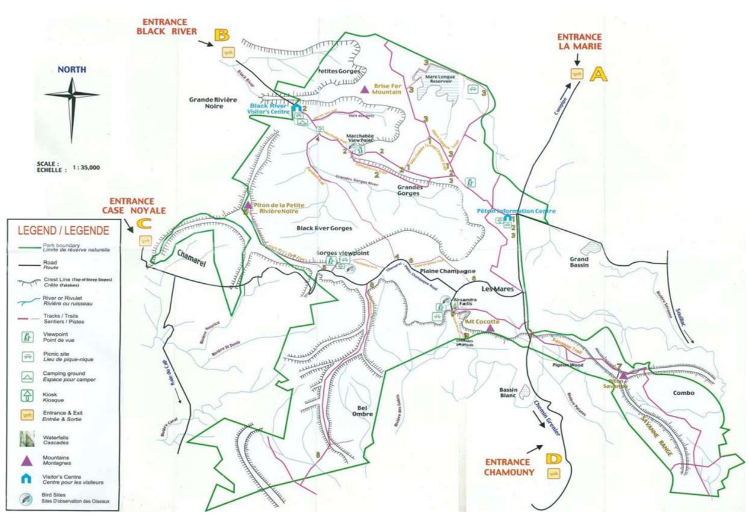


Figure 5. Map of the protected reserve of Black River Gorges [22].

3.3.1 Nest site selection and nest description

Swinnerton (2001) concluded that for pink pigeons, nest tree selection is not confined to native species and likely depended on tree structure and the availability of a continuous canopy [8]. They demonstrate adaptability in nest tree selection, utilizing both native and exotic species based on tree structure and canopy availability [8]. Exotic trees were preferred at Pigeon Wood and Bel Ombre, with high use of *Cryptomeria japonica*, while native species like *Diospyros* were favoured at Brise Fer and Ile aux Aigrettes, reflecting site-specific vegetation influences [8]. The wind climate in Mauritius has also been known to significantly influence nest orientation on Ile aux Aigrettes, where nests facing south were less common [8], likely due to strong southeast Trade winds that heavily impact the islet [27], showing the birds' high adaptability to the pristine Mauritian climate.

Nests are typically made by both sexes: the male brings the material while the female builds the nest [15]— generally constructed with loosely woven twigs lined with materials such as pine needles (from *Cryptomeria* or *Pinus*), ferns, lichens, tree roots, feathers, and dead leaves [8]. Pink pigeons also exhibit some adaptability to exotic species like *Ligustrum* and *Pinus*, commonly incorporated into nest construction in mainland sites, where these exotic trees are found in abundance [8]. Pink pigeons also demonstrate a tendency to reuse their own nests or those abandoned by other birds, such as the Malagasy turtle dove [8]. Nest-building in wild birds is typically completed within a day or two [26, 28], while captive birds may take several days [29]. However, Swinnerton (2001) noted prolonged construction, often exceeding a week, with timing influenced by the interval between male site selection and egg-laying, which could extend beyond two weeks [8].

3.4 Feeding ecology

The natural diet of the pink pigeon includes buds, leaves, flowers, fruits, and seeds from both native and exotic plant species, but fruits and seeds are more nutritious [29]. The bird frequently consumes *Nuxia verticillata* ("Bois Maigre"), *Erythrospermum monticolum* ("Bois Manioc"), and *Aphloia theiformis* ("Fandamane") [15], while showing a particular preference for the flowers of the Bois Maigre tree, and typically focus on smaller food items in their diet [5]. They like to forage up in the branches of trees and shrubs but will descend to the ground for fallen seeds and fruits when necessary [15]. Their diet shifts seasonally; flowers are abundant in early summer, while consumption of fruits and seeds increases as summer progresses [15]. In late "autumn" (the tropical island does not really experience autumn) and winter, food availability declines, requiring increased foraging efforts, and potential food shortages may occur towards the end of winter [29].

To combat food shortages and as part of the conservation efforts, provisions of supplementary feeding have been made throughout the subpopulation areas [30]. Feeding platforms –which provided a continuous supply of cracked maize and wheat via hoppers– were strategically placed near the release aviary and within breeding grounds [31]. Feeding stations for pink pigeons are designed to restrict access by rodents and introduced birds while minimizing grain scatter; adjustable trays accommodate small pink pigeons while excluding smaller dove species, and wire-spoked guards limit passerine entry and reduce disease transmission through multi-species interactions [30]. The supplementary food supported birds during food shortages, enhanced breeding productivity, and improved fledgling outcomes by increasing squab and fledgling survival, reducing fledgling dependence, and shortening recycling periods [31]. A study by K. Edmunds *et al.* (2008) concluded that supplementary feeding is a must for pink pigeons by allowing compensation for shortages in natural food availability, especially during periods of severe weather conditions [30].

3.5 Breeding biology and behaviour of pink pigeons

Pink pigeons are diurnal, that is, they are active during the day. This is observed notably during nest building where birds were most active from dawn to dusk [8]. Their vocalisations range from low-pitched, repetitive coos to squabs making loud 'whistling' vocalisations, especially during feeding [8]. Male pink pigeons display territorial behaviour such as elevated perching and wing-clapping display flights, also getting aggressively involved with birds in territories next to their own [8]. Aggression has also been noticed in females chasing away their male partners in captive breeding due to incompatibility [32]. Incidence of aggression has also been observed at supplementary feeding sites [30].

Pink pigeons exhibit social monogamy, forming long-lasting pair bonds often maintained beyond the breeding season, with some lasting over a year [8]. Despite this, approximately 41% of pairings end in divorce, influenced by factors such as pair incompatibility, low reproductive success, availability of better mates, or poor territory selection [8]. Around 30% of partnerships dissolve due to the death of a partner [8]. Extra-pair copulations, often observed as males mounting submissive females or juveniles, are primarily interpreted as displays of dominance rather than true mating behavior [8], potentially allowing females to change partners and improve genetic diversity in offspring. Unisexual pairings, where males adopt behaviors resembling heterosexual pairings, are also noted, likely due to sex misidentification caused by similar plumage or limited female availability [8]. These pairs, unlike heterosexual ones, contribute equally to nest construction [8]. These insights highlight the complexities of pair bonding and reproductive success in pink pigeons, emphasizing the importance of compatibility and environmental conditions for sustaining stable relationships.

The breeding ecology has been thoroughly studied and explained in Swinnerton (2001), and will be briefly discussed here. At the onset of the breeding season, male pink pigeons establish and defend their territory around chosen nest trees [8]. Females lay a clutch of one or two eggs, which both parents incubate: the female broods from late afternoon to early morning, while the male takes over during the day [8]. The incubation period lasts approximately 13–15 days [8]. Hatchlings are initially underdeveloped and receive regurgitated "crop milk" from the parents; after four days, leaves and seeds are gradually added to their diet [8]. The young are lightly covered at first, with feathers emerging by one week and full feathering around ten days [8]. Fledglings leave the nest at 18–22 days but often remain near the parents for additional care for one to two weeks post-fledging [15]. However, with introduced supplementary feeding now [30], their dependence on parental support for food during this period has been greatly reduced [8].

The breeding activity and seasonality of pink pigeons has been described in Staub (1976), Jones (1987) and Swinnerton (2001), showing variability across studies, likely reflecting differences in site-specific conditions. Jones found peak breeding from January to June, with the highest egg-laying rates between April and June, and noted a decrease during the dry season —however, birds in captivity breed throughout the year [29]. Staub observed breeding year-round, with seasonal peaks [33]. Swinnerton's findings at Pigeon Wood indicated limited breeding in the colder, wetter winter months, and a significant drop in activity in February and March, likely due to heightened cyclone risk during these wettest months [8].

3.6 The decline in the pink pigeon's population

Until the first human settlers had arrived on the island in 1598, the only predators of the Mauritian fauna were three birds: an owl, a harrier and a kestrel, and two snakes; it should be noted that these predators preyed on the avifauna to a lesser extent as compared to the later introduced invasive animals [5]. Along with establishing human settlements in the 16th

century came the introduction (accidental or intentional depending on species) of predator animals such as the crab-eating monkey (*Macaca fascicularis*), ship rats (*Rattus rattus*) (and to a lesser extent, the brown rat, *Rattus norvegicus)*, mongoose (*Herpestes edwardsii*), and feral cats (*Felis catus*) on the island [25]. Of these introduced invasive animals, the tree-climbing macaques and rats were the most threatening to arboreal bird species through destruction of nests and consumption of chicks, nestlings, and birds [9, 25], while feral cats and mongoose hunted the ones feeding on the ground [5]. The Mauritian fauna, thus, became easy prey to both humans and newly introduced predators since they practically evolved without mammalian predators [34].

Other introduced species such as the deer (*Cervus timorensis Blainville*) and pigs (*Sus scrofa L.*) disrupted the ground and inhibited the growth of native vegetation, while introduced birds, such as the bulbul (*Pycnonotus jocosus L.*) encouraged weed growth and invasion in remnant native vegetation via exotic fruit dispersal throughout the island [35]. Direct competition between this bulbul and the Cardinal *Foudia madagascariensis*, another endemic bird species in the island, may limit the range, abundance, or both of related native species [25].

Exotic plants introduced in the 17th century, with the most invasive ones being strawberry guava (*Psidium cattleianum*), rose-apple (*Syzygium jambos*), traveller's palm (*Ravanala madagascariensis),* white popinac (*Leucena leucocephele*) and Mauritius hemp (*Furcraea foetida*), extensively harmed the native forest of Mauritius, choking vegetation and preventing the regeneration of the native plants [5, 9]. Some of the worst instances of invasive weeds' negative effects on native plants can be seen in Mauritius [35]. Moreover, there appears to be significant variation in exotic plant species invasions both within and between islands — the exact factors are unknown, they most likely include the exotics' vigour, reproductive tactics, and ecological needs in comparison to those of the native species that share the same environments [36]. Some native bird species have been able to adapt to these changes, utilizing the new vegetation for their needs, as seen with species like the Mauritian Grey White-eye (*Zosterops mauritianus*) –the most abundant of the endemic bird species –and, to a lesser extent, the Paradise Flycatcher (*Terpsiphone bourbonnensis*) [25]. However, other native bird species, notably the pink pigeon, were unable to adapt, leading to a decline in their populations as they became restricted to smaller, isolated patches of native vegetation [25]. The proliferation of invasive plants further fragmented the pigeon's habitat, making it increasingly difficult for the species to survive in the remaining patches of native vegetation. This resulted in reduced biodiversity and increased vulnerability of native bird populations to further environmental changes and disturbances.

These introductions fundamentally altered the balance of Mauritius' ecosystems, setting the stage for the decline of many native species, including the pink pigeon. All but two Mascarene species, the Malagasy turtle dove and Mauritius pink pigeon, have survived due to the slaughter of large numbers of pigeons by early settlers in the 18th and 19th centuries [5]. However, comparatively to the dodo which was hunted down to extinction for food (along with other factors such as habitat degradation and nest predation by invasive mammals preventing regeneration of the population), according to an excerpt by Jean-François Charpentier de Cossigny (an engineer and botanist, working for the French East India Company), the pink pigeon was widely considered as toxic, whereby, if consumed, would produce convulsions and partial paralysis — which might have been attributed to a seasonal fruit but could not be proven by the settlers [5].

Furthermore, as a tropical island, Mauritius is susceptible to intense tropical storms, or cyclones, during the summer months, primarily between December and April [11]. These natural weather disasters have influenced the evolution of the forest ecosystem and could have also influenced the animal populations. Severe storms can lead to partial defoliation of the forest and the destruction of flowers and fruit, leading to food shortages for the birds afterwards [5]. Pink pigeons are highly affected due to foraging limitation, and reportedly been seen weak and sick after cyclones [29]. Cyclones, which damage vegetation and disrupt food sources, are an additional stressor, particularly for a species already struggling due to habitat loss and invasive species.

The introduction of invasive species, coupled with habitat degradation, disease, and the effects of human activity, led to significant declines in the pink pigeon population. By the late 1970s, only 10-15 pigeons could be found on the island [5]. The lowest point in the population came in the 1990s where only nine pink pigeons existed in the wild [37]. Though the pink pigeon faced devastating declines, targeted conservation efforts have helped stabilize and even increase its population to over 600 [37] in recent years.

4 Pink pigeon pathology

The pink pigeon's susceptibility to pathogens in the wild may stem from several factors: (1) the introduction of exotic species carrying unfamiliar pathogens, against which the pink pigeon has limited immunity; (2) the vectors for diseases may not have accompanied the pigeon’s ancestors to the Mascarenes, resulting in the disease dying out and subsequent loss of immunity; (3) pathogens failed to persist in the pigeon’s small population, leading to diminished exposure and immune response over time [8]. Complicating these scenarios are inbreeding effects, habitat degradation, and the introduction of non-native hosts and vectors, influencing the pigeon's vulnerability to disease [8].

Disease likely contributed to the historical decline of the pink pigeon, especially in lowland habitats with higher densities of exotic doves [38]. The impact of pathogens on species with small populations, such as the pink pigeon, can often be obscured by other factors, such as predation [8]. The detrimental effects of disease became more apparent once other limiting factors were mitigated, and population size increased [8]. The pathological causes of mortality and morbidity in pink pigeons have been well researched and documented over the years. Those studies have found multiple causes of sickness and death in the birds, with avian trichomoniasis and leucocytozoonosis, identified as the primary factors contributing to population declines [8, 38–42]. Moreover, pink pigeons may also lack natural resistance, making parasitic infections an ongoing concern for recovery efforts [40], and despite efforts to control the limiting factors, disease continues to play a significant role in restricting both the size and distribution of the population [8].

4.1 Trichomonosis

Avian trichomonosis (canker), a protozoal infection that significantly impacts bird populations, was discussed in Stabler (1954): *Trichomonas gallinae*, with a direct life cycle (no intermediate hosts), affects primarily columbiform birds (pigeons and doves); often asymptomatic, it can also manifest as yellowish, caseous lesions or necrotic ulcerations in the upper digestive and respiratory tracts, often accompanied by a foul odour, watery saliva, and head swelling [43]. Mortality typically results from starvation or asphyxiation due to obstructions in the oesophagus or trachea [44]. It significantly threatens the conservation of endangered Columbid species, their avian predators, and small passerines like finches [45].

T. gallinae transmission in pink pigeons occurs directly via crop milk and regurgitated food (vertical transmission) or indirectly through contaminated food and water (horizontal transmission) [38]. The parasite was likely introduced to Mauritius in the 18th and 19th centuries through the establishment of exotic doves populations, including the Malagasy turtle dove (*Streptopelia picturata*), Zebra Dove (*Geopelia striata*), Spotted Dove (*Streptopelia chinensis*), and Feral Pigeon (*Columba livia*) [38]. Interspecies transmission probably occurred in the pink pigeon population following the bottleneck [45] when the species was highly vulnerable to pathogens and increasingly susceptible to infections.

The first recorded incidence of trichomonosis in pink pigeons was noted by McKelvey in 1976, when the disease was detected in a captive squab that had been fostered by Malagasy turtle doves [26]. No further cases were reported until wild birds encountered exotic species [8], and after the parasite was detected later in a population introduced to Pamplemousses Botanical Gardens in Mauritius [46]. The disease became further established on Ile aux Aigrettes, facilitated by the then-high density of exotic birds and limited freshwater sources on the coralline islet [8]. *T. gallinae* was also found to be the most frequent pathogen detected in European captive pink pigeons managed by the European Endangered Species Programme (EEP) [42], which is fostering a backup pink pigeon population.

Swinnerton (2001) noted varying clinical signs in pink pigeons, possibly linked to different *T. gallinae* strains or differences in squab immunity: they typically exhibited either mouth lesions (yellow cheesy nodules) or inflammation of the sinuses and surrounding tissues, with mouth lesions being less common or absent in some cases [8]. Mouth lesions impair feeding, and malnutrition further reduces survival [8]. Lesions have also been observed in exotic doves, feral pigeons, and Mauritius kestrels [8]. Pink pigeons also suffer from subclinical *T. gallinae* infections, which in asymptomatic birds were detected via direct wet-mount microscopy from crop swabs [38]. While wet-mount microscopy is the standard for diagnosing *Trichomonas gallinae* infections in birds, the InPouch TF method has been identified as a more effective method, detecting over twice as many positive infections [47].

Breeding seasonality can also play a role in the prevalence of trichomonosis: the non-breeding period, which coincides with the cyclone season, sees a decrease in infections, attributed to the increased availability and easier access to drinking water, hence reduced sharing and, thus, less horizontal transmission of parasites. In contrast, the breeding period, marked by heightened physiological stress and increased contact among pairs, may elevate susceptibility to infection [44].

Mortality from trichomonosis in pink pigeons may be influenced by immunocompetence, which is affected by factors such as previous exposure, inbreeding, nutrition, body condition, and co-infection with other diseases [8]. Pink pigeon squabs and fledglings are particularly susceptible to die, with most infected nestlings succumbing to the disease [44]. While adult pink pigeons are more probable to get infected, the disease has been found more common in young pink pigeons less than 3 months of age [44]. Even though squabs suffer from high mortality due to trichomonas [44], the ones surviving infection likely develop immunity, and repeated re-infections over their lifespan enhance resistance [39].

Multiple *Trichomonas gallinae* strains can coexist within a population, with highly virulent strains potentially driving significant mortality [8]. A retrospective mortality review of captive European pink pigeons found only one death [48], while a similar review of the free-living Mauritian population found 51.2% of deaths due to trichomonosis [41], which may point to the possibility of a more virulent *T. gallinae* strain in Mauritius, or that the Mauritian pink pigeon population may have lower resistance to the disease [38, 41]. A study conducted by D. Gaspar da Silva *et al.* (2007), the first to examine *T. gallinae* genotypic diversity in Mauritian columbids, found no evidence of multiple subspecies, but noted evolving genetic heterogeneity among isolates, in correlation with host species and geography [45]. Therefore, it is very imperative that both prospective and retrospective analyses across diverse host species and regions are carried out for better understanding of trichomonosis epidemiology in wild bird populations [49].

4.2 Leucocytozoonosis

Leucocytozoon marchouxi was first identified in the pink pigeon in 1977 and later considered a potential threat to the species' recovery [50, 51]. These protozoan parasites are typically transmitted by Simuliid blackflies, with *Simulium ruficorne*, the only Simuliid species present in Mauritius, proposed as the primary vector for *L. marchouxi* [50, 51]. Most subpopulations of pink pigeons in Mauritius inhabit environments (temperate, humid climate) conducive to blackflies [30]. Notably, a high prevalence of *Leucocytozoon marchouxi* was observed on the coralline islet, Ile aux Aigrettes, despite its lack of freshwater streams, which are typically unsuitable for blackflies. This could be explained either by blackflies bridging the 625 m gap from the mainland [52, 53] or by the presence of an alternative vector, such as *Culicoides* spp. [40].

Clinical leucocytozoonosis leading to mortality in pink pigeons may include additional contributing factors, such as co-infection, food scarcity, and genetic impoverishment. While its precise impact on overall mortality is challenging to detect –with some birds surviving even after high levels of infection– the disease remains a significant factor [39]. In Bunbury *et al.* (2007), juvenile age appears to be a key confounding factor in survival analyses. Juveniles exhibit both higher infection rates and generally lower survival than adults, which may obscure or exaggerate infection-related mortality patterns. Thus, age-stratified analysis is recommended to better understand *L. marchouxi*'s effects across life stages and accurately assess risks to pink pigeon recovery [40]. Moreover, *L. marchouxi* exhibits seasonal latency in its host, potentially becoming most pathogenic during its reproductive phase [40]. This seasonal pathogenicity could complicate conservation efforts, especially if host species, like the pink pigeon, are particularly vulnerable during these periods.

Many Columbids species in Mauritius, including the Malagasy turtle dove, spotted dove, and zebra dove, may act as potential reservoir hosts for *L. marchouxi* [39], preserving the parasite, but the current high-density subpopulations of pink pigeons could now facilitate its spread [40]. Pink pigeons appear to have some immunity to *Leucocytozoon*, though less than exotic doves. As the pink pigeon population grows, it is expected to become an increasingly important maintenance host for *Leucocytozoon marchouxi* [39], which is likely to pose an ongoing challenge to the pink pigeon conservation programme [40].

4.3 Other parasites

Additional blood parasites have been found in pink pigeons: an unknown *Rickettsia* species was found in a blood smear from an adult; a trypanosome was detected in a juvenile; and a microfilaria was identified post-mortem in a 47-day old bird [39]. Coccidia oocysts were found at low to medium levels in group samples from wild and released birds at Brise Fer [8]. Pink pigeons were also infested with *Ornithoctona plicata* (Hippoboscid flies) and squabs were particularly affected by the tropical nest fly, *Passeromyia heterochaeta* [8]. These flies have been to known to act as vectors for various blood parasites, such as *Haemoproteus*, trypanosomes, and microfilaria, with blackflies also capable of transmitting microfilaria [54, 55]. *Plasmodium* spp. and *Haemoproteus* spp. have both been detected in other Mauritian birds [50].

Parasitic cestodes (unidentified) and trematodes (assumed to be *Paratanaisia bragai*) have also been found in pink pigeons [41]. The trematode genus *Paratanaisia* may have been introduced to Mauritius alongside exotic species, and the intermediate host for this parasite is likely the introduced land snail *Subulina octo*; however, the life cycle and occurrence of this trematode species in Mauritius remain unclear, so further investigation is needed [41]. A new species, *Eimeria mauritiensis* (Apicomplexa: Eimeriidae), has also been isolated from pink pigeons in Mauritius while no other coccidian parasites have been reported in other columbiform species present in the island [56] — the Mauritian pink pigeon population may have developed reduced immunity due to limited exposure to such parasites [42].

Mites, specifically *Hypodectes propus* of the Hypoderatidae family, have been reported in pink pigeons. Although not considered to be lethal to pink pigeons and rather representative of poor host condition, they warrant further investigations as these pathogens may represent recent additions to the bird's parasitic fauna [41].

4.4 Bacteria

Based on a study conducted in a European captive pink pigeon population, Shopland *et al.* 2022 identified the main bacterial pathogens that could heavily impact pink pigeon populations in Mauritius as well: *Chlamydia psittaci*, *Salmonella* spp., *Mycobacterium avium*, and *Yersinia pseudotuberculosis* [57]. Prevalent in Columbiformes, *Chlamydia psittaci* is zoonotic and typically causes chronic, subclinical infections in birds [58], and was found as a concurrent infection in a post-mortem examination of a European captive pink pigeon [48]. The most significant bacterial disease found in species like pigeons and doves is paratyphoid, primarily caused by *Salmonella typhimurium* var. Copenhagen, with less frequent occurrences of *S. arizonae* and *S. pullorum* [59]. In Austria, Salmonella outbreaks caused mortality in wild passerine birds (Fringillidae) [60], highlighting the potential risk of infection in the pink pigeon population, especially if they share habitats or resources with susceptible species. Given its worldwide distribution, both *C. psittaci* and Salmonella spp. are possibly already present in the island [57].

In captive pink pigeon populations housed in European collections, infectious diseases were the second leading cause of death in adults, with *Y. pseudotuberculosis* being the most prevalent, and *M. avium* the second most common infectious disease [48]. However, given Mauritius' climate, *Y. pseudotuberculosis* is least likely to affect pink pigeon populations in Mauritius compared to the European ones due to its affinity for low temperatures [57]. There has also been a documented case of avian mycobacteriosis in a female pink pigeon from the Czech Republic zoological collection [61]. Given that pink pigeons aren't likely to be as resistant to *M.* avium as other Columbid species [48], avian mycobacteriosis may yet pose difficulties in conservation efforts for the pink pigeon.

4.5 Viruses

Pigeon pox virus (PPV), of the *Avipoxvirus* genus, was first recorded in Swinnerton (2001) in 10% of the population in Ile aux Aigrettes: both wild and captive birds were infected, suggesting that the virus might be unknown and unique to Mauritius [8]. The disease could only be detected in birds showing obvious lesions —asymptomatic birds or birds showing mild or subclinical signs might have gone undetected [8]. Both the cutaneous (dry) and diphtheric (wet) forms were seen in the infected birds: the cutaneous form, characterized by nodules on the beak, feet, eyes, and other body parts, was most observed, while the wet form, seen in a few cases, involved creamy nodules on the tongue and throat, and resembled trichomonosis [8]. Pox-like lesions have also been found in other bird species (e.g., common mynahs, Mauritius kestrels, house sparrows) [8], with PPV infection in Mauritius Fodies (*Foudia rubra*) also resulting in mortality [62]. This could suggest that interspecies interactions could play a role in disease dynamics; understanding these interspecies relationships and the role they play in disease transmission is crucial for developing broad-spectrum conservation strategies, especially in the case where rising frequency and occurrence in previously unaffected species globally indicate that this may be an emerging viral disease [48, 63, 64].

While not reported in the Mauritius pink pigeons, other widespread viruses such as pigeon circovirus, adenovirus, and herpesvirus, causing immunosuppression and increased pathogen susceptibility in young birds, can occur alongside young pigeon disease syndrome (YPDS) [58, 65–67]. Moreover, several serotypes of paramyxoviruses infect pigeons, including avian paramyxovirus-1 (APMV-1) –of which the pigeon paramyxovirus-1 (PPMV-1) is a variant–, and avian paramyxovirus-7 (APMV-7) [68].

4.6 Disease management

From 1987 to 1993, pink pigeons were screened for bacteria and parasites before release [31]. Since 1993, broader disease research focused on blood parasites, trichomoniasis, and *L. marchouxi*, as well as additional screenings for herpesvirus, avian reovirus, adenovirus, and paramyxovirus were carried out [31]. Infections were controlled at feeding stations, and water was treated and changed daily to mitigate disease, especially in Ile Aux Aigrettes which saw water shortages during certain months of the year [31]. Pigeons were periodically treated with anthelmintics, and survival of treated versus untreated squabs was monitored [31]. Moreover, to prevent disease transmission between different avian species, feeding platforms for supplemental feeding have been designed in such a way so as to limit multi-species interactions with the feed [30].

Disease and parasite surveillance is crucial in conservation management and recovery programmes for endangered species [56]. A health screening of the free-living Mauritian pink pigeon population would enhance understanding of their disease susceptibility and exposure, guiding pre-export protocols and informing preventative measures to protect captive-bred pigeons upon translocation [42]. Implementing regular testing in the pink pigeon populations could enable early detection of viruses, and prevention of epidemics.

5 Conservation

Islands are critical for bird conservation, supporting over 1,750 species (about 17% of all bird species globally). Among these, 402 species (23%) are threatened with extinction, making up 39% of the world's endangered bird species. The extinction rate for island birds has been especially high—around 40 times greater than for continental species—with 97 island species having gone extinct, compared to just 11 on continents. Since 1600, approximately 32 islands or island groups have recorded bird extinctions [18].

The Mascarene Islands (Mauritius, Rodrigues, and Réunion) in the Indian Ocean illustrate this trend acutely, with 28 extinctions since 1600, representing over half of their native avian species. Additionally, threatened island species are often concentrated in a few geopolitical regions, for example, territories like the Hawaiian Islands, Mauritius, and Seychelles, collectively host more than half of all threatened island species, underscoring the importance of targeted conservation in these areas [18]. The proportion of threatened single-island endemic species (SIE) remains high across all islands: Mauritius (81.7%), Rodrigues (77.8%), and Réunion (50.9%). The primary threat across these islands, however, is the impact of invasive alien species, including both animals and plants, which disrupt native ecosystems [6].

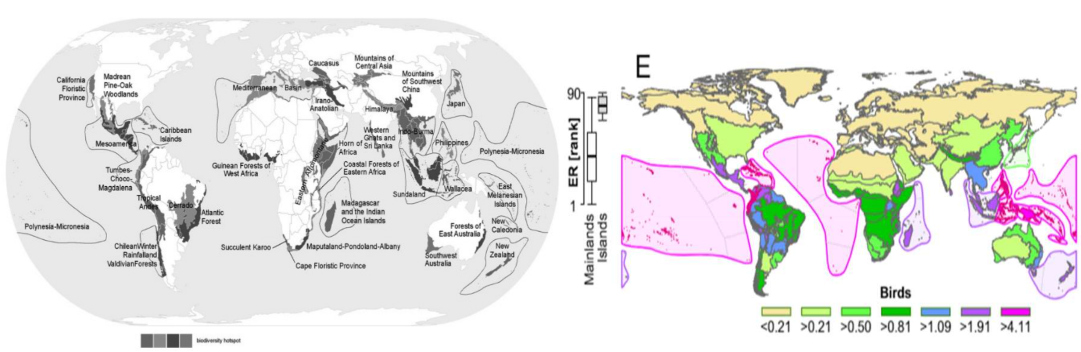


Figure 6. Left: Madagascar and the Indian Ocean Islands (including Mauritius) are considered as a "biodiversity hotspot" [4]. Right: global patterns of endemic richness, particularly high for the Mascarene Islands region [1].

5.1 Conservation of the pink pigeon

Conservation efforts have been highly successful, resulting in the pink pigeon being downlisted from Endangered to Vulnerable in November 2018 [37], despite estimates from the 1980s and 1990s indicating that the pink pigeon was on track to become extinct in the wild by around 2002 [8]. The pink pigeon recovery programme is a collaborative effort between the NGO Mauritian Wildlife Foundation (MWF) and the government-run National Parks and Conservation Service (NPCS) of Mauritius [30]. The recovery of the pink pigeon was part of a broader effort to restore Mauritius's native biodiversity, aiming for whole ecosystem restoration, where the success of the pink pigeon programme inspired broader efforts like habitat restoration and protection at the national level, allowing the establishment of the national park and reserve Black River Gorges National Park [8].

The conservation of pink pigeons has been thoroughly documented over the years. This literature review will briefly attempt to summarise the key points based on the IUCN report by Kirsty Swinnerton *et. al*. (2000). The pink pigeon conservation programme started in the 1970s, and reintroductions into native forests began in 1987 [31]. The captive breeding programme for pink pigeons was established in Mauritius in 1976 with three males from the wild population at Pigeon Wood, and at the Jersey Zoo in 1977; the *in situ* population was established between 1976 and 1981 with an additional male and three females at the Gerald Durrell Endemic Wildlife Sanctuary (formerly Black River Aviary) while the *ex situ* population was established in 1977 with three males and one female [34].

Between 1987 and 1997, 256 birds were released at two sites in the Black River Gorges: Plaine Lievre and Bel Ombre, and at a third site, Ile aux Aigrettes, with the majority being captive-bred at the Gerald Durrell Endemic Wildlife Sanctuary (GDEWS) and five birds at the Jersey Zoo [31]. Releases were conducted in small groups, and prior to release, the birds were kept at an aviary for acclimatisation with the other birds and the keeper, as well as establishing the aviary as a focal point for food for the birds [31]. The release process evolved to include ‘softer’ methods [29, 32], where food was provided to encourage birds to stay near the aviary. Population growth was significant, peaking at 297 individuals in 1998, and by 1997, releases ceased as the number of wild-fledged birds increased [31]. After peaking at 398 birds in 2000, the pink pigeon population declined and stabilised at 340–360 individuals, despite the addition of a fifth subpopulation in 1999 [69]. Initial slow population growth was partly due to the development of experimental release and management techniques, with subsequent growth resulting from refinements and improvements to these methods [8]. Birds were monitored with colour rings, radio-tags, and hawk bells, and the programme showed that juvenile birds were more successful in reintroduction than older individuals [8, 31]. An emphasis was laid on predator control to improve survival of the birds at release sites by laying out traps (for mongooses and feral cats) and using anti-coagulant poison for rats [31].

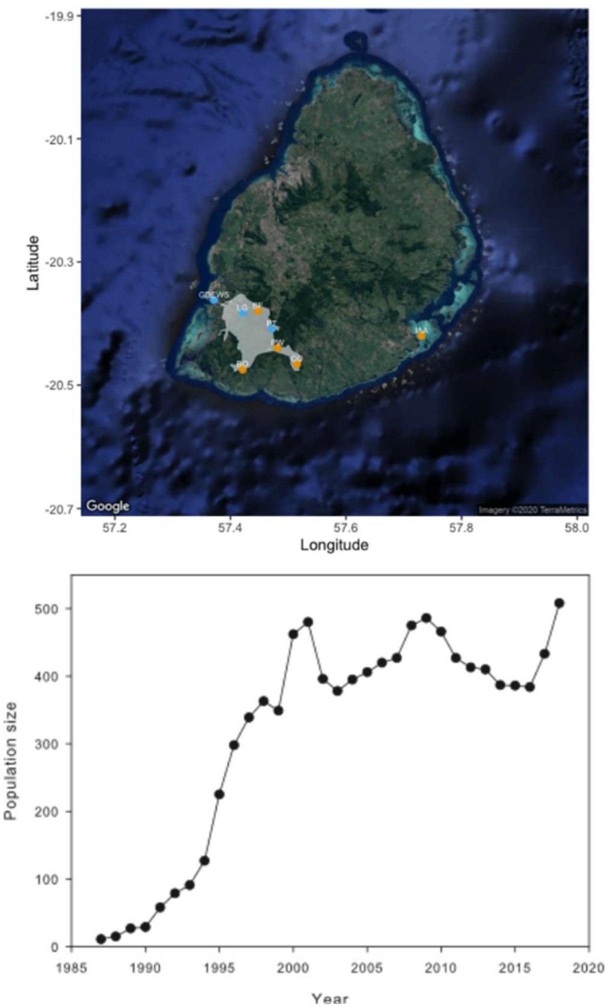


Figure 7. Top: The shaded area represents the Black River Gorges National Park where the subpopulations of pink pigeons are found: Lower Gorges (LG), Brise Fer (BF), Pétrin (PT), Pigeon Wood (PW), Bel Ombre (BO), Combo (CO), and including GDEWS (Gerard Durrell Endemic Wildlife Sanctuary), and the coralline islet of Ile Aux Aigrettes (IAA) [34]. Bottom: Population trends of pink pigeons in Mauritius: 1987-2020 [34]

With ongoing conservation efforts by the Mauritian Wildlife Fund, a subpopulation of free-living pink pigeons has been established on the offshore island of Ile aux Aigrettes (IAA), while six additional subpopulations are present within the Black River Gorges National Park, with two sites (Pétrin and the Lower Black River Gorges) accessible to the public; while a captive population established at the Gerald Durrell Wildlife Endemic Sanctuary (GDEWS) supports the species' recovery by producing offspring for wild release [37]. The release of pink pigeons on Ile aux Aigrettes supported species recovery while providing an educational opportunity for visitors and school children [8]. Robert J. Whittaker *et al.* (2007) define minimum viable population (MVP) as the smallest population size required to ensure long-term survival of a species, often defined as maintaining a 95% probability of persistence over 100 or 1000 years [70]. Further releases of 30 pink pigeons in Ferney Valley (2017) and 50 in Ebony Forest (2018) expanded the species' range, contributing to the population surpassing 600 individuals by 2023, thus achieving the targeted minimum viable population threshold for avian species [37].

5.2 Challenges and achievements in the conservation programme

Numerous challenges have been identified and overcome since the establishment of the pink pigeon recovery programme. The pink pigeon conservation programme identified key limiting factors, such as predation by exotic mammals, food shortages, and poor egg fertility, and progress was achieved by controlling their impacts [8]. While most pink pigeon mortality could be attributed to the aforementioned factors, the species also suffers from inbreeding depression and high disease susceptibility, likely due to low genetic diversity [34]. Inbreeding depression arises from increased homozygosity, leading to the expression of deleterious recessive alleles, and reduced heterozygosity, lowering fitness —both effects diminish genetic variation, adversely impacting population survival [8].

Predator control for pink pigeons included cage traps for mongooses and cats and Brodifacoum bait grids for rats at release sites, feeding stations and breeding areas, creating predator-free zones, protected nests, reduced food spoilage, and minimized disease risk [8]. Predator control at Pigeon Wood raised annual survival rates from 49.8% in 1992 to 84.3%, demonstrating the critical role of predator management and supplemental feeding in enhancing pink pigeon survival [8]. Furthermore, inbreeding depression and reduced adaptive potential raise concerns that the pink pigeon may be entering an extinction vortex since the captive population lacks genetic variation found in the wild [57]. As part of the EEP Long-term Management Plan, individuals from the EEP captive population has been translocated to Mauritius's breeding colony, where the release of their offspring will enhance genetic diversity, improve fitness, reduce genetic load, and help establish a more sustainable wild population in Mauritius [34, 57]. Given increasing pressures on wildlife, it is uncommon for threats to endangered species to be entirely eliminated; most species and their habitats require ongoing management to ensure their survival [8].

Swinnerton (2001) highlighted the various factors (discussed below) that made the pink pigeon recovery programme a success: the biological aspects of the pink pigeon biology, the improvised management techniques used and the unique features of the geographically small island of Mauritius that enabled successful re-establishment of this endangered species [8]. The pink pigeon recovery programme succeeded through in-country captive breeding (at GDEWS), reducing risks related to importing birds, and use of accessible, protected release sites. Soft-release techniques, such as site-based aviaries and gradual independence, encouraged site attachment. Intensive post-release monitoring, including population censuses, health checks, and supplemental feeding, countered threats like food shortages, predation and disease. Biological advantages, including rapid growth, early breeding, multiple clutches, and tolerance to handling, accelerated re-establishment. Adaptability to non-native species for nesting and cohesive group behavior post-release supported survival. Egg harvesting, fostering, and cross-fostering techniques maximised productivity and preserved genetic diversity, while sub-population establishment tested habitat flexibility and minimised disease spread [8].

5.3 Future of the conservation programme

As the pink pigeon population stabilises, new challenges arise, such as increased interactions between birds and humans, leading to risks and potential mortality. One such issue has been road collisions, with reports indicating that at least 23 pink pigeons were killed by vehicles in Pétrin; the presence of food stalls in the car park and the public's tendency to feed the birds attract them to the road, where they are vulnerable to vehicle strikes [37]. Achieving sustainable populations with minimal human intervention will be a key goal.

Limited habitat and predator impacts on Mauritius suggest that supplementary feeding and predator control may remain necessary for a long time [8]. However, continuous efforts in habitat restoration and the removal of invasive species could reduce management needs over time, with interventions likely focused on core areas to support nest success, productivity, and survival as population “sources” [8]. Effective management of the pink pigeon and its habitat is crucial for the species’ persistent survival, given the ongoing threats of habitat degradation and predation by invasive species [8], while ensuring the pink pigeon’s survival in maintaining its role in seed dispersal and ecosystem dynamics, contributing to the health of Mauritius’s native forests. The programme’s future depends on overcoming challenges like habitat loss, climate change, and reliance on intensive management.

The Mauritian Wildlife Foundation (MWF) actively advances conservation science as joint research projects with Durrell related to the Island Restoration Programme, with focus on ecology, geology and genetics [30]. However, greater emphasis is needed on pathogens and disease management to address the growing threat of emerging diseases in Mauritius, and how it could impact its delicate wildlife. As with inbreeding depression, further studies need to be carried out to find out links between conservation and potential diseases in the pink pigeon. The pink pigeon conservation programme serves as a model for integrated conservation approaches, combining intensive captive breeding, habitat restoration, and population monitoring, while proactively overcoming challenges like inbreeding depression. Its success could inform similar efforts for other critically endangered species, especially from islands, across the world.

6 Conclusion

The recovery of the pink pigeon (*Nesoenas mayeri*) serves as a testament to the resilience of species when supported by targeted and sustained conservation efforts. Once on the brink of extinction, the species has made remarkable progress with the help of habitat restoration, predator control, supplemental feeding, captive breeding, and intensive monitoring. These interventions have not only stabilised but also grown the population, surpassing the minimum viable population threshold of 600 individuals as of 2023.

However, this success also drags along ongoing challenges, including predator control, disease management, habitat limitations, and the problems created through human-wildlife interactions. The continued persistence of the pink pigeon will require adapting current conservation strategies, with a focus on long-term sustainability, reducing human intervention, and addressing and counteracting both enduring threats such as predation by invasive animals, and emerging threats like climate change and novel diseases.

Importantly, the pink pigeon recovery programme highlights the broader implications of conservation work on island ecosystems. It has inspired habitat restoration, created a wave of environmental concern and biodiversity protection in Mauritius, and served as a model for species recovery worldwide. The lessons learned from this programme emphasise the need for collaboration, scientific research, and adaptive management in conserving endangered species. As a symbol of hope and resilience, the pink pigeon exemplifies what can be achieved when commitment to conservation is paired with innovative solutions.

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