

Chapter 6

Biodiversity of Papua New Guinea (PNG): Attempting a More Meaningful Conservation Description and Approach of Its Use, Co-evolution, Generic Status and Grim Outlook



Neither the government of PNG nor of Indonesia shows the necessary capacity or commitment to actively conserve mammal species and their critical habitat.

Beehler and Laman (2020, p. 220)

The most extraordinary and the most beautiful of the feathered inhabitants of the Earth.

Edgar Wallace reference to Birds of Paradise (cited in New South Wales State Library, 2022)

Bats can hear shapes. Plants can eat light. Bees can dance maps. (This citation exist in several variations. And one may easily add infrasound, 3D and ocean issues, magnetic detection, and the feelings and counting skills by plants and trees etc.

Overall, if all of those things are already occurring, what do we not know yet and how biased are humans in their knowledge, perception and subsequent conservation management? There is more than what meets the eye. PNG deeply entrenched in its cosmologies can open those pathways to the non-believer.

Unfortunately, I know of many PNG experts that are not among those people but who remain with conservative, parsimonious descriptions of the Western Society the most, instead of seeing the wider, telecoupled, more holistic picture that PNG offers us and that its citizens know for millennia already.)

@CryptoNature in Ludlam (2021, p. 272)

Abstract Papua New Guinea (PNG) is one of the few megadiversity nations in the world. It's essentially an ancient species engine and hosts world-relevant populations of wildlife and plants, with a co-evolved human society for over 47,000 years. Many of the species in PNG are among the oldest in the world and endemic providing unique DNA and lessons of evolution for global mankind and well-being. One can see in PNG the more original set up of species in the tropics, and the world. Many international and grand expeditions, collections and research were done in PNG but with virtually little sustainability success. Most data remain not available, hardly known. However, while PNG was forced to engage in a global commodity market during colonial times and subsequent globalization the conservation status for most of those species and habitats in PNG remains poor and with little relevant action or vision presented. It follows a loose laissez-faire model from Australia added with neocolonial attitudes and Asian input. PNG remains a 'feast' for the global enterprise. It's

shown that the current nation set up and governance for megabiodiversity nations like PNG and wider Melanesia results in the wholesale destruction of otherwise globally relevant world wilderness, species, ecological services and sustainability.

Keywords Papua New Guinea (PNG) · Biodiversity · Multispecies · Conservation · Wallace Line · Endemism · Ecology · Global Biodiversity Information System (GBIF.org)

6.1 Introduction

Like many tropical nations, Papua New Guinea (PNG) is known for its unique biodiversity; much of it is deep, ancient and endemic but virtually all of it co-evolved with a low density of humans (Beehler and Laman, 2020; Diamond, 2011; Flannery, 2002). By now it's probably public knowledge that PNG is part of the 17 megadiversity nations in the world (https://en.wikipedia.org/wiki/Megadiverse_countries). But despite being a 'tropical' nation PNG's equatorial biodiversity stands in wide contrast to the widely heralded and promoted biodiversity patterns and concepts in Central or Latin America, Africa or other parts of Southeast Asia for instance. PNG is not much 'packed with species' like Costa Rica is (Huettmann, 2015 and citations within), and the species and diversity densities tend to differ also. PNG is south of the Wallace Line, which creates a schism in Southeast Asia; paradoxically PNG is virtually free of monkeys and squirrels (other than a few introduced species etc; see subsequent chapters in this book). It's also affected by Weber's line, driving fish species distributions (Beehler & Laman, 2020 and citations within). In an evolutionary earth history sense, birds and mammals of PNG are usually younger, whereas plants and insects are the older groups. But it's the insects and plants that crossed the Wallace Line.¹

PNG sits at the Australian craton—essentially a geologically ancient rock connecting Australia directly with PNG that still moves geologically—and thus PNG belongs to the wider Sahul region, initially all part of a unified Gondwanaland (Beehler & Laman, 2020; Flannery, 1990, 2002). PNG is essentially a rugged landmass with many island fragments surrounded by saltwater located between Australia and Southeast Asia. And therefore it was isolated for quite a long time with an associated human co-evolution (a selected visualization of those aspects is shown in Figs. 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22, 6.23, 6.24, 6.25, 6.26, 6.27, 6.28, 6.29, 6.30, 6.31, 6.32, 6.33, 6.34, 6.35, 6.36, 6.37, 6.38, 6.39 and 6.40).

Islands are known to present us with 'biological labs of evolution,' somewhat independent experiments that unfold over time in various directions. But while PNG as a nation is facilitated by a large island land mass, it's also defined by a myriad of islands and islets and by all of its interactions as a wider whole (part of Melanesia,

¹ There is a good question where the Wallace Line and Weber Line actually are located, and how that is determined. In reality, one needs to be prepared to argue those details and to handle a grey zone instead.



Fig. 6.1 Papua New Guinea is home to the oldest fig trees. It's where much of the forest cover and its co-evolution with the biotic and abiotic world starts

the Pacific and beyond). The ocean plays a big role for PNG. Most of the islands are covered with closed canopy vegetation. Non-forested areas in PNG are relatively species-poor but they still carry unique species, e.g. specific snakes in the grasslands (of which some are rather poisonous).

Biogeography processes relate to barriers and dispersal (MacArthur & Wilson, 1963); this makes saltwater, barriers and mountains a prime topic to study, just as it applies still to PNG (see at Beehler & Laman, 2020 for a New Guinea perspective). The discipline of biogeography studies typically distant islands, island size effects, comparable high and low islands, land bridges, highly movable species, corridors and mountain-top 'islands.' Elevation effects are dominant in biogeography, as described by Alexander von Humboldt for South America two centuries ago and also found by Wilson and MacArthur (1967) and Diamond (1976) for PNG, besides many others (not all are given credit). Further, for PNG Species-Pair Competition and Ring-Species were also described (e.g. Mayr and Diamond 2001). Other effects shaping biographic patterns are the harshness of the environment. In PNG that's for



Fig. 6.2 Large orb-web spiders: a good welcome to Papua New Guinea's biodiversity

instance, ancient glacier effects and the El Nino dry events affecting fire occurrence and subsequent species set up for land and the ocean.

PNG features most aspects of the classic Island Biogeography theory from Wilson and MacArthur (1967); this theory is essentially a common sense approach published from the 1960s though. It actually falls quite short on accounting for human impacts, and it is not much based on modern data and the latest assessment methods (e.g. best-available globally compiled data sources at hand, DNA evidences, survey detection statistics, habitat data, disease information and computing-intense analysis for better inference. The knowledge about evolution also progressed dramatically since then).

But in addition to those research topics, PNG has many additional dimensions foreign to short-term outside observers, one of them is 'deep time' another one is, year-round effects as well as cosmology (Baraka, 2001). As a living place PNG makes for a unique set up that the Western World has a hard time to understand and to grasp with, or to manage well for sustainability. PNG is not like Europe or North America



Fig. 6.3 Ancient beetles

(but where most of the theory-driving investigators, actors and publishers for PNG currently are coming from). And PNG is just one of many places in Asia; the Pacific Rim is indeed a big place, truly connected with deep earth, and that the Western World has a difficult time with and fails frequently (for evidence of this true'ism just see Myint-U, 2006 for Burma experience; Glavin, 2008 for ocean explorations, Rauzon 2016 for Pacific Island set up, or Krishna et al., 2022 for rabies as a wider landscape disease).

As stated by Beehler and Laman (2020), PNG is a great species generator for plants and animals. And so in that regard, PNG compares easily with the much larger Amazon basin and Congo. PNG provides us with a gift of species and human co-evolution on a global level. That is specifically so due to the 'young' geology making a universal link across all forms of live we can see and experience, land and sea.

And PNG's biodiversity is not only shaped by a 'set of isolated islands' located south of the Wallace Line and the Weber Line allowing us to see ancient species, e.g. for insects and plants. Due to the elevational gradient, the diversity of species increases and then falls after c. 2500 m (Beehler & Laman, 2020), and associated endemism is highest in mountain areas (Beehler & Laman, 2020). As well, PNG acts as a North–South species conduct, and thus it is part of the exchange corridor between Australia and Indonesia, South East Asia, with a peak biodiversity from both regions, as it is the case for insects and plants, let's say (whereas other species groups mixed and moved less, e.g. mammals and birds). All of those details matter



Fig. 6.4 ‘Walking stick’ species

for the species set up found in PNG and its human co-evolution. But this matters more for some species than for others. It gets complex...

PNG is a geographic species bottleneck and acts as a biogeography textbook in action; and much of that book’s chapters have not even been written yet. In the meantime, one hopes PNG’s nature remains in a good shape so that its study and subsequent conservation can be achieved. That is unlikely though. The current outlook looks rather grim (details in the following chapters of this book).

While many of PNG’s species are usually described as ancient, more simple and primitive—in the evolutionary sense—but they are not less fascinating as they allow us to see species concepts that are already gone. Often those are simply ‘unique’ and among the first species we know of that existed or that are leftover for humans to experience. In PNG, we can see into Earth and Earth’s history, under the sea surface, what it was like and where we ourselves come from, and how we connect to the universe overall. In PNG, we can truly understand ourselves!

A great example for that are the ancient figs and the orchid diversity of PNG, or some large butterflies (= largest in the world; see Beehler & Laman, 2020 for such species and their trade).

From that any scholar, student and naturalist easily can conclude that PNG species can open your mind and understanding of what species and ecosystems consist of, what earth really is, how we evolved under the wider universe, and where species might have come from. A typical example for that are the mammals, where in PNG it’s



Fig. 6.5 Butterfly collection from Papua New Guinea; many species are bred and exported, alive or dead—for the world’s butterfly lovers

the only place where all major clades of living mammals coexist: monotremes (egg laying mammals), marsupials (pouch-raising mammals) and placentals (mammals with a placenta as essentially found worldwide and often seen, wrongly though, as the quintessential mammals); e.g. Flannery (1990), Martin (2005). Many species here co-evolved with the environment because PNG is a few of the world’s unique places where species had much time to do so, all done without much initial pressure from human densities. Endemism is consequently high in PNG; we currently just see what is left of it. Due to this unique set up, many PNG species now carry a conservation concern (because species that are simple, slow and big get eaten and collected fast...)! The Sahul region has already experienced such a species loss over time (details further below; see also Flannery, 2002; Martin, 2005).

6.2 Birds: The Cheapest and Effective Conservation Platform Left Widely Unused

PNG has one of the most diverse avifauna in the Pacific, c. 900 species of birds, c. 9% of the world’s species (app. 9,750 species worldwide; but with more DNA research, political lobbies and Birders pushing for species splits this number is to increase soon whereas most of the actual species and their habitats on earth are more



Fig. 6.6 Butterfly cocoon in the wild

threatened than ever). Arguably, a sole species focus—such as Birds of Paradise—ignoring habitat issues and context is misleading for conservation, as can easily be shown for PNG.

Like in many British colonies worldwide, birds from those places to be settled in the British Empire got promoted for a long time. They are presented and get promoted in paintings, by artists and writers (e.g. Cocker, 2006 for a typical style) and are made ‘special,’ e.g. with narratives and through paid ‘experts’ (whose assumed job it might well be to show the citizens of the kingdom how special and thus worthwhile the place and its species are, promoting such colonial constructs. One may easily argue that the work by David Attenborough—as part of the BBC—is an outcome of such a long tradition now entrenched as a global culture and in modern media, that otherwise was not so prominent in other colonies and royal courts, e.g. with the Spanish, Portuguese or French, let’s say. Due to competitive collection expeditions to bring home ‘curiosities’ for the cabinet those colonial nations do still have large museum collections with assigned curators and experts; details can be tracked just partly in GBIF.org because not all data are not widely shared with the global audience; see also Beehler & Laman, 2020 for expeditions and institutions; Huettmann, 2020; Table 6.1 for more details). A quick GBIF.org search for PNG data shows available data from the 1940s onwards, hardly before (but where major specimen collections were actually made, likely in the hundred thousands; more details are below and in textboxes).



Fig. 6.7 An ancient species group with its own co-evolved species famous for Papua New Guinea

Like found elsewhere in the tropics, bird species assemblages can be a patchy occurrence in the (tropical) forest landscape; for PNG those can consist of over 30 species (see also Beehler & Laman, 2020). Having spent much time in PNG forests myself, I hardly see that many species though! And so it's nothing unusual for a bird watcher in PNG to encounter much less species, or for a long while none at all...Perhaps the birds have to find you instead!?! Despite its fame, PNG remains a challenge for bird watchers as birds do move fast, are smart (e.g. corvids), are used to human prosecution and escape fast, and often operate in high and complex canopies. Detectability is 'a thing' in PNG (in my own work in PNGs' rainforests, I only see app. 20% of birds, whereas I get over 80% of species and individuals just by hearing. Arguably there are very few sound recordings and ID guides for PNG available making reliable bird surveys a true challenge to most people and incoming students. Doing mist netting, shooting, camera-trapping and telemetry does not overcome this problem of very low detection rates and thus bias. This puts an incredible confidence question and liability on bird work in PNG and one wonders how earlier scholar dealt with it, e.g. E. Stresemann, E. Mayr or J. Diamond? Metadata do matter for such works. For instance, the German colonial bird work presented by Stresemann, 1923 carries large issues around spatial accuracies and data availabilities, e.g. in GBIF.org for Germany as a signatory, lacking metadata; compare also with Beehler & Laman, 2020 on that issue of German and other colonial expeditions).



Fig. 6.8 A megapod (bird) mound: those breeding ovens include eggs which can be harvested sustainably over time

A noteworthy finding in the ancient forests of PNG is the ground nesters, as it's a common finding for remote and rel. undisturbed wilderness areas, such as PNG (see Freeman et al., 2013; Mack, 2014 for ground-living birds and findings). When stray dogs, cats or other mammals and predators come into a landscape (dogs came into PNG rather late, perhaps 2,500 years ago), this cohort of birds tends to disappear quickly. And PNG had dogs and specifically hunting dogs to aid that process (e.g. Flannery, 1990, 2002; Martin, 2005).

There are of course many other very interesting aspects in birds of PNG and their conservation (the latter subject is poorly tackled though for a meaningful policy and impact studies; see Richards, 2018; Richards & Whitmore, 2015 for examples and where rapid species lists dominate but accepted taxonomies, meaningful research design and statistics are side-lined for valid inference and meaning). In PNG vultures are missing, but Black Kites are now found in large abundance in human-changed areas and at forest fires and around garbage dumps, e.g. in the Ramu sugarcane area. Forest birds in PNG have often two eggs, sometimes spread out over several months. Switching of the ecological niche can be observed, such as with the pygmy parrot, operating in a 'nuthatch niche' (Beehler & Laman, 2020). PNG has the world's largest pigeon, the smallest parrot in the world and also rather large parrot (the Papan Vulture Parrot).



Fig. 6.9 Nest attractant of a bowerbird

Textbox 1: The ongoing fallacy of specimen collection: Pseudo-science without relevant research design and controls, Neocolonialism in museums and utter lack of conservation and habitat progress

Nature and its biodiversity are ‘really big,’ it’s megascience. The associated complexities increase manifold when collecting over time for specific time periods, or years. One can easily collect oneself to infinity and get exhausted for live but still not get it all described or done well. As many collectors have experienced, it’s virtually not fundable! Arguably, that creates a bias in itself. But it’s virtually impossible to describe nature in objective terms and being ‘complete’ or representative, as nature is wider than what humans, or a group of humans, perceive. Putting those collections in an institutional



Fig. 6.10 Chick of a cassowary; those chicks are often caught in the wild and sold or kept. However, in captivity those can turn rather aggressive and in the first year get usually released or killed (= eaten) as those birds are pretty tasty. Worth to mention that those birds are cute but over time can be rather dangerous and can injure and even kill people

framework involving human lives, careers and 8 h-a-day employment makes is a formidable task indeed.

And so, many of the commonly encountered biodiversity issues worldwide are now also found in PNG—Earth’s grandest island in many respects. Often those issues are of international relevance and carry a price tag to deal with. One of the typical stereotypes encountered center around the traditional style of collection expeditions carried out for ‘remote’ PNG. Virtually all aspects of endemic species from PNG are collected by museums, herbariums and zoos, usually with governmental approval, visas, permits and public or private



Fig. 6.11 Moss, a mystery species set for Papua New Guinea

funds- embassies included. Many of those examples can be found documented as data in GBIF.org, but many more not all (e.g. many records of the colonial times; see also Huettmann, 2020 for some PNG details). Insect collections, namely butterflies and beetles, as well as early plants, might lead that list of 'no shows' in the publically available realm (see Flannery, 1990; Martin, 2005 for paucity of records for mammals despite centuries of study efforts in PNG).

Beehler and Laman (2020) reported on science xenophobia and overregulation of field work (p. 57) making it difficult for the traditional sciences. In New Guinea, that can be based on religious beliefs, e.g. Islamic governance, indigenous cosmologies and/or bad century-long legacy of western efforts in that region. Australia dominates many of the biodiversity topics,



Fig. 6.12 Forest ecosystem with fungi at its finest in pristine Papua New Guinea; those wilderness forests and ecosystems, and their ecological services, are on the decline

e.g. taxonomic Delta keys (<https://www.delta-intkey.com/www/overview.htm>) or tree guide of PNG and all its field data get sent to Sydney and collection managers there (https://www.idigbio.org/wiki/images/e/e9/Guide_to_trees_of_Papua_New_Guinea.pdf). The claim made by Beehler and Laman (2020) that all such collections are globally shared is just 100% not true and not much applicable, nor that much is learned; as the missing conservation progress and crisis for PNG presents. The ecology knowledge from those collections remains bleak, as any literature search for PNG can easily show, and as stated by Beehler and Laman (2020) in their own words.



Fig. 6.13 Old-growth trees loaded with epiphytes: wilderness habitats at its finest and of disproportional relevance (e.g. Taylor et al. 2022)

Besides large decade-long collection expeditions in PNG shown in Table 6.1, many many more exist; not all are well known even. One may add here many local collection efforts such as the Wau Ecology Institute (https://en.wikipedia.org/wiki/Wau_Ecology_Institute) now in a funding crisis, if even operating effectively.

To convince in an argument, the western science world centers around ‘evidence’; the smoking gun. For species presence and taxonomy, this is usually provided with a voucher specimen to refer to as ‘proof’. Voucher specimen allow to confirm and investigate a species detail. ‘*One must have a bird in the hand,*’ so to speak. However, in the year 2022 this is a very outdated concept when nowadays DNA records drive much of taxonomy and when statistics and online analysis are done ‘in the cloud.’ to actually make the case. This now sits at the core of knowledge production but is rarely fully available, certainly not understandable for the lay audience.

In the ‘*cabinet of curiosities*’ mentioned for specimen by Beehler and Laman (2020) as the root of modern taxonomy to go from, certainly for PNG, the major (public) museums competed for exotic species and specimen and collected



Fig. 6.14 A typical epiphyte load in a canopy of old-growth trees

accordingly. The collection expeditions served virtually no other purpose. Institutions and their funders boosted against each other who has most (exotic) specimen and from which locations. It was as simple as that. And the royal courts and wealthy nobles were leading such vanity approach to science and seeking funding, as well described by Beehler and Laman (2020), Martin (2005). In the year 2022 one should move forward and beyond though, serving the public at large, e.g. Graham et al. (2004). Science does not need to be intrusive, unlikely should be (see Humphries et al., 2018 for options). Of course, all old material should be made available, fully described, in a good format, and usually be fully analyzed first before new ones get collected. One may have an embargo on research collections till then; why not?



Fig. 6.15 An orchid harvested from a tree canopy

While many people keep collecting, for the sake of collecting (e.g. ‘...PNG is seriously undercollected...’; Beehler & Laman, 2020, p. 123), the intense collection efforts made in PNG must appear dubious to many people. Many nations competed and participated, not all such expeditions were successful, many are not shared and a wide ‘bycatch’ exist—also in the social aspect of it for impacts. And if the data are shared, they are shared in a filtered form and incomplete fashion. A typical example is with the Bird of Paradise specimen and the tree kangaroo ones without proper locations, or even without a source (widely discussed in Flannery, 1990; Martin, 2005) or any standardized meta-data across languages and disciplines to understand for a global audience what was done (see Huettmann, 2020 for examples).



Fig. 6.16 Tropical flower beauty

The birds of PNG are arguably a global conservation highlight; many of the species are highly sought after by most bird watchers (e.g. Snetsinger & Pratt, 2003), researchers and certainly by museums and their eager curators in the world who are paid and funded for collecting them (see for instance bird collections mentioned in Diamond, 2011; Mayr & Diamond, 2001, and as mentioned in Mack, 2014, and listed in Beehler & Laman, 2020 with taken numbers, easily in the many thousands), and with the Birds of Paradise (BoP) easily on the prime list (e.g. Laman & Scholes, 2012). Graduate student projects from many nations collecting hundreds of bird specimen can also be found. BoPs have actually been intensely collected for centuries by many actors, with 100,000 s of individuals exported over many years (see subsequent details in the BoP section below). Arguably, the collections intensified with colonialism and globalization, and they have not stopped; a recent international poaching upsurge has been observed due to apparent demands by Asia

And of course, nowadays people are also interested in other avian highlights like *'the bird with poison feathers'*: The Pitohui (as stated in the western media; details in Beehler & Laman, 2020; Mack, 2014 with citations within). This bird represents the first chemical defense found in any bird really ...by Western people, as the locals knew this species and its 'bad taste' for long time. It was not tasty and simply avoided. There is another species of this sort, the Blue-headed Ifrit also has a light poison and due to feeding ants that seem to produce such a toxic substance (Beehler & Laman, 2020). But this is 'just' another bird item to be hyped up about PNG while PNG



Fig. 6.17 Ferns growing on tree stems and branches; it's a large contribution to forest biomass and non-timber value

remains very deep and complex with selected bird narratives falling short of wider and earnest conservation overall, or of any western understanding of PNG well and appropriately. In the following I continue to present some more details about PNG's birds:

The 20 species of bowerbirds—famous for their nest attractants and using modern shiny features—are also of great ecological interest for various reasons, but they are much less recognized by a global audience, or their scientists. Most of such species are widely under-researched and actually lack relevant and serious conservation efforts.

Birds that I have seen a lot myself in the deeper jungle during many years of fieldwork are sulfur-crested cockatoos, and Blyth's Hornbill, but almost no Papan Vulturine Parrots. Was I just lucky, or unlucky or has that a wider conservation meaning? Arguably, those species are easy to detect by call and flight, and thus biased detections.

Further, PNG features ground doves as well as various parrots, but no real hummingbirds. The latter group is likely compensated by flowerpeckers and other species instead. Notably, but not new, are the specific elevational associations of avian endemics and ecological niches (as widely described by Diamond, 1973; see Beehler & Laman, 2020; Steadman, 2006 for citations) and then also the many island ranges as some species failed to colonize islands and sites across saltwater and islands vary in elevation.



Fig. 6.18 Field work is demanding: hiking and researching ancient forest trails connecting the coast with the highlands that were used for millennia

The bird biogeography described by Diamond (1973, 1976) onwards became of world fame. It set a template and consists of elevational gradients, island hoppers, island skippers and other peculiar cases. See also work by Mayr and Diamond (2001), Thibault and Cibois (2017) on islands, seabirds and the island declines (Steadman, 2006). Each island has its own set up and history; a microcosm of life.

Shorebirds—part of waterbirds—are also of interest for PNG but a bit overlooked, specifically the ‘peeps’ (sandpipers) at mudflats (see Long et al., 2021 for a PNG Ramsar wetlands affected by oil & gas industry), and Far East Curlews (see Fig. 6.36 for estuary habitats) as those come from Russian Far East, Australia etc., and appear on the decline now. And then also the other many long-distance shorebirds that migrate between Russia, Australia and landing in PNG’s wetlands like the Ruddy Turnstones, and Rednecked Stints; some plovers might connect with Tibet and the Hindu Kush-Himalayas or Mongolia. Others might just extend from Australia across the Torres Strait, including gulls terns and some white-bellied sea eagles.

And many people might not know that PNG acts as a wintering ground for Russia’s and Alaska’s Aleutian tern species, many now on a dramatic decline. It’s part of a wider species movements and similarly connects sea turtles and sharks from Hawaii and even from the Californian current and from parts of southern Alaska. Along the same lines, PNG is globally connected with marine mammal migration, e.g. humpback whales, sperm whales and associates. Birds are often part of such ocean communities and we can just see and comprehend the left-overs now.



Fig. 6.19 Matschie's tree kangaroos, in captivity (where most people see them; in the wild they are rather elusive in the deep old-growth canopy and remote and rugged forest areas)

Many biodiversity aspects actually do move and migrate indeed, often as a wider community; exact details are not well known yet and discoveries are still made. Thuna might play a role as their foraging follows fish flocks and brings them to the surface for other species like seabirds to feed and to join. It comes as a co-evolved wider migratory community, and that aspect is widely unstudied because polar environments are still not perceived—hardly studied—as directly connected with the tropics (Zoeckler, 2012), or with PNG for that matter. PNG gets still widely seen as a stand-alone unit, but is more than that and requires context. Research on avian influenza tends to support that due to virus exchange (e.g. Gulyaeva et al. 2020).

Already those migratory species carry with them many conservation issues from the outside. This can be zoonotic diseases or population questions and acting with a time lag; many of those aspects are not studied well and hardly known, certainly not acted on in valid management scenarios. Examples would be found with Zandri et al. (2009 and in Robbins et al. 2016).

Without doubt, PNG remains a bottleneck and deal breaker in case you want to enter the World Birding club (see public biography of one of the leading world record birder, the late Phoebe Snetsinger: https://en.wikipedia.org/wiki/Phoebe_Snetsinger; Snetsinger & Pratt, 2003), there are app. 103 endemic species to pick from in PNG. If you want to be a relevant world birder, PNG is a 'must see.'



Fig. 6.20 A scrap mark of a tree kangaroo on a tree; ‘presence only’ data in the wild

The latest ‘rare’ bird chases for PNG involve subspecies, as well as Beck’s and Heinroth Petrels (e.g. Flood et al. 2017; see also Davis et al., 2018). It’s another continuation and spin-off from the age-old western colonial bird pursuit, ticking, as an off concept for conservation but still heavily pursued by BirdLife International (a UK-based organization and funding platform), helped by such ‘experts’ and many amateurs from New Zealand and Australia, the funders of oil and gas, U.S. Fish & Wildlife Service and so on. Such minds and their projects never run short (see Long et al., 2021; Richards, 2018) while the actual conservation of birds, seabirds and their habitat remains an increasing worry and is a wide neglect towards absurdity. That is certainly true for PNG, and with few exceptions its citizens are usually excluded from such work on their own land and knowledge, e.g. on an author level or for being able to join. A quick science, funding and literature search on birds of PNG for PNG authors and PNG institutes will easily confirm that, see in Laman and Scholes



Fig. 6.21 Chewing and grazing signs from tree kangaroos that come down from the tree to feed; experienced ‘rangers’ (=“Waldläufer”) can read and interpret the forests like no others

(2012), Mack (2014) for BoPs. The few token authors from the region make that argument even further. ‘Modern’ Ornithology has a privilege and elite problem of untackled magnitude. In PNG that does not only include local PNG citizens and their absence, but also bird workers from nations other than UK, U.S., Australia and New Zealand. How many native African, Latin American and tropical-experienced bird researchers have worked and published in PNG?

In terms of ‘using’ birds for livelihoods PNG offers many examples. Cassowaries are frequently caught and young birds kept as pets (they tend to turn very aggressive after a few months and thus get eaten; Mack, 2014 for studies on those topics; see Gillison, 2002 for more photos). Pet cockatoos can be widely found in villages, and their feathers are used in singsings and for instance in the YAMS dance (Cousteau & Richard, 1999).

For ornithologists of the world, PNG is world famous for the work by Diamond (1973, 2011). It’s an archetype of field work in exotic field camps. Indeed it provided great baseline data, concepts and put birds on the global agenda and international arena, asking ‘interesting’ questions, but often this was based on specimen collections, little statistical research design and likely had quite a local impact. It was essentially done with a shotgun approach and without statistical detection and modeling considerations a pioneering but blunt concept that still dominates in most

Fig. 6.22 Leaves are beautiful



museums and is pursued and done that way, e.g. with Burke Seattle Museum specimen holdings for all over the Pacific (<https://www.burkemuseum.org/>). In addition, this work by J. Diamond is not well-tested statistically, modeled, predicted and/or really updated and was never done with GIS and environmental layers, or with any relevant modern quantitative methods, and it awaits field-based counts and statistical detection surveys, or DNA assessments. Modern man-made Climate Change questions rule in their absence. Diamond's work was not digital and thus remained widely unprovable with modern data, with a quantitative rigor and confidence, hypothesis, valid research design and quantitative data and models (but as science is widely done now these days). As bird distribution data for the general public do virtually not exist for PNG—or is not publicly shared in a meaningful digital form with metadata to understand it—such an assessment has not happened. Instead, detailed multiyear nice-looking photographic efforts were done with narratives (see Gillison, 2002; Laman & Scholes, 2012) not adding much to the sciences and conservation that was recommended as best practice and that had been possible or was suggested. Opportunistic field work still rules in PNG, what is a research design, and for whom?

Consequently, the bird data world in PNG remains wide open (e.g. Freeman et al., 2013 for new findings; for digital study approaches see also Huettmann, 2020). All of this stands in contrast to what Jerry Diamond expressed, that birds of PNG are essentially all discovered now and studied, with robust and well-proven principles of biogeography; quite far from it). Simply dealing with detection bias and correction

Fig. 6.23 Leaf structure in a tropical fall; PNG rainforests have little seasons and many biological events occur interwoven



factors for presence and abundances, or model-predictions and remote sensing habitat layers in PNG in the Anthropocene will likely make for a big change and update on what we know about birds of PNG, their range and biogeography. An ornithological culture is to change and modernize still.

Just because a few studies have done phylogenomics and many opportunistic point-location shotgun collections are carried out does not mean PNG Ornithology is in the twenty-first century; Beehler and Laman (2020) are far from correct on that assumption. Even after decades of study the BoP taxonomy is not agreed and well resolved at all, and no protection levels really exist, neither for harvest nor for habitats and forestry, or for fishery impacts and seabird bycatch. A good focus species on that would already be the Frigatebirds, or kites.

People that are actually experts on birds of PNG — including nest finding and bird calls essential to ID and detect them in the field, or on life history details—are far and few, and beyond specimen collections much of the research focus is not very deep, well-coordinated or well-published even. Bird collection, camera traps, mist netting, banding—and now geotagging—and an ongoing, easy but aged obsession with species descriptions, naming and taxonomic splitting, and some DNA works still drive most of the widely fragmented research agenda of PNG birds, hardly with a Melanesian-style conservation focus whatsoever. A bird banding recovery atlas or



Fig. 6.24 Plant specimen for herbaria. Virtually endless attempts have been made in PNG and elsewhere with (plant) specimens collected by international actors in PNG in the millions. But what has been learned, what was the research design and location, when done, where are the data, what synergy result, and how does the (plant) conservation fare in Papua New Guinea? In the meantime, many specimen collections fade away by themselves and remain totally understudied and insufficiently analyzed for their global sustainability value and contribution; PNG has little plant conservation whatsoever nor is that promoted or achieved by many botanist. In reality, PNG is a total global botanist society conservation failure

meaningful band/ring recoveries for PNG birds shared wider does not exist (A good example found with the shorebirds and waterfowls as studied along the flyway by Australia, New Zealand, China, South Korea etc). It's disappointing to see and when new scholars and students engage that way, e.g. via research proposals of their 'dream' project by their supervisors to be funded for them in PNG, all based on repeated and widely empty-handed ornithology narratives and claims handed down over time but achieving so little. As a reviewer, I have personally seen such applications all the time in various reviewing platforms, e.g. National Science Foundation, NGOs and with graduate, PhD students and postdocs. and their institutions, zoos included But what for? Birds of PNG are still not better off, likely will not be the next decade

Accordingly, while many birds of PNG migrate within PNG and by altitude, many details are not well known and shared; despite years of study. Some known intercontinental migration occurs, mainly shorebirds, waterbirds and seabirds. Some birds connect between Australia and PNG; noteworthy here is for instance the brolgar (essentially a Sarus Crane species), as well as some large gulls and shorebirds.



Fig. 6.25 A tropical species of begonia widely seen in Papua New Guinea's forests

While PNG supports a large number of avian fruit eaters and nectar eaters, the ecology of seed dispersal is widely not understood or untangled but remains very relevant for forests and forestry, let's say. One of the longest and best studies on that topic used cassowaries but conservation outcomes remain little (Mack, 2014). For instance, the connection to forest harvest, done in a science-based manner for sustainability, is widely missing in PNG. No wonder then that environmental impact assessments, e.g. done for mining or oil & gas projects, get totally lost in species lists, and thus, have no relevance to actually express 'the impact.' The World Bank, a large funder of forestry works in PNG, never truly used such ecological works for policy, hardly asked for them. Why is that? In my view, any bird research done in PNG now should have a conservation requirement before it gets carried out and done, not?

While it should be clear at least that forest canopy clearings, and when done in mid-elevation valleys, should result in bird changes, even this simple fact is not agreed upon, e.g. for Birds of Paradise (Beehler & Laman, 2020, whereas the expert publication by Laman & Scholes, 2012 remains widely silent on the topic all together, so does most of the work by Jarred Diamond. A lot of cutting happened in PNG from the 1950s onwards, certainly 1970s (see chapters on forestry in this book)).



Fig. 6.26 A ‘touch-me-not’ plant frequently encountered on trails in Papua New Guinea. Likely this species is spread by humans to ‘beautify’ the trail. A typical example of the ‘PNG Garden’ and the Anthropocene but in a style that was rather sustainable for millennia. PNG leads the way

Textbox 2: “*We sort’em post mortem*”: Taxonomy *ad absurdum* without any relevant conservation perspective other than self-interest and money/greed?

In a classic sense, taxonomy is the study of species descriptions, names, and their evolutionary trees. The approach usually is based on a genus and a species name, all as promoted in the seventeenth century by Carl Linnaeus in Sweden, as the state-of-the-art back then. It reminds of first name and last name, applied to humans. This concept then got applied worldwide and even today 300 years later in times of DNA and digital approaches (Beehler & Laman, 2020). What has really changed ? Well, the human footprint expanded and many species declined or got extinct, and that is not a cycle but a trend and consequence from unconstrained human consumption.

This taxonomy is essentially a western classification approach to the world’s environment, but which is now often flipped on its head. Instead of Sweden and Europe, the species cradles are often in the south, but which got described the last, but with a structure done from the North and with voucher specimen that



Fig. 6.27 Flower beauty in red

are actually evolutionary younger than many tropical ones where the species started to evolve.

For PNG, this is obvious in the concept of its ancient figs, insects and amphibians, including crocodiles (many of such species virtually did not exist in Europe but where many of the taxonomic experts are sitting and acting from the remote, including the IUCN with the U.N.).

When it comes to taxonomy from collected bird specimen, PNG has already left a global impact giving a name to a penguin that does not live there, the Gentoo penguin scientific name *Pygoscelis papua*. As a matter of fact, three penguin species got initially assigned to PNG (Mayr & Diamond, 2001). The authors provide longer list of taxonomic errors and impacts, see for instance Lowe (2004) for primates in Indonesia, and Steiner and Huettmann (2021) for squirrels and some global aspects. Just the language choice alone creates problems to describe species. While a numeric description for a species, a taxonomic serial number (TSN) makes it easier to compute and store, it does not resolve well the problem of the species question *per se*. Does it add to the confusion?

PNG has over 700 languages, Melanesia has many more, and Pisin English is a major language there but not well written down by its users, whereas



Fig. 6.28 A white flower beauty

colonial powers all have their own species names, changed them over time, and now use mostly English while taxonomy is based on Latin and ancient Greek terms. Arguably modern species taxonomy is very complicated! But who truly needs taxonomy?

It was a hope that taxonomy will get better over time and when using 100s of criteria, as it is suggested for some species to ID them ‘correctly.’ The use of software such as the DELTA Key from Sydney/Australia is to provide help and solve issues and ID species in a more objective fashion for PNG and beyond (<https://www.delta-intkey.com/>).

And then DNA methods are used to eventually provide ‘the truth’ to follow and to apply. And that ‘train of reasoning’ was widely followed the last 50 years and pushed throughout the science enterprise and its journals and paid editors. But more advanced methods came online, new lab machines frequently occurred, and those ‘new methods’ are not all in agreement neither; ‘revisions’ get frequently published and updated (typical examples are found with the late American Ornithological Union AOU bird lists, e.g. shown here <https://www.audubon.org/news/here-are-biggest-changes-aou-checklist-north-american-birds>). Retractions are record high in the DNA disciplines. And then there are also species that cannot really be done with DNA



Fig. 6.29 A commonly found flower in village gardens of Papua New Guinea

methods well (e.g. Vasilita et al., 2022), or where DNA is ‘not there yet’ to do so. There are also experts and nations that tend to reject DNA methods and who stick with morphometric criteria instead, besides others.

Mis-identification also remains a rampant issue, even with specimen collections; see Mayr and Diamond (2001) for historic examples over time.

It’s ‘*taxonomy ad absurdum*,’ again: All what western institutions and their employees often know and do in PNG is to describe specimen, but no ecological insights or conservation are really possible from such collections and harvest expeditions, as shown and stated by Beehler and Laman (2020).

Man-made climate change provides once more a good example for the lack of progress in the collection-based taxonomy worldview, e.g. the concept of “*all needs to be known first before we can act*”: The curious glaciers and snow areas of New Guinea have been studied for many decades, and they were a piece of research early on, e.g. for British explorations (as described by Beehler & Laman, 2020; see citations within). Mt. Hagen was climbed by many Alpine celebrities, including Reinhold Messner (famous for Mt. Everest etc climbs). Flannery (2022) even had referred to the changes of these areas early in the 1990s onwards due to global warming, but a relevant recognition or actions to stop climate change did not come from it to the very day. Historically, these



Fig. 6.30 A red flower with big volume

areas were heavily ‘collected’ though. But still, no relevant climate change actions have come from it, see [The Guardian \(2020\)](#) for public statements.

To the outsider, and as widely portrayed, taxonomy appears like a sound and robust science, based on respected institutions even describing new species to justify their administrative funding existence. But a closer look will easily reveal an institutional debacle of the endless kind. PNG shows that very clear with its ‘penguin,’ the Birds of Paradise (disputed for centuries), albatrosses, the super complex reef and marine species (virtually not well inventorized even in a century of effort; see also for cryptic species, e.g. crayfish, [Blaha et al., 2016](#)) and unnamed but occurring new species for insects, frogs and plants.



Fig. 6.31 White and sophisticated: PNG flowers are magnificent

Beehler and Laman (2020) actually described rather well how taxonomy and its naming schemes functions: running after European nobles to please them all done as a competitive race among scholars for greed and fame. Naming, the new species after some powerful ‘august’ or member of royal family to get support. It became a sport, with countries like PNG as an arena. For PNG, we see such concepts applied and now everybody needs to live with it in perpetuity, written in stone. Conservation efforts were ignored. For instance, it was tried to do so with Queen Carola of Saxony, bird of paradise (Beehler & Laman, 2020, p. 291). The science of taxonomy simply works that way, taking up western institutions. In the meantime, those species names can be rather confusing and



Fig. 6.32 Flower beauty in the microview

a whole barrage exists for the same species a group (see any example in Rhodin et al., 1980 for turtle names).

For PNG, with over 100 species of amphibians new to science coming online, but not officially described yet (details in Beehler & Laman, 2020) a naming frenzy is to happen further. Amphibian numbers can easily be expected to double. Who can pay for it, who can keep the books and who manages it all well for conservation, validity or quality? PNG insect numbers are also to increase, more bird species are likely getting split, and many mammals are still poorly described or known such as tree kangaroos. PNG easily puts western taxonomy *ad absurdum* while collectors keep collecting anyways; it's a pleasure. Done by helicopter and similar "*fly me in and out, please, ...and others pay for it*" as described as a common concept by Beehler and Laman(2020, p. 293), but it has no real landscape and reality context of the place—and the people—where they work in and what they analyze.

One may easily call taxonomy a bad, failing and repeated book-keeping approach to nature (Alcorn, 1993; Faith et al., 2000; Beehler & Alonso 2001 for such compilations; see Wikramanayake et al., 2002 for a similar approach using Ecoregion clustering), done by dominating, money-hugging and power-grabbing western institutions and their employees and subcontractors (many



Fig. 6.33 A small orchid (PNG is the world's headquarter of orchid species; in comparison, Hawaii just has 3 original orchid species)

National Academies actually operate as contractees) and often paid by extractive industry. So where really is the science, and why based at public scientific institutions?

And it does not end there. To better describe species and their biology, one applies for help. Citizen science offers such shared workloads in excess of a curator, and para-taxonomists are now used worldwide, also in PNG. Many more species get described, more people are looking, but who sorts it out for overlaps and accuracy, or effective conservation? What is the truth and where located? Arguably, there is more work to come...but thus far conservation certainty remains elusive.



Fig. 6.34 Typical ornamental flowers in a village of the Huon Peninsula, Papua New Guinea

6.3 Widely Misunderstood Birds of Paradise (BoP) and Hyped World Records Lead the Way...into a Superficial World Audience Ignoring Conservation Reality?

Arguably, the ‘Bird of Paradise’ (BoP) is a headline for any naturalist coming to PNG. They have been called ‘*Birds from Paradise.*’ This group of species still makes for a great discussion item at any cocktail party, for those people who feel ignored and seek the attention (and subsequent money or other fame). But whoever has pursued BoPs in the wild and watched the wider BoP scene will agree: These are far from easy birds to find and to see, or to photograph (Latam & Scholes, 2012 as acclaimed BoP experts and photographers; see camera-trap imagery and gear used within).



Fig. 6.35 Ferns are found in many shapes and forms in Papua New Guinea’s rainforests

BoPs are smart like crows (as they are essentially ‘tropical corvids’), social, fast, occur in the canopy individually or in small flocks, either hidden by the shadow or the sun glare, and are often found in remote steep-sloped areas; depending on the species. Seeing BoPs also usually means you actually need to be in rural PNG first of all; a trip most people do not do or dare (a few species occur in Australia and Indonesia also).

Because BoPs are part of the taxonomic corvid group (e.g. crows, ravens), they are similar to any other of the world’s corvids (a group known for their intelligence). Depending on the taxonomy used, there are 40 BoP species to choose from—38 of them in PNG; their headquarters. Some people are ‘obsessed’ to see all their species or to photograph them, now done frequently with high-powered lenses (Gillison, 2002) or even better, camera traps (Latam & Scholes, 2012); it’s done for their records, for status, money, fame and a certain cultural world dominance; PNG citizens, villages and the sophisticated landscape maintenance are widely excluded (Latam & Scholes, 2012). That’s specifically the case in the western world, and in Europe where BoPs were promoted by the remote royal courts and by the powerful for their own agendas. For instance for Australia, John Gould—an ‘obsessive’ bird collector—promoted BoPs in PNG early on for the global audience (<https://australian.museum/learn/collections/museum-archives-library/john-gould/>). It does not come as a surprise really that virtually no PNG authors are included in any of the BoP literature. It’s as PNG

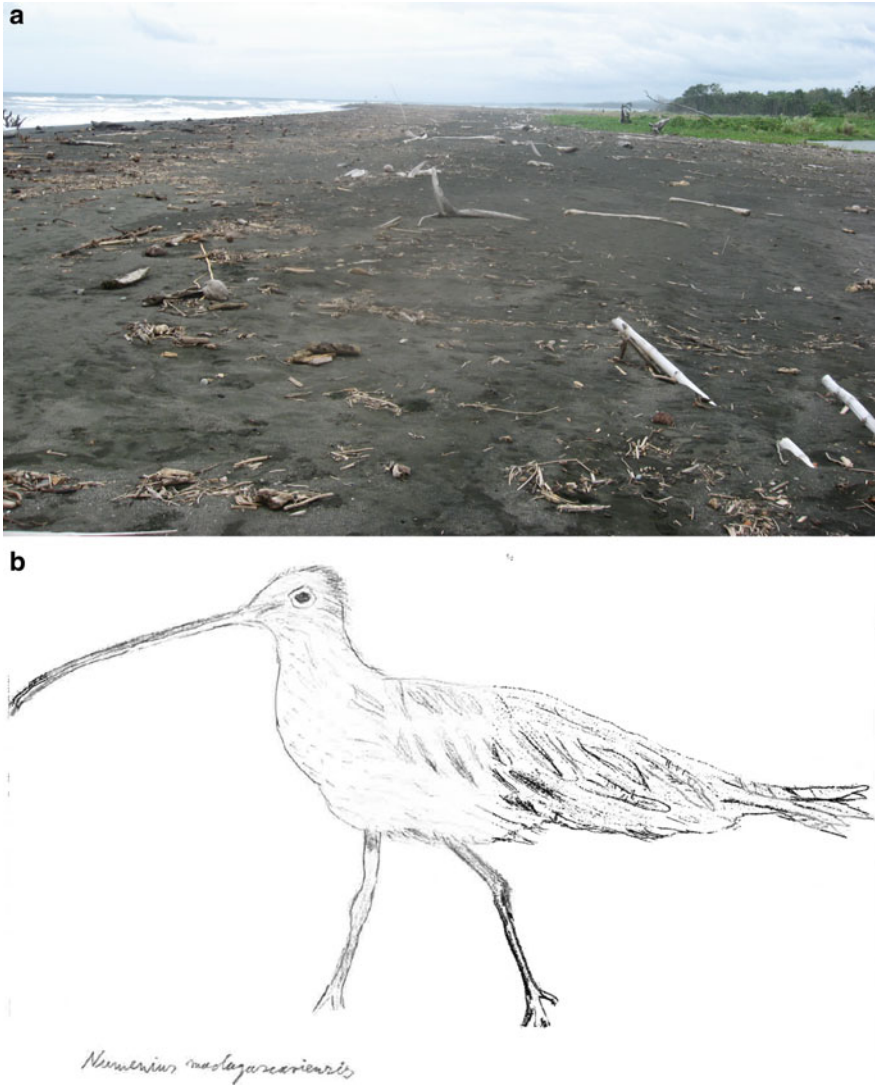


Fig. 6.36 A beach in Papua New Guinea (a), staging site for migratory curlews (field sketch; (b)) (the latter species group is now of conservation concern along those type of habitats)

people do not exist in the BoP research, while they have been with those birds for millennia.

Perhaps one of the easiest BoPs to see in PNG is the Raggiana (e.g. see Gillison, 2002), also the iconic national bird of PNG. As a matter of fact, many locals in PNG clearly know the western obsession for this bird and track them well for that very reason, and for western observers. If not careful, one may easily become prey



Fig. 6.37 Stray village dogs found on shorebird and sea turtle nesting beaches; those are not good friends...

of the BoP and their culture and get looped into endless fund raising campaigns on such matters. Locals in the PNG bush build permanent blinds for people to encounter the BoP at a given time of the day (or to hunt them for the bird skin to be traded). But beyond a plain birding tick (“*I think I saw them, well must be*”), one can also buy a BoP skin (it’s illegal in PNG but remains ongoing and widespread; details in Beehler & Laman, 2020. See also Flannery, 1990 for such trade around mining sites, whereas many mine sites make hunting illegal for impact reasons).

Clearly, the breeding displays of BoPs are the highlights for the bird watcher, and global audience, ideally with a great photo, or now with a YouTube video or to skype it to your relatives overseas—in-time. ‘*Why not being like David Attenborough with the BBC?*.’ Arguably, that is not to happen for most people and birders ‘though.’ (the few seconds of BoP TV fame are coming from years of high-level effort, tries and gear; see Laman and Stoles 2012) But keep trying... People literally tried to build Eco-Lodges and entire helicopter tours around BoPs (see details in Beehler & Laman, 2020; Mack, 2014; West, 2006). An assumed win-win for everybody, and for the birds. But it turned into a triple whammy, and worse (West & Kale, 2015). Needless to say that those ‘lek’ matings are crucial for BoP reproduction and thus for BoP nesting, population maintenance and conservation. Saving the leks means saving the birds and their habitats. It’s therefore not possible to loose forests at the current dramatic rate but BoPs would still be fine. BoPs have co-evolved over time in a



Fig. 6.38 Pigs found on shorebird and sea turtle nesting beaches in Papua New Guinea

complex setting, with humans being around in the landscape and pursuing them. That's likely where some of the mis-understanding comes from, that BoPs would simply be able to stand the human pursuit and habitat loss (doomed surplus, 'spilled milk' concepts from the 1930s but proven utterly insensitive and not applicable; see Karger et al. 2021 for global forest loss). BoPs cannot stand it, just like many other species can't in PNG and beyond.

The fascination with BoPs is part of a PNG culture for thousands of years. The western obsession with BoPs is not so new neither and also reaches back from the start of western contact with PNG. In the absence of gold found, BoPs reached high on that list to justify the colonial efforts. In addition to the spices, BoPs were seen as 'wealth from the colonies,' to get 'value' from those remote colony areas and to make it all worthwhile. One had to bring back something! It is believed that the first BoP skins came to Europe already in 1522 by the surviving crew members of the *Victoria* (the only ship that has completed Magellan's circumnavigation voyage around the entire globe; State Library New South Wales, 2022). In 1630, Rembrandt was one of their painters among many others and helped to bring them to world fame. A colonial PNG PR trick was born, ongoing til today (e.g. Laman and Stoiles 2012, Beehler and Laman 2020).

As reported by, and in display with, the State Library New South Wales (2022) the aforementioned naturalist and painter John Gould (1804–1881) visited Australia in 1838. Gould became famous for his seven volume works *Birds of Australia*. But



Fig. 6.39 Birds of Paradise skin in a bus to bring luck

later he was also engaged in compiling *The Birds of New Guinea and the Adjacent Papuan Islands* (finally completed after his death by Dr. R. B. Sharpe). This work then further contributed to the wide exposure and appreciation of BoPs and of PNG. But it also helped to set the foundation for Australia as a connoisseur, curator and thus control-agent of PNG and BoPs, and similar relevant items. It just came as another British fabrication in order to promote and dominate colonies (and their people) while PNG citizens, BoP habitats or BoPs themselves were mostly ignored. Traditional Ecological Knowledge (TEK) around BoP is described little, if at all (see Gillison, 1993 who studied nearby a BoP research hotspot).

Bird taxonomy is widely in flux. Depending on the taxonomies used, there are app. 38–43 species of BoP, but the BoP taxonomy remains dubious and done in English (Beehler & Laman, 2020), and splitting of species is not so clear, e.g. for the Superb BoP (<https://www.birdsofparadiseproject.org/new-vogelkop-superb-bird-of-paradise-changes-up-the-old-song-and-dance/>). There are long and severe disputes on BoP taxonomy and its phylogeny for many decades, and it is still widely unresolved! What's a subspecies in BoPs?

As PNG hosts all but two of the c. app. forty BoP species, there is a deep and co-evolved BoP culture in PNG on the ground. The tribal societies of New Guinea traditionally used BoP plumes in their dresses and rituals (Gillison, 2002 for rituals). Among many, men from the Yonggom tribe for instance were very knowledgeable about these birds and successfully hunted the Greater Birds of Paradise. Their feathers



Fig. 6.40 Close-up of a Bird of Paradise skin in a car; an image widely found in PNG

were used as adornment on the ceremonial headdresses. Those were worn during ritual dances (Latam & Scholes, 2012). The amount of skins and species used in those PNG ‘sing sing’ events can be easily in the hundreds (! Details shown in Latam & Scholes, 2012). Arguably, BoPs are heavily pursued.

BoP ecology is not well known, but these species operate as seed dispersers and they might create a high-quality seed rain. Already a single fig tree can have up to 40 bird species (Beehler & Laman, 2020). Still, details of such relevant forestry aspect are easily hindered by tree species and fruit identification, lack of an agreed taxonomy and study methods. How to conclude?

BoPs are also sexually dimorphic, males occupy ‘fixed leks.’ Despite their massive and fascinating, defying evolution and subsequent pursuit, BoPs only lay one egg though. Predators seem to be few. And while forests with BoPs are on the generic decline, one can spend a fortune to see and photograph BoPs. And a few people do

Table 6.1 Short selected list of major collection expeditions for Papua New Guinea

Expedition	Focus	Nation	Citation	Comments
Crane expeditions	Sepik region, done by a fish researcher	U.S.	Herre (1936) in Webb (1995, 1996)	Two years work with a photographic focus and record of many PNG details. Context is discussed by V. L. Webb but actual interpretation just comes many decades after the fact
Dutch colonial expeditions	New Guinea	Dutch	Holthuis (1949)	National Dutch explorations while Holland still had the oversight of its colony
Archbold expeditions	New Guinea	U.S.	https://www.archbold-station.org/documents/publicationspdf/lohrer_2019_11ArchboldExp.pdf	Famous and very long expedition work with the American Museum, 7 expeditions done directly in PNG, and a few others
British speleological expedition	PNG	British	Holthuis (1978)	One of many British expeditions for New Guinea (see Beehler & Laman, 2020 for more details)
Finisterre Gebirge expedition	Colonial exploration	Germany	Zöeller (1891)	Germany explored in its accessible areas a lot, but little information reached the mainstream research body of today, e.g. due to language barriers and efforts not designed well to be shared globally
Ok Tedi mine and Fly river Cambridge expedition	Fly river region with a focus on the Ok Tedi mine project	British	Boyden et al. (1975)	A classic for funding/support, 'objectivity' and elite research. See the rainbow fish species that carries Ok Tedi in its name (https://rainbowfish.angfaqlid.org.au/Oktedi.htm). Such mind-sets still drive a lot of the research world and in PNG today

(continued)

Table 6.1 (continued)

Expedition	Focus	Nation	Citation	Comments
German botanical collections	Northern PNG (German colonial sectors)	Germany	Hiepko (1987)	Many of those specimen information are typically blurred, published with a vast delay, hardly in GBIF.org, carry no metadata and are debatable for (modern/international) taxonomies, etc.
German ornithological collections	Northern PNG (German colonial sectors)	Germany	Stresemann (1923)	Many of those data are not available in English for a wider audience, hardly for a PNG audience

There are many more collection expeditions and surveys done in Papua New Guinea, here a list with expedition years to be inquired more (sources found in Hays 1993 etc); they all have deep stories to tell with data underneath: Borgman (1960/61), Brass (1928–1939), Carr (1935), Clemens (1931–1936), Lederman (1914), Liditker and Ziegler (1968); see also Huettmann (2021) for tree kangaroos etc

spend it (see Latam & Stoles, 2012 for equipment and travel list; funders not much exposed).

But ask yourself, and after people having done it for over 300 years: What came from such intense pursuit? Did the people of PNG benefit, and the PNG nation, or the habitats and birds overall? So then beyond some photos and ‘birding ticks’ (Gentile, 2009), who really has understood a BoP and who really truly cares for them, or for their habitats? The conservation status of BoPs is supposed to be ‘stable’ with virtually no species having been assessed in demonstrated quantitative terms, and with a defensible conservation status even. What is the BoP management method and who does it, and does it follow any wildlife management principles, other than ‘*laissez-faire*’? Thus, an assigned ‘status’ as done by IUCN or BirdLife International etc sounds perplexing and it cannot really be ‘stable’ when forests are their prime habitats and when those are lost in a record-high rate and without any forest management or data whatsoever (see subsequent chapters of this book).

Beehler and Laman (2020) think that the BoP harvest, now and historically, has little to no impact. Laman and Stoles (2012) widely ignore the subject all together. That assessment one would judge as very doubtful. The authors provide no real data on their claim that BoP are of no conservation concern but rely essentially just on the ‘*surplus harvest argument*,’ which has been disproven so tragically worldwide for many decades already (Williams et al., 2004) and which the authors use all the time in reverse on PNG’s large mammal decline (e.g. high human pursuit levels). Because BoPs have little conservation and little shown and available data and management, they are in a precarious state with experts that do not notice it well. And we have been there before.

6.4 Trees of PNG: Precious, not Surveyed, not Understood, Mis-labeled, Unpreserved but Dramatically Cut-Down all with the Global Community Watching and Consuming

PNG is known globally for its virgin forests. Compared to other areas in the Pacific and worldwide, many of them are still widely spread, relatively pristine, diverse and gigantic, and even widely unexplored! Such forests are true retreats and the ‘living room’ for a remaining civilization of the last thousands of years. Indeed PNG has one of the largest blocks left of intact old-growth rainforest in the Pacific (Beehler & Laman, 2020).

Already the known tree diversity covers c. 600 tree species (<http://www.pngplants.org/PNGtrees/>). But with a deeper taxonomic inquiry over 3000 trees can likely be expected for PNG. A one-hectare plot can already support app. 70–200 species (Beehler & Laman, 2020). There are Antarctica beaches, 150 rhododendrons but just a few Diptocarp species (less than found elsewhere in SE Asia). Locals do know the relevant trees and what they have to offer; a certain symbiosis and co-evolution with humans and beyond were developed (e.g. for Melanesia see for instance Demeulenaere et al., 2021). Trees up to 45 m in height can be found, e.g. the Benuang (*Octomeles sumatrana*). So how to ‘manage’ it sustainably with a massive cutting ongoing?

This book has a specific chapter devoted to forestry, and a wider PNG context is presented there. But it’s worth to mention here that forests are a core-livelihood feature for most people in PNG, and there are a great many noteworthy forest species and ecology aspects in PNG forests to mention, such as the oaks, tree ferns as well as ancient figs (with PNG as the cradle). Already the fig trees are important for many BoP species, and those can cluster around them. For BoP survival figs play an essential role! Many other aspects are not well known yet and certainly not managed.

‘Swidden forestry’ carried human society in PNG for many thousand years, people modified forests with fire and planting nut trees, and later, timber trees (those might have been introduced, such as Casuarina tree arriving app. 1200 years ago. Similar applies to betel nuts and their palm trees; Beehler & Laman, 2020). Further, in PNG people beautify their forest trails, e.g. with *noli-tangere* species due to their beautiful flowers, and fruit, and thus, ‘garden species’ can be found widely dispersed in the wild and remote bush. It makes for a unique, sustainable landscape feature. PNG locals are the great landscape gardeners, and it’s quite sustainable and has been for over 47,000 years! So why now the destruction?

But despite forestry ministries, international experts, forest policy revisions, development aid, certified forest markets and sustainable forestry, industrial Australia as the next-door neighbor and advisor, one must say to this very day: There is no pixel-based PNG-wide forest inventory or a decent distribution map for PNG trees, nor is it really known how many tree species there are in PNG, their life history, or any approach on how to manage them.

As a profession, 'Forestry' as well as Botany and such sciences and institutions clearly served PNG poorly (examples are provided in Cousteau & Richards, 1999, pp. 206–207; see also Beehler & Laman, 2020).

6.5 Plant Overview: Power to the Flowers

Already a non-expert in plants will easily detect the poinsettia flowers that are planted all over the nation. They have leaves looking like actual flower petals and give a great testament to the fact that PNG is the great garden, man-made! PNG likes flower beauty. Much power sits within that.

Arguably, orchids, moss, some domesticated flowers, ancient figs and tree ferns might be dominating the discourse about PNG plants; but there is so much more. With perhaps 13,000–20,000 plant species in New Guinea overall, PNG is among a world record plant nation and island. The grasslands, usually carrying much less species than forests do, but add another relevant dimension (Beehler & Laman, 2020). While grass is very complex for a species group and its ecology, it's even less studied and known. Most grasslands are man-made, likely a certain effect of fires started by humans throughout the 47,000 long history for better access, farming and hunting (Robbins et al. 1976); and part of a swidden forest process (details for PNG in Beehler & Laman, 2020; Flannery, 2002). In the traditional absence of large (animal) browsers, it's a co-evolved 'grass-scape.'

Plants of PNG are described and collected for centuries by imperial-funded scientists (see Beehler & Laman, 2020 for overviews and expeditions). However, relatively little precise information and conservation maps came from it; and virtually no conservation efforts (unless it is of outermost commercial interest and invokes DNA copyrights, bioprospecting investments, international trade and consumption). That is certainly true for PNG. See for instance work and data in Hiepko (1987) for the decades-long colonial German collections but which are widely lacking international context, metadata and are hardly found and accessible in Genbank or GBIF.org with context to be used for scholars, with a research design or for progress. And then, see Paijmans (1976) for an actual PNG plant atlas (not in a digital format, and species taxonomies widely debated still). Nowadays, plants of PNG are covered in the ongoing and incomplete 'Flora Melanesia' (<https://floramalesiana.org/new/>) with all data to be shown in GBIF.org for a global reference and appreciation. However, no lay audience is able to really use and employ this information yet and species naming concepts are widely diverse across cultures and languages (PNG has over 700 languages, Melanesia has many more, and Pisin English is a major language but hardly written down, whereas the many colonial powers for the area have their own names, changed them over time, and now use mostly English while taxonomy is based on Latin and ancient Greek; a concept very remote from PNG but which had their plants known and used for over 47,000 years in a sophisticated fashion which is c. over 44,000 years before the Ancient Greece did. Arguably plant taxonomy is

a complicated topic which will favor PNG but which currently botany or taxonomy are not doing!). Farming of many tropical food species likely started in PNG!

PNG carries many botanical world records, already its lichen diversity is the highest in the world; add the mosses. It further features the largest orchid species hotspot in the world (Montgomery & Bishop, 2006), with *Bulbophyllum* and *Dendrobium* (Spatulate orchids) being specifically species rich (Orchid Society of Papua New Guinea Inc., 2006). Some members of the species group of orchids can be immersed in ocean water and feed off salt spray. Most orchids are epiphytes, and app 85% have a high endemism (Beehler & Laman, 2020). Overall, New Guinea has app. 2850 orchid species (Beehler & Laman, 2020), and there are likely less in PNG (details remain unknown though while orchid trade and harvest are ongoing virtually unabated or managed; associated enforcements are virtually not heard of). In villages of PNG, some orchids are used for ‘arm and wrist bands’ and get planted for that reason in a certain domesticated fashion (Beehler & Laman, 2020).

While the study of the PNG flora remains in its ‘youthful’ stage (Beehler & Laman, 2020), studying plants should also help for a better forest management. However, thus far it has widely failed to do so. I spoke with botanists about this topic, and most just ignored it or just threw their arms in the air. It was clear that they ignored the subject and were even angry when I raised that question. Non-timber products seem not to be much *en vogue* with such botanists. But in reality, those are essential in any forested landscape; now more relevant than ever.

Textbox 3: Environmental Impact Studies in reverse: *Laissez-faire* in real life

Environmental impact studies sound like a great idea: Assess whether an industrial effort is harmful, and if so, it will be stopped, addressed and/or mitigated

Well, judged by the ever-increasing industrial footprint, that has rarely happened, and it has not happened effectively to stop bad industrial impacts, or to improve. Already just looking at man-made climate change and the release of CO₂ shows that clearly. Mostly, the legal argument of impact assessments are a smokescreen, a true greenwash and used for demagoguery; nature is not given a real chance. For PNG, those questions get more complex and more sensitive because it involves people, funding and the fundamental national set up, as the case in Bougainville showed (see chapters in this book). Can one accept an impact for the wider public good?

To get at the actual impact, there are many questions what to measure, how done and by whom, and who pays for it, and whether that is even possible and meaningful?. Classic studies for PNG used for such purposes and with such questions are found with Boyden et al. (1975) involving Cambridge University, Ok Tedi mine and water supply affecting PNG and food security for a long time. A more complete picture on that impact can be seen in Kirsch (2014). Similar works exist and are frequently done, e.g. Richards (2018); see Earthworks,

Deep Sea Mining Campaign et al. (2015) for a review of seafloor mining impacts.

The binding framework how such impact studies are actually to be used matters also. Sullivan (2015) showed that those studies get often used as a '*pick and choose like cherries*,' which puts doubt on the objectivity, purpose, effectiveness of such efforts and on the legal use of such studies. The latter profession gets exposed for their actual 'impact'.

Taber and Payne (2003) show and discuss those failing concepts for North America—many more by now exist—and it's clear those steps are legally required, but hardly perform. Those assessments can turn into public soap operas, and many of those exist, while the economic development industrial efforts are steaming along either way, anyway; business as planned proceeds regardless then, globally (Czech, 2020).

So what value do such (rapid) assessments really have, when not done thoroughly, without thinking and reflection, and when not given a chance to truly show, critique and stop the development, often just favoring a strategic use and subsequent destruction of the natural resource? Impacts cannot be divorced from the process, or simply bought out. A de-coupling is not possible on a finite space and resource (Daly & Farley, 2010), e.g. in a sophisticated and interconnected island-state like PNG. This basic reality and the inherent flaw in such measures rarely comes to the forefront though, and those weak steps of policy are to be addressed and resolved better, if nature is to have a fair chance, or PNG for that matter.

So what should a botanic scholar really do, and write about PNG plants overall? Typical examples of those open questions for PNG are found with Webb et al. (2005) based on Harvard references and with CSIRO and NGO support. A concept that is sold to the indigenous people that way also for (western) relevance and authority. But it's narrow, not holistic, lacks conservation and one easily can do more and better, considering the forest landscape and its complexity is of global relevance but they simply get 'lost' at a record rate; conservation does matter.

While it appears to some people perhaps like an off topic, one may easily report first that (western) botany in itself is in a crisis. While often funded by commercial entities and wealthy donors, botanists and their institutes usually never clarify whether it should be a capitalistic botany, to make rich people richer, celebrate colonial efforts and insist on copyrights and privatizing the common good, plants and their DNA and clones, e.g. for farming or medical reasons? Most of the PNG botany done by the international community sees it no other: bioprospecting and providing steps to get there and set it up with species lists and some whereabouts; now all done online. Habitats do not matter in such a plant science. Much of the PNG botany stems from those types of questions, and while PNG remains deep and difficult to

study it indicates that such botanists never really tackled the ‘real’ questions and the context among themselves for a good outcome of their doings:

What really are the research questions in botany worthwhile, and for a sound and robust botany in Papua New Guinea with a Melanesian view point?

Just sticking to ‘names’ in various languages, digital or not, intransparent inventories without proper and agreed- upon ID keys or research designs, and ‘just’ then century-old naming of items collected is not objective, hardly useful or even science (e.g. what is the hypothesis tested, and how done, what research design and sample design, what sample size, how mapped and how assessed quantitatively with statistics and confidence, shared with the wider global public in a transparent and repeatable manner?).

And how are all the other many aspects of botany catered, including representative sampling, use of latest methods, environmental and social justice, inference for generalization, landscape scales, and PNG needs which are all so embedded in food and thus in plants (for PNG those are essential questions: Demeulenaere et al., 2021; Narokobi, 1975, 1983; see Heinemann et al., 2009 for Agriculture at the Crossroads report)? Botany can be pursued in so many directions. But the western route primarily took on the commercial DNA taxonomy and book keeping one. It was done through ‘white mans’ angle as the mainstream, a path of greed—with a bit of added ecology to ponder and justify complexity (which humans and experts have such a hard time to grasp). Staying in that mind-set, most western-style Botanists can only add here to the endless bias and write it into stone further with species lists while trying to hang on to their funding and employment positions. PNG plants are just a collateral that game, so are the people of PNG who rely on those plants.

For PNG, it took the collection, ecoclassification and bioprospecting angle; much of PNG’s botany done by experts is simply stuck in collecting, documenting, botanical plots, and selling flowers and (genetic) plant parts abroad, breeding them, and at best, clustering and describing them, e.g. in photo books for the coffee table and creating income and ‘slash funds’ for professional societies (Orchid Society of Papua New Guinea Inc., 2006) but doing virtually nothing though on robust science, people, climate change, and effective conservation, let alone data for good use and progressing the nation, or plants for that matter. The latter two would be rather honorable goals; so why not pursued? Like with many tropical botanies, PNG botany still sits largely in the colonial mind-set; arguably it is widely dominated by Australian efforts and their agencies, helped by Europe and the U.S. - as the dominating science power in the world.

Botany work in PNG had over 400 years to do otherwise, but still it did not. It took the wrong exit. The wide fallacy of such a botany dominated by just a few driving entities can easily be seen in the very sorry and pity conservation state of tropical plants and their management and policy, see forestry itself; a world crisis. While evolution-wise, PNG has the world’s oldest plants (likely millions of years ago), the taxonomy used actually still comes from remote Sweden, seventeenth century onwards. Our worldwide dominating taxonomic and evolutionary understanding was built up from

the North, using Latin and ancient Greece, but this is far from the cradles of biodiversity, such as PNG is (examples discussed in Martin, 2005 for mammals). So how can such a system and its experts ever cope with PNG, its plants and do it good justice (details in textbox taxonomy; see also chapter in this book on Forestry)? One awaits for answers while the habitat angles got virtually ignored. Already moving into a Landscape Ecology perspective would be progress.

It's clear that so many more plants still await their research, discovery even, and that it can lead us into new directions eventually, but the conservation policy hardly exists to do so in a modern world for PNG or for the tropics. So what does that show and where does that leave us?

6.6 Insects: An Overview and Description is Next to Impossible

People not familiar with insects in PNG will still easily recognize the huge spider webs by the large orb weaver spider. But while PNG features actually a relatively low number of spider species overall, for people with sharp eyes, they will detect many other fascinating insects, e.g. the 'walking stick' (an ancient species group, many species exist within). And PNG is globally known for the bird-wing butterfly, Queen Alexandria's bird-wing (as the largest butterfly in the world highly sought after by naturalists) but now highly endangered, subsequently also a highly prized collector's item. Values increase with conservation declines, and a high pursuit of 'world record species' will put pressure on them (many examples for that pattern exist, e.g. large beetles or for birds, the Ivory-billed Woodpecker in the U.S and Cuba Gotelli et al., 2012). Insects are often popular with collectors and 'insect lovers', e.g. done in PNG for the markets abroad through the Insect Farming and Trading Agency (https://www.pngyp.com/company/1513/Insect_Farming_Trading_Agency). Species get collected in the wild but are hatched in captivity for the export trade. Collections play a large role, as shown in Beehler and Laman (2020, pp. 141–142). As a matter of fact, selling butterfly cocoons for market export is a real business and one that thrives in PNG (Beehler & Laman, 2020; Cousteau & Richards, 1999). Butterfly farms, such as in Bulolo, present a new form of cash crops. One may find it a bit dubious as those are used abroad for releases in weddings, parties, religious mercy releases and the like, e.g. in Australia and Asia (it remains unclear where the butterflies go from there after the release; presumably they are left to die). While collected in the wild, they usually hatch in domestic conditions and get sent off from there for a profit for such uses; PNG fully participates in such efforts.

New Guinea has app 300,000 insect species (Miller, 2007 in Beehler & Laman, 2020). That's app 5% of all insects in the world. Typical representatives are the mentioned stick insects, but also katydids, cicadas and crustacea. Further, app 10,000 species of moths are found in New Guinea. For beetles, PNG is a hyper-diverse site

and the Giant Horned Beetle is another collector's item. In PNG some insects are also eaten, like grubs found in tree stumps.

As long as insects—the invertebrates—are not recognized with any animal care rights such trades will continue though and with a somewhat Australian oversight and approval, usually with Asia as a 'big market.' It's a bit strange because one of the world's leading animal right activists comes from Australia, Peter Singer (https://en.wikipedia.org/wiki/Peter_Singer), but no real progress is made for insects on that matter in the region. Whereas in contrast most indigenous and PNG people understand and know for millennia that we are all connected with the universe, and its animals, butterflies included. Traditionally, the pursuit and bycatch of insects, including their habitat loss and transition, has never been that high in human history, all helped now by colonial powers and the western world and globalization, e.g. in pursuit of economic growth on a finite space. What culture is sustainable, and which one is not?

6.7 Study Insects for What, How Done and for How Long?

Along the same lines, and close to the heart of western society and its sciences, sits the actual study of collected insects in PNG. For instance, tree canopies over 20 m high up to 45 m are widely understudied for insects in the wild and have an attractive appeal. Tree climbing or canopy cranes are often used to address that, e.g. there is a PNG canopy study site in the Baitabag Village 45 m high (in Beehler & Laman, 2020), and it really looks spectacular. But how does it conserve PNG and insects, considering record losses of rainforests have been realized in PNG without any relevant constrains? While describing insects and count them how is insect research effective on those essential (habitat) measures relevant for mankind?

Instead, insects are typically still studied with collections and get pinned in boxes for an assessment. DNA just adds a new tool in that limited portfolio ignoring effective conservation measures and policy. As Beehler and Laman (2020, p. 51) showed, 100,000s of insects get collected that way in expeditions and their repositories. Presumably the real number of collected and killed insect individuals is in the many millions, but to what outcome? In PNG, a research group—from Czech in Europe—actually dominates this approach and section of biodiversity work in PNG for decades already. The method of choice remains counting and obtaining the insect in the hand, e.g. done via 'fogging.' This essentially means one kills them off, with blunt insecticides done for 'science.' It has many scientific and other problems, one is unintended and widely uncontrolled 'bycatch.' In that method it's nothing unusual to kill off entire tree canopies, e.g. by cutting the entire tree down and fog the accessible canopy, and then count out the 'exotic' insects falling on the ground or accessible. It's essentially a textbook approach to studying insects worldwide for over 200 years ("*we sort'em post mortem*"). While this approach makes sense to some people, it's bare-bone human-old work, but now even paid to Czech and its researchers through the EU and by the National Science Foundation (NSF) of the U.S. Scientifically, it hardly

allows for an individual-based research design or a shown wider inference. Other methods like non-intrusive predictive modelling or data mining of the insect data holdings are not on the table, that expertise is widely ignored for decades. The established researchers for PNG simply fell in love with their method...and got stuck there. But so are the outcomes. Ethically, nobody can really count, and identify, all species that live in canopies of such large trees and in old growth. Many new species can get detected; it comes with the job and is expected for taxonomists; it's expected of them. Thus, nothing special. Fogging can often just ID and study a tiny fraction of the insects killed; the rest goes to waste (as those individuals were fogged, it makes for contaminated waste!).

In reality, it's simply the 'agreed practice' in such professions for publications, power and funds abroad. It gives them a job, and thus it all continues that way. Usually, as just a fraction of insect species 'fogged' gets sampled, a large number of the caught species 'dies' and is widely left unaccounted for; it creates bias which puts pressure on the scientific rigor and validity of such a science in the first place. A research design would be critical, but is almost impossible to achieve for parametric inference. In the meantime, this work is labor-intensive and requires funds for students and field workers in a nation (PNG) where many people earn less than \$4 day. Science for what and how done? It's certainly not done for conservation or to serve PNG and its people, as the progress on that issue shows and is 'tiny,' if even that. Is insect research colonial?

Considering that insects present a large chunk of biodiversity, so where then does that leave us for any informed and defensible discussion on biodiversity progress and insect ecology and conservation research for PNG?

While non-invasive methods exist, those are not much used or accepted nor is there a strong and enforced insect conservation policy, not even meaningful trade and export laws, as CITES underperforms wholesale even for its trade concepts, certainly for taxonomies and conservation (which it was not designed for). It's not well under control in Asia, certainly not in PNG; for details see annual TRAFFIC reports: <https://www.traffic.org/>. How can there be quantitative assessments done on species like endangered small beetles with a complex life history and grubs (hidden away in a tree stem or underground)? How can the ever-changing species taxonomies be checked for trading? And how are insect laws enforced and by whom? The Asian trade reviews on poaching, bushmeat and species trading show us an abysmal performance picture: Borders are virtually totally open in Asia to whoever wants to cross them for products; the tiger, elephant or rhino poaching situations show us no other (see also CITES websites <https://www.traffic.org/> and <https://cites.org/eng>; see Dinnen, 2017; Supuma, 2018 for PNG).

Let's agree, and like with bird research (Mack, 2014) or the earlier discussed plants, insect research in PNG—as developed, overseen and promoted by Australia, colonial powers, Europe and North America—has not moved much forward beyond Neanderthal-style vanity collections, selective species naming abroad and information narratives, and that such institutions, funders and practitioners got stuck in such a mind-set cloning new graduates along those lines set for perpetuity. The use of DNA methods does not make it better. Most of this is well critiqued by Beehler and

Laman (2020) who refer to such collections as ‘*the cabinet of curiosities*.’ It would be nice for PNG to move into progress regarding insect research; arguably, with the funded actors involved that is not to happen any time soon though.

6.8 Mammals of PNG: What This Species Group Really is About

App. 244 terrestrial mammal species are found in PNG (in New Guinea app. 293 overall; Beehler & Laman, 2020). Like with the other species groups, it’s a classic and world-wide renowned but complicated research topic (Flannery, 1990; Martin, 2005). It remains widely unresolved for a good mutual agreement on species, taxonomy and abundances (Huettmann 2020 or tree kangaroos; see Chap. 28 for squirrel ecological niche discussion; consider the marine mammals also poorly inventorized).

While many endemic mammals are found in PNG, the geography and land mass of PNG is not really the typical island of mammals (as known from the ‘Old World’). Already the ‘Old World’ mammals are not found there, e.g. primates or squirrels (but gliders etc., might fill that niche instead; see chapter in this book). PNG is not really short of mammal species as can also be seen below with marine mammals. But then, already the diversity of bats in PNG is to be reckoned with! Tropical nations generally tend to have a high species diversity of bats and associated species. But PNG features app. 31 bat species with microbats being a biological highlight, also including the flying foxes and the mentioned gliders.

Emblematic mammals of PNG are the echidnas (insect-eating, egg laying mammals that are found only in New Guinea and Australia) and marsupials, including wallabies, tree-kangaroos and the possum-like cuscus. Those are rather odd species indeed for Europeans and spark interest with any scientific-minded conservationist (those species are conservation poor; see Beehler & Laman, 2020; Flannery, 1990, 2002). Those must not miss in any mammalogy lecture because it will show the true diversity found in mammals, not just mammals of the Old and New World

Much is still to be learned about mammals and of PNG ones, including bandicoots, dasyurids, bandicots, striped possums, pygmy-possums, tree kangaroos and their subspecies, wallabies, cuscuses, rodents, ringtails, fruit bats, microbats and the marine species.

The advent of the (hunting) dog some 1000 years ago changed much of the PNG ecosystems and set ups (Flannery, 1990, 2000). With those ones, the cuscus and quoll can get widely sought after for its fur (see details in Flannery, 1990). Mammals avoided humans for 47,000 years and thus are usually nocturnal and cryptic, unless a dog can find them. The decline of long-beaked echidna species and tree kangaroo species speak to that impact (see for instance Huettmann, 2020; Wildlife Conservation Society, 2009).

For the tree kangaroos, depending on the taxonomy used (Martin, 2005) 14 species exist worldwide but only PNG—as the only place in the world—has as many as 12



Fig. 6.41 Isolated and fenced Matschie's Tree Kangaroos in a Mountain Zoo in Colorado U.S.; what's here the conservation gain, for the species, for PNG and for the world?

species left. Australia lost them early on and just retained 2 species out of that pool. This species group has received major attention by Australians (Flannery, 1990, 2002; Martin, 2005), specifically in similar habitats than PNG, the Atherton Tablelands/Australia (but which got widely destroyed for its original old-growth forest; Ludlam, 2021; Martin, 2005)!

The archeology of PNG and the Sahul region overall is widely studied but actually leaves us with just few sites and little outcome for real-world conservation and practice; it's usually just based on a few point samples. The now extinct thylacine

(marsupial wolf) received a lot of public attention and was for instance found as artifacts in caves of PNG until the Holocene. And a small sea cow was probably the first/oldest mammal species found in PNG's history (while the sea cow is extinct, the dugongs are in a rather poor shape now also). The question remains, again: What was really learned for conservation or mankind, e.g. Fig 6.41, 6.42?.



Fig. 6.42 Sign post for the Matschie's Tree Kangaroos in a zoo from Fig. 6.41 Is that all of the information we need and want? That's the justification and outreach for such a complex species and conservation subject? It's widely uninformative and totally underwhelms

6.9 Amphibians and Reptiles

App. 395 amphibian species are found in PNG (And app. 424 in New Guinea overall Beehler & Laman, 2020) with numbers actually expected to double (!) while new methods and more field work come forward. Over 100 species already just await publication and wider acceptance boosting New Guinea and its amphibian species list further (Beehler & Laman, 2020) but leaving protective efforts even more desolate because money for those ‘new’ species remains widely unavailable by agencies in charge. It’s a typical example for inappropriate business models in nations like PNG, e.g. a trickle-down economy. In the meantime, many people who study and promote amphibians and reptiles flock to New Guinea and such regions to find new species and to be able to name them... is that not like describing the deckchairs on the Titanic? And why done and a good use of resources? And where are the people of PNG in all of this?

The first structured herpetology expeditions to PNG were made 1826 onwards. PNG features freshwater as well as an estuarine crocodile with six turtle species and over 100 snake species, some are deadly (e.g. the Papuan Taipan, Eastern Brown Snake and Papua Black Snake). The Papuan Monitor as the largest lizard on earth is up to 4 m long. With its tropical rainfall as a world record, PNG is an amphibian island: 90% of PNG frogs are endemic. The Spike-nosed (Pinocchio) Treefrog got famous, it just was discovered recently and described by an Australian researcher (e.g. <https://www.smithsonianmag.com/smart-news/meet-newly-named-long-nosed-pinocchio-frog-180972385/>). In the meantime, the toxic cane toad that got introduced to control the Sweet Potato Moth went *havoc* in PNG, as in other places in the world.

With that many frog species in Papua New Guinea, it’s a given that many are ‘new to science.’ Conveniently for fame, this group was widely claimed by another research group from another nation, namely the Bishop Hawaii Museum (<https://www.bishopmuseum.org/>) of the U.S. But beyond the endemic species, and assigned national science topic budgets in the \$100,000s the world of amphibians and reptiles is in crisis and will likely remain so for decades. Massive species loss is almost the rule, and fungi and invasive, in addition to habitat decay, habitat transitions, wholesale habitat transitions and climate change (warming–drying) tend to make it a grim world for amphibians to live in. And the many new species described to science will not change that and can provide an utterly wrong message when ‘naming the deckchairs on the Titanic’ while the Titanic actually sinks in full steam.

6.10 Marine Biodiversity

The oceans and waters around and in Papua New Guinea carry their own record; they have virtually no equal due to being so little explored (Cousteau & Richards, 1999

for details; compare with the Caribbean for instance; Huettmann, 2015 and citations within; see related chapters in this book).

This is well known and documented for over two decades by now (Jackson, 2013). But what is done about it to halt and improve the trend of ocean decay? It is here where the western model fully fails us all again; as shown for many years in any coastal ocean of the world and their status (e.g. Jackson et al., 2001).

Major fish groups found in PNG consist of—but are not limited to—sharks, sawfish, sting rays, herring and anchovy, catfishes, garfish, tuna, perches, grunners, snappers, biddies, croakers, porgies, archerfishes, mullets, blennies, gobies, gudgeons, soles, thuna and Barramundi as a major eaten fish species; world-renowned are the rainbow fishes.

But the freshwater fishes should also be mentioned for PNG; e.g. eels that are found in rivers. The freshwater fishes have received much attention as their distributions in lakes and watersheds show fascinating distribution patterns, e.g. Weber Line, and some are affected by mining effluents in rivers and estuaries, e.g. classic study by Boyden et al. (1975); see Kirsch (2014) for an applied example.

The largest freshwater lake in PNG, Lake Murray, is now exposed to invasive fish pushing out endemics (Beehler & Laman, 2020, p. 25). Like found in other tropical nations (e.g. Nicaragua, Australia) sharks are frequenting those brackish water sections, often very close to humans. Bull sharks are found in freshwater lakes such as Lake Yamur on Papua (Beehler & Laman, 2020, p. 25).

Coastal fish harvest is usually done by kids and women (Beehler & Laman, 2020). As it will be treated in another chapter, thuna and sharks are widely overfished, as stated by Barclay and Cartwright (2008).

PNG has all the general marine species and set ups found in the tropics. But then it has more; the marine mammals are one aspect of those. River dolphins as well as dugongs are found there in the estuaries and in the excessive seagrass areas; those are all now in decay. Same can be said for the river dolphins (Leatherwood, 1991). The dugongs in Torres Strait region carry a more tight management regime than in PNG (see for IUCN listings and details: <https://www.iucn.org/resources/publication/dugong-status-reports-and-action-plans-countries-and-territories>).

On the pelagic side, many whales, ocean dolphins and porpoises are also in PNG waters, at least 15 species. It's a minimum estimate because of taxonomic splits and the beaked whales (a group of app. 24 species worldwide) are not fully detectable and studied for their range and occurrences, and most whales tend to move and migrate—usually under water—long distances, and all are now affected by climate change in many ways. It is debatable to some experts whether the abundances for those marine species are declining due to bycatch of commercial fishing, microplastics or due to seismic shockwaves intruding into ocean depths due to seabed exploration and military and civil shipping and navigation, submarines included. But the marine resource declines are a generic scheme reported by locals (e.g. Marsh et al., 2015 for concepts). While PNG seriously lacks detailed marine data some surveys found rather low counts of whales. Marvae et al. (2021) documented at least 6 marine mammal species, with spinner dolphins and pantropical spotted dolphins both as the

most frequently sighted and abundant species within that group (see also Hamilton et al., 2009).

Noteworthy to the western whale watcher are perhaps the pygmy killer whale and then the pygmy sperm whale as well as dwarf sperm whale. The regular sperm whales of PNG reached a sad world fame for their contamination (lead) loadings (Savery et al., 2014). Unique orca behaviors have been described for Wuvulu Island, northern PNG, by Cousteau and Richards (1999, p. 217).

Arguably the coral reefs are a highlight around PNG (Jackson, 2013), but those are also under threat (see also other chapters of this book). With climate change, there is no good outlook for those reef regions acting as the certain climate refuges (Dixon et al., 2022; a very misleading term considering Global Change comes with many dimensions and remains widely unaltered

And not short of records, PNG is part of the world's deepest water trench systems—e.g. Manus Trench, New Guinea Trench and nearby Challenger Depth—one of the deepest known, and its species await more exploration but while plastics are documented there already.

Crocodiles fared very well in PNG for millennia, and a deep culture and worshiping centers around them, e.g. in Sepik river region (Cousteau & Richards, 1999). It's a unique culture! But they also represent a real danger to people to this very day (just as they are in other tropical nations such as in Central America; e.g. Huettmann, 2015). However, the wild crocodile skin resource was overharvested by colonialists already a long time ago, certainly in the 1960s (Beehler & Laman, 2020; Burgin, 1980). Crocodile farms were set up, e.g. at Angoram, Sepik river, and crocodile skins are sold to EU and Japan; see Burgin (1980) for more details.

Fisheries remain another black eye for modern sustainability management in New Guinea and its waters (see Radio New Zealand, 2018 for 18 PNG fishery observer deaths just recently reported). PNG and Indonesia cannot really get their EEZs under control, and outside it's even worse for control and management. Modern (international) pirates do occur, in the fishing industry and outside

Information from undisclosed inside sources provided to the author go that way:

“The world's largest purse-seiner was operating north of New Guinea, within their EEZ, but much without permission. Spain is involved through the EU, in part. A Fishery Observer who was murdered came from further south, and possibly from a longliner. In parallel, the U.S. Coastguard apprehended two South American vessels fishing illegally north of here, in Micronesia, likely for albacore, but released them without penalty as instructed to do so by the State Department, who needed to be consulted for such cases. State said that these vessels were owned by a country which was ‘friends’ with the U.S. and thus released. Greenpeace had the details & photos of this vessel online at the time”.

6.11 Endemism and Its Centers

Arguably, not all species are distributed randomly or equally. Instead, centers of species diversity can be found, e.g. due to environmental harshness over time, other biogeographic factors mentioned above (as expressed in Biogeographical theory),

or due to more recent human impacts. PNG is known to be an endemic center for spatula orchids, and for tree kangaroos—a global hotspot (Flannery, 1990; Martin, 2005; Montgomery & Bishop, 2006). But also for species like giant butterfly and most of the Birds of Paradise. And then, mountain tops and some specific islands serve as endemic centers (see Montgomery & Bishop, 2006 for cloud forests and tree kangaroos). Many of those centers are not even well known yet and DNA research might prove insightful for such assessment and for connectivities. Those known centers of endemism got highlighted in conservation priority reports and rapid assessments (e.g. Alcor, 1993; Hamilton et al., 2009; Richards & Whitmore, 2015 for marine areas). However, neither their locations nor their processes got really protected yet, have a budget, and modern management and wider global buy-in, nor is that a meaningful approach really when data are not well shared, analytical methods remain cryptic without documented open source code, a public land tenure exists and needs to be catered (Baraka, 2001). At minimum, national park-type protection efforts need to be reconsidered and to follow a wider community approach to be effective in PNG (e.g. Narokobi, 1983).

Where are the centers of endemism exactly? While this question needs a lot of science and data to answer, it's a bit of a dilemma then. After over 400 years of scientific collections and research, nobody can really answer that question yet with good certainty for all of PNG, or for parts of it even. One may be pragmatic and use some data at hand, but it will usually highlight existing hotspots, mountain peaks and areas with a large track of undisturbed rainforest lacking roads (and people; or mining for that matter). For a PNG conservation, any protected pixel currently counts though while a generic onslaught hit Melanesia either way, e.g. by climate change or by 'Mine Melanesia' (Kirsch, 2014).

6.12 The Unknown, the Ecology and Toward a Better Nature-Environmental Relationship in 'The West' and Worldwide

And there is (much) more to the biodiversity story than just rapid assessments, limited ecology and DNA-based species lists that are consistently expert-revised (= the western and dominating biodiversity effort in PNG paid by tax papers and industry). PNG's deep ecology remains widely unstudied; that is certainly true for forest ecology and for marine ecology. No need to think of species new to science or undescribed, as typically found for instance in the remote forest, ocean and deep sea when searched harder. It comes with the job at hand. In PNG new species come as a fact and are expected; while PNG citizens usually knew them for millennia, and in their own words. So what's new, and what a discipline worthwhile would that be; Biology?

But even more so, much of the co-evolution and its ecology is not well studied for PNG's species and habitats at all (while again the locals know the species, their interactions and their uses and meanings very well for millennia, including the ecosystem connections and a link with the universe and their own being, and how it's all managed sustainably). But then think of cryptic species and new DNA studies showing us once more newly revised phylogenies and new but endless new splits and re-arrangements of existing species groups and species. That occurs virtually each time a new analysis method and lab machine provided by industry occurs on the western market. So what's objective, unbiased and what is the point of all of this? Technology drives species descriptions, its science, and so does the money paying for such a technology! It gets circular then and self-serving quickly. But how is PNG served and better served than before?

Instead, what one should study more in PNG is the wider and deeper connection of the living world with the universe and its people, locally and globally, the cosmology, and all done in harmony with Mother Earth, across land and sea, and in a sustainable fashion for future generations, holistically. It matches what the elders of this world report (<https://www.wisdomweavers.world/>). Conservation matters, as one cannot live without it. PNG is fully embedded in it and has much to share, but the western academy is just not listening, nor studying it! It makes no money for them.

This aspect of the acclaimed works by Wilson and MacArthur (1967), or Diamond (2011), Flannery (1990)—or David Attenborough (The Guardian, 2017 for the Blue Planet) for that matter—is widely absent in the public discourse. Why is that?

Textbox 4: Ecology anybody?

Ecology is not new and just a western and institutionalized concept, and it is also to be applied a bit to Papua New Guinea (PNG). But as shown in the species sections of this book, ecology is hardly known or studied even for PNG, a relevant policy link is missing. Consequently, wider views and policy impacts are essentially ignored; and relevant ecological science sits in its infancies for areas like PNG. Ecology is widely left unstudied there; a typical example can be seen in Cassovary's role in rainforest rejuvenation (Mack, 2014), and when considering these birds distribute seeds and communicate with low-frequency sounds. With PNG having such deep cosmologies, all is connected and links with the wider universe, certainly within a complex forest ecosystem; but how linked, how studied, and how all connected and managed for ecosystem maintenance, sustainability for future generations? Nobody knows how done and how to apply it, unless the Melanesian way is followed more.

PNG is widely understudied, and under-researched; western humans never will understand 'everything' or apply it well anyways (just see man-made Climate Change where man-made CO₂ release is not achieved, after 300 years of international science). Arguably, the period of enlightenment and over 100 years of 'modern' research, in PNG one still got stuck in opportunistic

collections and primarily species descriptions across a few competing outside actors, but which are not even agreed on much. The Australian scientists see the world very differently from the UK ones, or the U.S. Birds of Paradise taxonomy make for a good point in time; a topic widely disputed internationally for decades with fierce infights. Taxonomy of benthos, and the deep sea, a topic where PNG has much to offer, is hardly tackled yet. Needless to say, the PNG scientists and citizens have little to say in this whatsoever; they are hardly on the table even.

But when it comes to ecology, the advanced study of interactions, even less is known and done. How many cutting-edge ecology studies are done in PNG, e.g. using telecoupling?

Most PNG ecology studies probably still relate to elevational gradients, which is an over two hundred years old concept from Alexander von Humboldt etc and conceptually nothing new for over a century, hardly exciting. Over 50 (!) years ago Diamond (1973) promoted already such works again for birds, islands and island peaks and corridors, and with little progress since. We all know that mountain tops differ in the climate and thus in their ecological and species set up; who would have guessed? Elevational bands are described for over 100 years globally, so is island hopping (or island skipping). Such type of studies, most just repeats, logic theoretical reasoning and study templates from elsewhere and then mindless applied to PNG with strawman questions (“would it apply to PNG also?”), are quite far from innovative thinking or the ecology definition and what it has to offer these days and how studied well, e.g. holistic concepts or telecoupling (Liu et al., 2018). Pollination is another one, but also got stuck in the descriptive co-evolution approach. Then there are some more high-tech studies such as the use of DNA trying to answer complex questions with complex methods. That has its own problem for inference. The notion of predators, ecology of fear, food chains or the Anthropocene have hardly entered PNG or its research practitioners. Instead one sees shallow studies that try to describe for a month or two what species eat, e.g. using indirect samples like feces.

In the meantime, the local PNG citizens know their living world since deep times and handle it accordingly. Who needs science, or ecology and an underlying taxonomy for that matter?

6.13 Biodiversity Conservation Anyone, Done for Purely Commercial Reasons Adding to Mining, Oil and Gas Explorations and Foreign Wealth and Power?

While the biodiversity in Papua New Guinea (PNG) is grand and unique, of world relevance and globally fascinating, the science-based conservation of this biodiversity and its track record is not; far from it. This is a typical state of affairs in conservation and tropical nations, and it's certainly true for PNG.

Still, PNG is part of the Megadiverse countries (see also public knowledge about the associated Cancun Initiative, and the Like-Minded Nations which PNG is not part of though (see public information for the Cancun initiative, etc. https://www.wikiwand.com/en/Megadiverse_countries)).

Measured by western metrics, the amount of protected land in PNG is very low, e.g. < 1%, and with just 3 RAMSAR sites (Mongabay, 2022; <https://www.ramsar.org/>); the RAMSAR sites are a EU centered and limited approach; they carry no relevant budget or protection levels anyways, hardly a meaningful administration or concept (nations of the highest density of RAMSAR sites are found in places like Holland and Switzerland, none of them have any large and true wilderness left while vast and quite lowly-populated nations and locations like Russia, Alaska (US), Antarctica or Canada have some wilderness left but are virtually free of any RAMSAR sites, and the ones that do exist carry almost no enforcement or wider recognition in the respective nations). Some biological reserves are outlined, and some are pondered—specifically for marine protected areas (MPAs; which are not ‘no take’ zones)—but many other key areas are left unresolved, and widely unprotected, water tables go down one-by-one, major rivers get spoiled, and precious ocean areas get misused; many bad examples exist about it, unrooting local people (see already Cousteau & Richards, 1999 for examples within).

And then there are works of this kind, e.g. for Papua New Guinea's Hindenburg Wall and its rapid biodiversity assessment (https://www.researchgate.net/publication/274961216_A_rapid_biodiversity_assessment_of_Papua_New_Guinea's_Hindenburg_Wall_region). Those type of assessments state things like “*The Hindenburg Wall, along with the Muller Range and Nakanai Mountains, is a part of a proposed UNESCO World Heritage Site called The Sublime Karst of Papua New Guinea (Hamilton-Smith 2006).*”

Sounds impressive indeed, but then, what does a UNESCO World Heritage Site really mean, and what do the landowners say, what research design and taxonomy standard really was used, and where do things stand now, 15 years later? Are such efforts really and truly meaningful if conservation and sustainability are the goal? According to D'Eramo (2014) likely not, the UNESCOcide just makes money for some, but ignores wider conservation needs for all.

And so, as per Beehler and Laman (2020) there are no real national parks in PNG neither (but see McAdam National Park, and then the Varirata National Park, near Port Moresby, mentioned in <https://www.britannica.com/place/Papua-New-Guinea/Daily-life-and-social-customs>) because of the public land tenure ownership in PNG. Resources in Melanesia—and also PNG—are more community-based and managed that way (Baraka, 2001; Nakaorobi, 1983); intense fighting about land is known to occur. Western-style national parks are not compatible with the PNG system of

landownership. A typical example for New Guinea is provided by Beehler and Laman (2020) in Western Guinea's Lorentz National Park (NP): It's hardly legally valid and accepted; people that live there do not really know about it and the applicable laws. The Lorentz NP got actually fully redrawn around the Freeport mine to keep operating. As shown already by Buckley (2020) and many others, such national parks can easily just be lip service and are green-washing destructive practices in wilderness areas and elsewhere. Those are 'paper parks.'

Instead, well-guided and advised community-based landscape projects, such as YUS (see subsequent chapter; details in Beehler & Laman, 2020; Montgomery & Bishop, 2006) are likely the best, and probably the only good and true way to go. Local landowners must be on board and vested. And even then, there are still problems with such land conservation though (see YUS chapter in this book for a wider review).

Whereas, the parsimonious 'bean counting' of species and diversity per land unit using convenient taxonomies—now aided with DNA—serves little; hardly for the proponents themselves, constantly seeking for funding flashes to stay afloat in their own offices and their staff. That's the reality of biodiversity work these days in the absence of solid underlying national sustainable business models. One can there hardly be cynical that the PNG biodiversity reference book of Beehler and Laman (2020) is—in some part—funded by "Porgera Joint Venture", actually a major mining corporation (but that does not even mention in the funding and operation the term 'Mine' in its title.² It's clear to anybody who just looks at it closer that commercial mining and industry like to use wildlife photography, experts, science and biodiversity conservation as their strategic and PR tools and to their advantage, as they can. It's textbook marketing 101. Many examples exist, e.g. Richards (2018) for such a science, and the wide lack of specific mining references and direct mentioning of conservation problems for PNG in works like Diamond (2011), Martin (2005) and Laman and Stoles (2012) must not be so surprising for readers.

On such a PNG reality, many species of conservation concern are to occur, as per Beehler and Laman (2020, p. 348). It's quite a tragic state of affairs on the birds etc. due to the governance, data quality and data coverage (Davis et al., 2018; see for instance <http://www.earthsendangered.com/search-regions3.asp?mp=&search=1&sgroup=allgroups&ID=283>³). As a matter of fact, conservation status-wise, virtually all large 'tasty' mammals are under pressure now in PNG, many are extinct or at least getting there. Similar can be said for most other large species, certain birds, and if they have meat or value. Precedence exists: By the end of the Pleistocene twenty species of Australian kangaroos and wallabies became extinct (Beehler & Laman, 2020; Flannery, 2002). And according to these authors, (p. 221 in Beehler & Laman, 2020) already three species of Long-beaked Echidna, Mrs. Scott's Tree

² It's clearly a deflecting and misleading project title, and hide-and-play with words when using 'Porgera Joint Venture' while it actually says in the subtitle of the project site that '*The Porgera Joint Venture owns the Porgera Gold Mine*' as per <http://www.porgerajv.com/>. The public does notice.

³ There are several sources and categories for endangered species in PNG; none fully agree or have deeper data even. This source here is a public web portal and can serve as an entry point, just as the IUCN Red Species List for PNG can. Based on personal experience, there are many inconsistencies and problems with the official sources and their meanings.

Kangaroo (Tenkile) and the Golden-mantled Tree Kangaroo are threatened and close to extinction; see also Martin (2005).

And then, for endemic places like PNG invasive species are a big threat and those topics are on the rise. Exotic species like common myna, house and tree sparrow, trout in mountain streams, Rusa deer, crab-eating macaque, house mouse, black rat, Norway rat, house cat, house shrew and axis deer are all found in PNG now. And on lakes and river systems, many more exotic species are found, e.g. floating weed, often helped by official agents and even international programs (Coates, 1984; Thomas & Room, 1986 for carp, Beehler & Laman, 2020 for a devastating assessment statement).

As a matter of fact, PNG as we know it, is probably strongly based now on ‘exotic’ species, namely dog and pigs and betel nut, which actually all have a relatively short history in PNG (Beehler & Laman, 2020; Diamond, 2011).

So what has the ‘modern’ aspect of biodiversity and conservation research really bought us, other than ongoing ignorance, inefficient conservation, decay and destruction on most fronts? “*More research needed*” and staying in the western mindset is not an answer in such cases and for PNG. Considering major progress in technological and industrial schemes, who then really gained, and by how much, and on what costs (see Taber & Payne, 2003 for North America)?

Using biodiversity and its study, PNG—the way of PNG and how its people operate (Narokobi, 1983)—simply shows us the mirror on how poor our modern western and dominating global society really is and stands.

“The reason why these animals survived is that no one has ruined their homes...”

Montgomery and Bishop (2006, p. 22)

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