5
The Christmas Island pipistrelle

The story now turns to focus on the ill-fated player in this natural drama. Before describing its fall, I will introduce the species and its characteristics, and those who showed interest in it. Mostly in the account below I will refer to it simply as the pipistrelle, although there are many other pipistrelles elsewhere in the world. In case you're wondering about the mildly odd word, pipistrelle derives simply from the Italian word for bat, *pipistrello*.

Historical record

Before the 'modern' studies, there was only brief and occasional published mention of the pipistrelle in inventory studies of Christmas Island and in taxonomic reviews of the bat family Vespertilionidae: an enduring classificatory mess. The first mention of the species was in the report by J.J. Lister on his survey with the *Egeria* in 1887, remarking that a small bat was seen on the island, but not collected (Lister 1888). As Lister successfully collected all other mammal species present on the island, this was perhaps a foretaste of a recurring pattern of oversight, neglect or frustratingly lost opportunity for this species. Likewise, around 1890, Henry Ridley reported on an energetic and very productive day collecting plants and animals on Christmas Island, but also missed the bat: 'I saw also a small insectivorous bat flying about, but could not catch it' (Ridley 1891, pp. 128–129).

Charles Andrews had better luck in his much longer sampling trip of 1897–98, collecting six specimens that formed the basis of his formal scientific description of it in 1900. Whereas Andrews' accounts of the four other Christmas Island mammal species includes interesting notes on their status and behaviour, that for the pipistrelle comprises only a brief, and mostly turgid, description of its morphology, although his introduction includes the generalisation for all mammals on the island that:

> The conditions of life are apparently extremely favourable, food being always abundant, and the hawk and owl, which are the only possible enemies, feeding mainly on birds and insects. The consequence of this is that all the species of mammals are extremely common, and the individuals are always exceedingly fat (Andrews 1900a, p. 22).

In his subsequent visit in 1908, Andrews noted changes in the abundance of all native mammal species except for the pipistrelle, on which he provided no comment (Andrews 1909). Ridley also revisited the island, for about a week in 1904, but his notes on the pipistrelle were again brief: 'in the evenings, the small bats only occur along the cleared tracks, and in open places' (Ridley 1906b, p. 138).

There is a quirky retrospective record from ~1910, in the collection of reminiscences of long-term Christmas Island residents, published by Marg Neale in 1988. Speaking then of long-ago childhood memories, Gladys Randell noted that in the dining room of her parents' house abutting Flying Fish Cove:

> tiny bats used to fly in through the open doors, and now and then you could see one fall off the light, or off somewhere onto the table, or into someone's soup (Neale 1988, p. 25).

There is another odd early record. In 1905, soon after graduating from medical school in London, Frederic Wood Jones was appointed as a doctor to the Eastern Extension Telegraph Company on the Cocos (Keeling) Islands, where he spent little time in medical duties, but much of his 15 month term engaged in the first detailed long-term study of coral reefs, developing a theory of their formation markedly opposed to that of the then prevailing view developed by Charles Darwin (oddly enough, mostly also from his experience on the Cocos (Keeling) Islands, over an 11 day visit there in 1836). Wood Jones published a book on the corals of Cocos, and their role in the development of atolls (Wood Jones 1912), and a general natural history account of the island group (Wood Jones 1909). These included reports of fauna from other Cocos residents including that:

> waifs and strays include bats of some small species that did not appear during my stay in the atoll, and that are said to be *Pipistrellus murrayi* Andrews, from Christmas Island. A large monkey is also said to have washed ashore and to have long survived on the islands (Wood Jones 1909, p. 136).

Wood Jones was himself a most remarkable character, worthy of a small diversion. His time in Cocos was notable not only for his studies of coral and natural history, but also for marrying the daughter of the laird George Clunies Ross. He left to undertake archaeological research in Egypt, from which he published a series of anatomical papers (including the definitive article on the most humane methods for execution by hanging). In 1919, he migrated to Australia, as Chair of Anatomy at Adelaide University: he was considered 'the most brilliant anatomist of his generation' (Guest 1991). But he also continued his very broad interests in the natural world (an abiding 'interrogation of nature': Guest 1991), writing (and illustrating most beautifully) the seminal three-volume account of the mammals of South Australia (Wood Jones 1924). He was one of the first and most influential of Australian conservationists, with particular concern for the decline of its native fauna, and protection of the Great Barrier Reef. He also wrote extensively, empathetically and forcibly about the plight of Australian Aborigines. A subsequent tribute noted of him that 'he knew probably as much of the cosmos as one man ever could' (Guest 1991).

Notwithstanding Wood Jones' distinction, there were no previous documented records, and there have been no subsequent records, of Christmas Island pipistrelles (or any other small bats) from the Cocos (Keeling) Islands, and this extra-limital record remains tantalising, or perhaps simply erroneous. Indeed, Carl Gibson-Hill, pursuing another nominally medical appointment on Cocos (Keeling) Islands after his term on Christmas Island, noted, with typical acerbity, that Wood Jones' accounts suffered 'from a considerable carelessness, and over-optimistic acceptance of unconfirmed visual records' (Gibson-Hill 1947h). Curiously, Gibson-Hill also used much of his medical term on the Cocos (Keeling) Islands to explore the nature of coral reefs, and likewise had strong and anti-orthodox views on their formation.

Back on Christmas Island, the pipistrelle was apparently not collected again until 1932, when the Singapore zoologist M.W.F. Tweedie stayed on the island for 5 weeks, and collected specimens (including the pipistrelle) for the Raffles Museum (Gibson-Hill 1947c), although those records were not mentioned in the report of his collecting (Chasen 1933b). The next written account of pipistrelles is by Gibson-Hill from his residence on Christmas Island between 1938 and 1940. His notes for the pipistrelle are brief, and wrapped in with those for the Christmas Island flying-fox:

> Both bats … were flourishing during my stay on the island (Gibson-Hill 1947f, p. 166).

The description of the species by Andrews in 1900, his very brief comment on its abundance in 1908, the snatches of two sentences by Ridley, and the above sentence by Gibson-Hill in 1947 represent the total published primary information about the ecology or status of the species before a modern series of studies commencing in 1984, mostly by Chris Tidemann (in 1984 and 1988), Lindy Lumsden and Martin Schulz and colleagues (intermittently from 1994 to 2009), and David James (from 2003 to 2007).

Description and ecology

It would be delightful to report that the Christmas Island pipistrelle is (well, was) a remarkable, beautiful and distinctive bat, but its morphology and ecology were fairly typical of small

The Christmas Island pipistrelle was one of Australia's smallest bats. Photo: Lindy Lumsden.

insectivorous (microchiropteran) bats. It was notable for its small size (adults weighing ~3–4 g, the weight of an empty matchbox; with total body length of 34 mm, much smaller than a matchbox): among the smallest of all 90-odd Australian bat species. The sexes were similar in size.

In his original naming and description of the species, Andrews provides a dryly thorough account of its appearance:

> Muzzle obtuse, but less so than in *P. abramus*; the glandular prominences rather well marked.
>
> Ears triangular, with broadly rounded tips, relatively longer and narrower than in *P. abramus*; outer border somewhat concave. Tragus with parallel borders and rounded tip; anterior border straight, posterior convex.
>
> Feet small; wing membrane attached just below base of toes. Distinct post-calcaral lobe. Last caudal vertebra (2 mm) free. Fur covers about the upper third of the humerus and half the femur; it extends very slightly on to the body membrane. On the ventral surface the fur scarcely extends below the anus, but sparse hairs clothe the interfemoral membrane nearly to the tip of the tail.
>
> Colour, a dark brown with yellowish tips to the hairs, but some specimens are a distinctly reddish brown. Fur on dorsal surface long and thick. In front of ear and round eye the skin is nearly bare, and the same is the case with the tip of the muzzle.
>
> The outer incisor is rather longer than the outer cusp of the inner, and on its postero-external surface the cingulul bears a small but distinct cusp.
>
> The lower incisors slightly crowded. The point of the first premolar is visible through space between the canine and p.m. 2.
>
> This species is considerably smaller than *P. abramus* and the common Pipistrelle. It is larger and much darker in colour than *P. pachypus*, and in point of size comes very near *P. tenuis*, which, however, is distinguished from it by its much blacker tint and the complete absence of the rufous tinge which is noticeable to a greater or less extent in all the specimens of the present species. In *P. tenuis* also the outer incisor is stouter than the outer cusp of the inner. *P. indicus* is brighter-coloured and somewhat larger (Andrews 1900a, pp. 26–27).

If that detailed description hasn't given you a picture of the species, imagine a small bat with perhaps pleasingly but only slightly unkempt fur that is mostly dark brown but distinguished blondish-red in parts, a short blunt face, small but alert eyes, and a relatively simple (for a bat) nose on a sparsely haired muzzle. As with other related bats, its small hairless tail is enclosed within a membrane stretching to the hind feet. For those who have never held a small bat, let me try to describe their odd physical sensation: they are far smaller and lighter than you'd expect; they are a contrasting amalgam of soft-fur core enveloped within wings of


Christmas Island pipistrelle. Photo: Lindy Lumsden.

a strange texture somewhere between fine leather and balloon fabric, spanned by the most delicate elongate finger bones. Some struggle and bite; others are passive droplets of life.

The pipistrelle fed on a wide range of small (typically less than 1 cm long) flying insects (especially moths and beetles), and, using echolocation to detect prey, foraged with erratic and highly acrobatic flight mostly relatively low to the ground (0.1–2 m), but around vegetation at all heights (Tidemann 1985). Early records, and extending to one observation in 1984 (Tidemann 1985), reported that the species sometimes foraged for flying invertebrates inside buildings.

For very small bats, active foraging behaviour expends considerable energy, and individuals may be constantly on a metabolic knife edge. Small insectivorous bats typically need to consume over half of their bodyweight in insects in a night. Driven by this demand, the pipistrelle foraged throughout the night (indeed starting up to 90 minutes before sunset), but was most active in the first 45 minutes after sunset (Tidemann 1985). A recent retrospective physiological and morphological analysis indicated that greatest vulnerability to food shortage was for females during the lactation period, when they would need 5–6 hours of successful foraging (defined as capturing a suitably sized insect every minute) per night (Beeton *et al*. 2010).

The home range (that area over which the activity of an individual occurs) is unknown. In 1984, Chris Tidemann found that individual bats repeatedly followed a beat of ~200 m of track, with these beats largely non-overlapping between individuals (Tidemann 1985). On morphological grounds, Norm McKenzie calculated that individuals could readily commute 3.5 km from a roost site to foraging site per night (Beeton *et al*. 2010). In a radio-tracking study in 2005–06, Lindy Lumsden and colleagues caught bats at a foraging site and followed them to roost sites up to 2.2 km distant (Lumsden *et al*. 2007).

During the day, the Christmas Island pipistrelle roosted, solitarily or in groups. Notwithstanding the abundance and variety of caves on Christmas Island, the pipistrelle spurned these, and roosted instead in vegetation, including under loose bark (particularly of dead trees), in small hollows and cracks in tree trunks and branches, and in dense foliage of palms, epiphytes and pandanus (James and Retallick 2007). At such roost sites, bats could enter torpor: a mechanism used by many small bats to conserve energy. In common with many other bats, females used communal maternity roosts, with roosts of more than 50 individuals being reported (Lumsden *et al*. 2007). In contrast, males tended to roost in smaller groups, or solitarily, but in the non-breeding season, both sexes could roost together (Lumsden *et al*. 2007).

The sex ratio was probably close to parity, but the proportion encountered in study captures varied seasonally, perhaps reflecting a larger range used by males during some parts of the year. Based initially mostly on dissection of 26 individuals collected in his 1984 study, Chris Tidemann determined that breeding was probably seasonal. This deduction was confirmed with a study in the wet season of 2005–06, by Lindy Lumsden and colleagues (Lumsden *et al*. 2007). Following mating, females would store sperm before ovulation later in the year, to coincide with peak food availability. Only one young (a 'pup') was born per adult female per year, around December–January (Lumsden *et al*. 2007), but ~20% of females failed to breed in the single year in which breeding information was collected. Recently born bats would be left for several weeks at the maternity roost ('creche') while the mother foraged, with the mother returning every few hours to suckle her young. Occasionally the mother would carry her young for short distances to new roost sites (Lumsden *et al*. 2007). By analogy with more-studied comparable bat species, the time from birth to maturity was probably about 6 months (but it is possible that females did not breed until their second year), and the lifespan was probably about 5–10 years.

The pipistrelle was once widespread on Christmas Island, occurring across all habitat types. Cleared land, forest edges and rehabilitated areas were most used for foraging (Schulz and Lumsden 2004). However, roosting was restricted to primary rainforest: cleared and rehabilitating sites did not provide the required resources for roosting (Tidemann 1985).

Scientific record

The literature record for the Christmas Island pipistrelle is scant. Over the course of its existence, no published scientific papers focused primarily on this species. For a mammal, this is an unusual and perhaps unsettling vacuum. In contrast, following its loss, several papers considered management failings that may have contributed to its extinction (Lunney *et al*. 2011;

Flannery 2012; Martin *et al.* 2012; Woinarski *et al.* 2017): in a sense, its loss excited more interest and sympathy than its life.

But the lack of formal publication about its biology belies a series of detailed studies on this species, undertaken primarily by consultants to, and staff of, the Australian environment department, and in some cases consultants to Christmas Island Phosphates, intermittently from 1984 to the extinction of the bat in 2009, and documented in a series of internal reports.

This publication record is worth a brief consideration. Reporting of science is critical; the work is largely wasted and invisible if not made publicly available. In most cases, reporting is either through the peer-reviewed public domain literature in scientific journals or it is contained within the typically limited-audience 'grey' literature of internal reporting. The advantage of publication in scientific journals is that it is more readily available to anyone interested, and hence more widely disseminated and considered, and its peer-review process provides some assurance of quality. Alternatively, there is some advantage in publishing through internal reports, in that the material can focus most explicitly on the communication of management interpretation and advice to the relevant management agency, but the main disadvantage in restricting study documentation to internal reports is that these may be 'buried' within the host organisation. In most consultancies, the funding agency demands an internal report, and reserves the right to approve or otherwise any more public reporting. On occasions, the funding agency may use this information control mechanism to stifle 'bad' news. Researchers from universities and science agencies preferentially publish in the science journals, at least partly because such publications are a professional currency. Researchers – such as those who contributed most to the recent studies of the pipistrelle – from government agencies or consultants to mining companies tend to publish internal reports, because these target most specifically the management message. For the pipistrelle case, there is no suggestion that the management agency sought to censor or bury the consultants' reports – although typically, these were not widely disseminated. However, at least one researcher in the agency experienced frustrations about the internal approval process for reporting pipistrelle studies (see Chapter 8).

Furthermore, in a continuation of the long-established awkward dance of the island's responsible entities, there were periods of frustratingly constrained information flow between consultants working for the mining company (or other proposed developments) and those working for the government's environment agency. For example, the national recovery plan for the pipistrelle (by Martin Schulz and Lindy Lumsden in 2004) sought to compile all information about the status and ecology of the species in order to frame and prioritise management responses, but the plan repeatedly noted the non-availability of information from recent relevant studies undertaken on the island. For example:

> Several consultancies for environmental impact assessments have incorporated investigations of the pipistrelle … however only one of these studies could be incorporated into the plan, as the others have not yet been released into the public domain (Schulz and Lumsden 2004, p. 8).

This was a critical and compromising constraint given how little information there was about the species.

Taxonomic position

Bat taxonomy is a fluid science. There is a large array of similar small-sized bats across the world in the very large family Vespertilionidae, all locked into a relatively invariant body shape and general appearance. The pipistrelles have proven a particularly fertile ground for taxonomic intrigue, with inconsistency in the treatment of which species are in the genus *Pipistrellus*, and in the bounds within its constituent species. There are now considered to be ~30 *Pipistrellus* species, which occur across Asia, Africa, Europe and Australia. This tally represents a considerable reduction from many previous treatments, following the recent recognition of the genera *Arielulus*, *Falsistrellus*, *Hypsugo*, *Neoromicia*, *Perimyotis*, *Parastrellus*, *Scotozous*, *Vespadelus* and *Ia* (containing the species with surely the world's best and wonderfully brief scientific name, *Ia io*): most species in these genera were formerly included in the grab-bag genus *Pipistrellus*. Previous classification was based on relatively minor morphological differentiation (in some cases focusing particularly on the shape of the baculum, the small bone within the bat's penis: Hill and Harrison 1987) across a generally consistent body form. More recent incisive and insightful determinations have also included a range of genetic analyses.

The Christmas Island pipistrelle has had an unsettled taxonomic history, notwithstanding (or perhaps partly because of) a relative dearth of specimens. Based on his collections of 1897–98, and with due consideration of comparisons with other then known similar species, Andrews described it as a distinctive species (Andrews 1900a). It was retained as a distinctive species in a 1942 overview of the taxonomy of vespertilionid bats (Tate 1942). However, many hitherto recognised pipistrelle species (including the Christmas Island pipistrelle) known from south-eastern Asia and Australia were combined ('lumped') into a single wide-ranging species, the least (or Timor) pipistrelle *Pipistrellus tenuis*, by Karl Koopman in 1973 (Koopman 1973). Koopman was then curator at the prestigious American Museum of Natural History, with a reputation as one of the world's foremost bat taxonomists. His 1997 *New York Times* obituary noted that 'he was one of the few people of whom it can be said that he was an authority on every kind of bat, all over the world.'[28]

Nonetheless, Koopman's assessment of pipistrelle taxonomy was contentious. The most recent taxonomic assessment gives little credit to Koopman's 1973 opinion, noting that it was:

> a four-page note based on an 'analysis' of three cranial measurements in about two dozen specimens. This truly facile account obscured and delayed a true understanding of Indo-Australian *Pipistrellus* diversity for decades (Helgen *et al*. 2009a).

In 1986, a far more detailed analysis of pipistrelles in Australia and New Guinea (but not including the Christmas Island pipistrelle), using many more morphological characters, identified and named several additional pipistrelle species, and dismissed the concept of *tenuis* as a single conglomerate species (Kitchener *et al*. 1986). Nonetheless, Koopman stuck to his lumping treatment in his 1984, 1989, 1993 and 1994 checklists (Koopman 1984, 1989, 1993, 1994), 'disappearing' the Christmas Island pipistrelle as a valid species. Although opinions wavered (Corbet and Hill 1991), Koopman's treatments were regarded as definitive works,[29] and Koopman's position was accepted in many 'official' checklists (Hill 1983; Corbet and Hill 1992;

Simmons 2005), up until at least 2005. Koopman's treatment was given less respect in Australia, with most Australian taxonomic opinion since about the 1990s resurrecting the specific distinction of the Christmas Island pipistrelle, although without definitive evidence (Churchill 1998; Van Dyck and Strahan 2008).

In terms of conservation priorities and outcomes, the taxonomic status of the Christmas Island pipistrelle is (or was) worthy of consideration. At one extreme, it could be simply a recent (well, at least 120 years ago) wind-blown colonist from Java with little or no genetic or morphological distinction, simply part of a widespread and common species, and relatively easy to replace (if considered necessary) from translocated stock from nearby islands. At the other extreme, it could be a distinct endemic species, which would be irreplaceable if the Christmas Island population was lost. In the imaginary large book of the Earth's biodiversity resources, species are more important entities than subspecies, contributing more to the world's overall diversity. In terms of conservation governance, it is far less tolerable to lose a species than to lose a population of a widespread species.

Seeking to settle the argument, in 2009, the Australian environment department commissioned a study by a group of authoritative taxonomists, led by the Smithsonian Institution's Kris Helgen. The simple question 'is the Christmas Island pipistrelle a distinct species?' belied the need for a complex analysis of a particularly confusing group of potential relatives, most with chaotic and inconsistent historical baggage in their previous taxonomic treatments, and many with few specimens, scattered across the world's museums. The study used morphological and genetic characters, across 11 pipistrelle taxa from south-eastern Asia, New Guinea and Australia (Helgen *et al*. 2009a). The morphological analysis focused on a set of 16 skull and teeth characters, all measured with painstaking precision on the tiny and delicate skulls. The conclusion was that the Christmas Island pipistrelle was not close to the type specimen of *Pipistrellus tenuis*, but rather grouped with a small set of pipistrelles (including the type specimens of *Pipistrellus tramatus, P. sewelanus* and, probably, *P. portensis*) occurring in Sulawesi, Bali and the Lesser Sunda Islands of Indonesia, the Philippines and Indochina. Distinctive (the term is relative) features of this group included a high domed braincase, concave 'foreheads' and elongate rostra (snout). Within this sub-group, the specimens of Christmas Island pipistrelle were the most clearly differentiated.

The genetic analysis was based on mitochondrial cytochrome *b* sequences and the nuclear gene *RAG2*, derived in some cases from 'ancient DNA' sequences from taxa where only old museum specimens were available. Its results complemented and reiterated the morphological results: the Christmas Island pipistrelle was different, and its closest relatives were *Pipistrellus tramatus* (from Indochina, the Malay Peninsula, the islands of the Sunda Shelf and the Philippines) and *P. sewelanus* (from the Lesser Sunda (Indonesian) islands of Lombok, Sumbawa, and Flores). Furthermore, the Christmas Island pipistrelle was genetically (and morphologically) relatively distant from *Pipistrellus tenuis*, the species within which it had previously been lumped by Koopman. The definitive and meticulous analysis was now complete: Koopman's treatment was wrong.

Based on this detailed forensic sorting among a set of very similar-looking nondescript small insectivorous bats with a messy and previously poorly resolved taxonomic history, Kris

Helgen and colleagues concluded that, indeed, the Christmas Island pipistrelle was 'best regarded as a distinct species' (Helgen *et al*. 2010). As a taxonomic entity *Pipistrellus murrayi* existed. This recognition may have come as cold comfort to the very recently extinct species.

The pattern of decline

The climax to this story was given away in the title and the introduction; the outcome defined in retrospect; the suspense gone. But try here to imagine yourself not so forewarned: much that seems inevitable in retrospect may not appear so at the time. This book is about trying to understand why decisions were or were not taken along the way, and about the extent to which the evidence of looming extinction was or was not compelling.

This section is about changes over time in the population size of the Christmas Island pipistrelle; the following sections discuss the factors that may have contributed to the changes in abundance, and the management and policy responses to the pattern of decline. We are spoilt in the management of humans by the recognition of the need for regular well-designed population censuses of ourselves. We are relatively easy to count: large-ish, individually recognisable, and mostly diurnal. Small bats are far harder to count. For some species that roost colonially in a few well-known cave systems, counts may be tractable and precise. The Christmas Island pipistrelle was not so amenable: it roosted singly or in small groups at widely dispersed sites in the dense rainforest that were often difficult to access. It didn't necessarily have fixed home ranges, and didn't necessarily occur uniformly over all forested areas (which made it difficult to extrapolate the total population size from a small sampled area). So, instead of attempting to assess total population size and its changes, for most of the period discussed here, population trends were assessed in relative terms, mostly through changes in the incidence of detection and activity levels at fixed monitoring sites.

Detection mostly relied on recording of the bat's echolocation calls. This is a conventional and generally reliable method for sampling small bats: most individual bat species have diagnostically different calls, allowing ready recognition of the presence of individual species. Bat detector devices effectively lower the frequency of bat calls to an audible level, and a record of the calls is logged, with increasingly sophisticated software capable of discriminating among species, relating calls to different modes of foraging activity, recording over long durations, and allowing switch-on-off programming of remotely set devices. Nonetheless, the bat detectors aren't capable of distinguishing whether 20 calls at one site come from a single bat patrolling the site over an extended period, or 20 different bats moving through the site, so they provide an imperfect technique for precise population assessment and its monitoring. Christmas Island was amenable to sampling of pipistrelles through the use of call recorders, because there was only one insectivorous bat species, so there was no scope for ambiguity in call detection. However, it was not entirely straightforward, with small insects of the rainforest making high-pitched noises ('stridulation') that were at times confused with bat calls, robber crabs munching through expensive recorders, and long periods of rainfall interfering with detection and electronics. It is a tribute to the ingenuity and field competence of a small group of researchers and park staff that these problems were overcome, and that a detailed record of change was compiled.