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Status of the White-throated Needletail *Hirundapus caudacutus* in Australia: Evidence for a marked decline

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Summary. There is some divergence of opinion as to whether White-throated Needletails *Hirundapus caudacutus* are declining at the local level. However, when trends at Victorian sites were analysed, significant declines in populations between the 1960s and 2011–2012 were found. When larger samples were examined at the state level and for the whole of Australia in each of the decades since 1950, significant declines were also detected. The causes of this decline may lie both locally and overseas, and reasons for decline are explored. The largest single cause appears to be the accelerated destruction of the Siberian forests, where a large proportion of the Australian population of Needletails needs old trees with hollows in which to breed. There is an urgent need for further research into the population and conservation status of this species.

Introduction

White-throated Needletails *Hirundapus caudacutus* breed in north-eastern Asia and migrate south from there for the boreal winter, with most spending the austral summer in Australia, and smaller numbers doing so in New Guinea and New Zealand. They arrive in Australia from September to December and leave in March–April (Tarburton 2009). Regular observers have become aware that periodically, in some localities, there are spells of up to several years in which Needletails are either not seen or there are only very few records. In other locations, there appears, from anecdotal reports, to have been a more persistent decline in recent years, particularly in south-eastern Australia. Elsewhere, for example north-eastern New South Wales (NSW), numbers of Needletails are reported to be reasonably consistent.

The important question, however, is what is happening to the total population of White-throated Needletails—is it stable or in decline? Based on data collected between 1998 and 2002, the *New Atlas of Australian Birds* (Barrett *et al.* 2003) indicated a 49% decline in reporting rates (number of records as a proportion of number of surveys, adjusted for the survey method, season and size of area searched) of Needletails compared with those of the first *Atlas of Australian Birds* conducted between 1977 and 1981 (Blakers *et al.* 1984). However, this comparison gives only a snapshot, and was confounded by different climatic conditions during the two atlas periods, suggesting that further investigation was needed to assess properly the comparative status for these two periods (Barrett *et al.* 2003). Anecdotally, it appears that most claims of local declines of Needletails are in

Victoria, and it is reasonable to assume that if the population is in decline then such change would first become evident in Victoria and Tasmania—the regular feeding habitats farthest from the Needletail's breeding range. If numbers of Needletails have declined, and if the reduced numbers could therefore find enough food over the forests of Queensland and NSW, why would Needletails fly all the way to the two southern states? To assess this, I examine if the mean number of Needletails observed per day has changed and, in particular, whether this has changed in Victoria.

Methods

I have collated all available data on numbers of White-throated Needletails in Australia (see below), and then looked at the data in three ways: (1) a comparison of the mean numbers of Needletails seen per observer per day recorded at three local sites in Victoria over time, (2) a comparison of the mean numbers seen per observer per day of all recorded sightings in each state over time, and (3) a comparison of mean numbers seen per observer per day nationally over time.

Sources of data

The largest pool of historical data on White-throated Needletails is the Swift & Swiftlet Survey (initially called the Swift Survey), which was run by the Bird Observers Club of Australia (BOCA; now incorporated in BirdLife Australia) in conjunction with the Victorian Ornithological Research Group. The Survey ran from 1951 to 1973. In 1951, Roy Wheeler asked observers to send in records of numbers of swifts as well as other information on behaviour, environment and weather. Wheeler was later joined by David Noonan and Ken Simpson, and they designed a standard form to promote the Survey and to bring some uniformity to the way that data were collected. Summaries and highlights have been published in *The Bird Observer* (e.g. Wheeler 1957, 1958; Simpson *et al.* 1969), but most of the data on these forms (9931 sightings) had not been used before the present study.

The completed Swift & Swiftlet Survey forms were given to me in 2009 by Simpson, and the data from them have been placed in a database (held and maintained by me) that already contains: (1) all locatable Australian records published since 1848 (including from journals, magazines and newsletters of all ornithological organisations pertaining to Australia available in the libraries of Birds Australia, BOCA and state museum libraries); (2) data from the initial *Atlas of Australian Birds* (Blakers *et al.* 1984) and *The New Atlas of Australian Birds* (Barrett *et al.* 2003) held by Birds Australia, Melbourne, but now both held by BirdLife Australia (see Birdata, available at http://www.birdata.com.au/homecontent.do); (3) data from the ongoing Atlas of Australian Birds (Birdata, as above); (4) data from the Victorian Biodiversity Atlas [Department of Sustainability and Environment (now Department of Environment and Primary Industries), Melbourne (see http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/victorian-biodiversity-atlas)]; (5) observations published on the national and state Birdline network at Eremaea Birds (see http://www.eremaea.com/); and records from the Atlas of Living Australia (http://biocache.ala.org.au), many of which are from the preceding sources; (6) the online records and discussion groups of Birdpedia (www.birdpedia.com/) and Birding-Aus (http://birding-aus.org/) (I have encouraged submission of sightings on White-throated Needletails from Birding-Aus readers since 1999); and (7) direct reports. The data analysed here extend to the 2011–2012 swift season for two of the three local Victorian comparisons and to the 2009–2010 season for the remaining local, state and national comparisons.

Once in the database, all records were sorted by date and then searched for duplicates. All the data from duplicates were then compacted into the one record and the extra records were deleted from the database.

Local sites in Victoria

Based on my Swift database, I located several sites where good numbers of White-throated Needletails had been observed, over periods of 3–6 years, in the 1960s, and conducted repeat observations at those, or nearby, sites in the swift seasons of 2009–2010 to 2011–2012 so as to make some objective comparisons. Three Victorian sites were chosen that could be either resurveyed or paired with a nearby site where contemporary observations could be conducted: Maramingo Creek, East Gippsland (eastern Victoria), on the Princes Highway south of the NSW border; Badgers Creek, east of Melbourne and south of the slopes of the Yarra Ranges National Park; and Nunawading, in eastern suburban Melbourne.

Maramingo Creek. Three of the original observers involved in the BOCA Swift & Swiftlet Surveys at Maramingo Creek, in eastern Victoria, still lived in the area, at Maramingo Creek (Ron Becker and Freddie Becker) or the nearby NSW town of Timbillica, which is only 8 km from Maramingo Creek [Irene Allan (nee Becker)]. Contemporary observations on White-throated Needletails were collected at both Maramingo Creek and Timbillica from the 2009–2010 to the 2011–2012 swift seasons for comparisons with the earlier surveys at Maramingo Creek. The sites have not changed much if at all in the ~40 years between the studies, and remain largely forested (R. Becker & I. Allan pers. comm.). The original observations were conducted between 1966–1967 and 1969–1970 (October or November to April), comprising a total of 401 observation days (of which 246 were days with no swifts observed). Each observation day usually comprised a number of separate observational sessions. Survey effort per day was not recorded. The original data were taken from the BOCA Swift & Swiftlet Survey forms and personal communications from R. Becker and Allan. R. Becker and Allan surveyed swifts between October and April from 2009–2010 to 2011–2012, comprising a total of 675 observation days (of which 443 days were days with no swifts observed) for the two sites. Both the original and contemporary observations were opportunistic, observers taking whatever opportunity arose to go outside and scan for swifts, so that each observation day may comprise a varying number of observational sessions.

Badgers Creek. Norm Bullas conducted surveys of swifts at Pine Avenue, Badgers Creek, where he managed an orchard, 40 years ago (December–April, from 1967–1968 to 1969–1970), comprising a total of 100 observation days on which swifts were recorded (number of days on which no swifts were observed was not recorded). He still lived at Pine Avenue in 2009–2010, and considered that the narrow farms intersecting the forested slopes below the well-forested Yarra Ranges National Park had changed little in the intervening years. The attraction of this site is that it is both a feeding site and flight pathway as well as being close to Ben Cairn, which may be a roosting area, particularly during January and February, when flocks of 50–100 White-throated Needletails have been seen heading into that area after dark, with small numbers fluttering around the foliage of trees on the slopes well after dark (K. Simpson & MKT pers. obs.). This behaviour is similar to that of the Needletails radio-tracked to their evening roost in Queensland (Tarburton 1993). As at Maramingo Creek, the original observations were opportunistic, although the observer at Badgers Creek was working outside in his orchard and took every opportunity to scan for swifts. For 2009–2010 to 2011–2012, I made observations at the same site for 65 half days and 10 full days, between 24 December and 20 April; half-day surveys typically started at 1300–1500 h and continued to 2040–2110 h (after sunset). Afternoon surveys were considered adequate because only 15 of Bullas' 103 original sightings were made in the mornings, and I saw Needletails on only two of the 10 mornings that I spent there. Days on

which no swifts were observed were not recorded in the original surveys, so comparisons were made using only the averages on days when Needletails were seen. In the recent surveys, Needletails were not seen on 39 days, but such data were excluded. Because Bullas did not use binoculars, only the birds seen without binoculars are used in the comparison for this site.

Nunawading. Alma and Bryan Mitchell conducted surveys in the Melbourne suburb of Nunawading between 1963–1964 and 1970–1971, comprising 180 observation days on which White-throated Needletails were seen (days on which swifts were not seen were not recorded). This site has changed between the observation periods, with former orchards reduced in area or degraded, and now a higher overall density of housing, and more extensive area of suburbia between the site and the nearest forests (A. Mitchell pers. comm.; MKT pers. obs.). As with the other sites, the original observations were opportunistic, taken whenever an opportunity arose to go outside and scan the sky for swifts. I conducted 35 continuous surveys (average 5.8 h per day) in 2009–2010 from a second-floor balcony of a house in the neighbouring suburb of Blackburn South. Surveys were conducted from 31 December to 31 March, between 0800 and 2030 h. Comparisons were made using only the average for days when Needletails were seen.

Analysis of data from Victorian sites

To analyse the data from the Victorian sites, mean numbers of White-throated Needletails seen per day at each site for the 2009–2010 to 2011–2012 seasons were compared with data collected from the paired site from earlier seasons. However, there were so few sightings for the contemporary surveys at Blackburn South that the Blackburn surveys were restricted to the 2009–2010 season only. Data were analysed as mean numbers of birds per day because Bullas and the Beckers combined the numbers from individual flocks seen each day. The numbers of days when observations were made but no swifts were recorded are not known, so the estimate of birds per day potentially overestimates the actual figure because days with zero birds cannot be included in the determination of the means. Means were compared using one-tailed *t*-tests with unequal variance (Bailey 1981). The mean number of Needletails seen per day for all previous seasons was compared with the mean for the same or nearby sites for 2009–2010 to 2011–2012.

Because both the original and recent samples were taken over just a few years, it is considered judicial to examine the data both as single units for each time period and as annual data blocks to identify any temporal difference in the trends. The former method has been used in Table 1 and the latter in Table 2.

Analysis of data from different states

For this analysis, I compared the mean numbers of White-throated Needletails seen per day per decade in the eastern Australian states: Queensland, NSW, Australian Capital Territory (ACT), Victoria, Tasmania and South Australia (SA). NSW was further divided into northern and southern NSW (north and south of 34°S, with the latter excluding the ACT), as some observers commented that there did not appear to have been a significant decline in numbers of Needletails and I wanted to avoid potentially masking possible declines in southern NSW by a steady population in northern NSW. I compared observations made before 1990 with observations between 1990 and 2010 (for the numbers of years for each state, see Table 3). As with the Victorian sites, numbers of birds from all flocks were combined for each day to provide a single total of birds per day because the numbers in individual flocks are not always known. Numbers of days when observations were made but no swifts counted are not known (as with the Victorian sites). Means were compared using one-tailed *t*-tests with unequal variance.

National analysis of data

The final method of analysis was to pool all Australian data to assess trends in the total Australian population of White-throated Needletails, from 1900 to 2010. There were insufficient data before 1950 to provide large enough samples for comparison, so data from the period 1900–1950 are pooled to form a single sample; data post-1950 were pooled in decades. Means were compared using one-tailed *t*-tests with unequal variance (Bailey 1981); the time periods for analysis are given in Table 4.

Limitations of the analyses

For the state-based and national analyses, a problem with assessing decline in White-throated Needletails using actual numbers, as done in this study, is that contributors of some records from some data sources, such as the Atlas of Australian Birds database and the Victorian Biodiversity Atlas, have recorded presence or absence rather than counts or estimates of the number of birds. Such records do not provide data that can be used for this analysis and have therefore not been used here.

Secondly, for the Victorian and state-by-state analyses, the numbers of days when observations were made but no swifts counted are not known, so the estimate of birds per day potentially overestimates the actual figure because days with zero birds cannot be included in the determination of means.

Lastly, most daily reports are of single flocks of White-throated Needletails, but a significant number (particularly of older records) are of multiple flocks. Because an unknown number of the latter were added together in original reports, I have chosen to add all multiple sightings (where known) by the same observer on a given day to provide consistency. It can be argued that doing this requires a consistent period of continuous observation each day, in order to legitimately make a comparison between the years and decades that this study undertakes. However, because none of the atlas studies, the Swift & Swiftlet Survey, or the personal observations used here ever required observers to spend specified uniform amounts of time each day outside looking for swifts, that option is not available. To check whether grouping an observer's sightings for each day did make a difference, a parallel analysis was run by substituting individual flock sizes (where known) in each of the state and national comparisons made in this paper. These were tested by the Spearman Rank Correlation procedure.

Results

Comparisons at local Victorian sites

The results of the comparison of paired local Victorian sites between the 1960s–early 1970s and 2009–2012 are shown in Table 1. All three sites in Victoria showed a statistically significant decrease in the mean number of White-throated Needletails seen per day between the 1960s–1970s period and 2009–2012. When compared on an annual basis between these time periods, only 5 of 35 comparisons did not show significant declines in the mean number of Needletails per day (Table 2).

State-by-state comparisons

Table 3 summarises the mean numbers of White-throated Needletails seen per day in the eastern Australian states before 1990 and from 1990 to 2010. There was

Table 1. Mean number of White-throated Needletails seen per day at three sites in Victoria during the period 1963–1971 compared with 2009–2012. Data for 2009–2012 were collected at either the same site or at a paired site close to the original site (see Methods). For Maramingo Creek, recent surveys (2009–2012) were conducted at both Maramingo Creek and Timbillica (8 km north of Maramingo Creek), both of which are compared with the original data (1966–1970) from Maramingo Creek. In the table, *n* = number of days when Needletails were seen, S.E. = standard error; probability (*P*) values were determined using *t*-tests.

Location	*1963–1971*				*2009–2012*			*P*
	Years	*n*	*Mean*	*S.E.*	*n*	*Mean*	*S.E.*	
Outer Melbourne								
Badgers Creek	1967–70	100	164.7	11.6	34	31.6	8.4	<0.01
Suburban Melbourne								
Nunawading	1963–71	180	30.8	4.6				
Blackburn South					35	0.7	0.6	<0.01
Eastern Victoria/ southern NSW								
Maramingo Creek	1966–70	154	55.9	5.0	29	27.0	3.6	<0.01
Timbillica					201	32.5	2.5	<0.01

Table 3. Mean number of White-throated Needletails observed per day in eastern Australian states before 1990 and between 1990 and 2010. In the table, *n* = number of days when Needletails were recorded, S.E. = standard error, NS = not significant; probability (*P*) values were determined using *t*-tests.

State	*Pre-1990*				*1990–2010*			*P*
	Years	*n*	*Mean*	*S.E.*	*n*	*Mean*	*S.E.*	
Queensland	1960–89	340	107.3	17.8	1517	32.7	1.9	<0.01
Northern NSW (N of 34°S)	1960–89	1228	80.3	7.9	2338	48.2	4.3	<0.01
Southern NSW (S of 34°S)	1900–89	290	114.0	16.6	554	59.2	9.9	<0.01
ACT	1950–89	470	50.9	6.4	727	26.0	3.3	<0.01
Victoria	1960–89	5159	81.9	4.1	1695	50.0	1.2	<0.01
Tasmania	1900–89	387	117.7	20.6	353	61.7	8.3	0.05
South Australia	1900–89	112	45.6	11.5	194	64.7	11.5	NS

Table 2. Mean number of White-throated Needletails seen per day at three sites in Victoria during the period 1966–1971 compared with 2009–2013. Data for 2009–2013 were collected either at the same site or at a paired site close to the original site (see Methods). For Maramingo Creek, recent surveys (2009–2013) were conducted at both Maramingo Creek and Timbillica (NSW), both of which are compared with the original data (1966–1970) from Maramingo Creek. In the table, *n* = number of days when Needletails were seen, S.E. = standard error, NS = not significant; probability (*P*) values were determined using *t*-tests.

Location	*Years*	*n*	*Mean*	*S.E.*	*Comparison*	*Years*	*n*	*Mean*	*S.E.*	*P*
Outer Melbourne										
Badgers Creek	1967–1968	52	167.0	18.2	Badgers Creek	2009–2010	30	21.0	5.7	<0.01
						2010–2011	18	8.6	1.9	<0.01
	1968–1969	19	100.7	18.4		2009–2010	30	21.0	5.7	<0.01
						2010–2011	18	8.6	1.9	<0.01
Suburban Melbourne										
Nunawading	1968–1969	19	93.5	38.3	Blackburn S	2009–2010	9	12.8	2.8	<0.01
	1969–1970	16	114.3	41.2			9	12.8	2.8	<0.05
	1970–1971	24	33.3	7.7			9	12.8	2.8	NS
Eastern Victoria										
Maramingo Creek	1966–1967	47	53.5	4.7	Maramingo Creek	2010–2011	9	12.1	5.1	<0.01
						2011–2012	15	15.3	3.4	<0.01
						2012–2013	12	8.6	2.0	<0.01
	1967–1968	45	55.0	12.2		2010–2011	9	12.1	5.1	<0.01
						2011–2012	15	15.3	3.4	<0.01
						2012–2013	12	8.6	2.0	<0.01

Location	*Years*	*n*	*Mean*	*S.E.*	*Comparison*	*Years*	*n*	*Mean*	*S.E.*	*P*
Maramingo Creek	1968–1969	43	69.0	6.6	Maramingo	2010–2011	9	12.1	5.1	<0.01
					Creek	2011–2012	15	15.3	3.4	<0.01
						2012–2013	12	8.6	2.0	<0.01
	1969–1970	52	62.3	10.7		2010–2011	9	12.1	5.1	<0.01
						2011–2012	15	15.3	3.4	<0.01
						2012–2013	12	8.6	2.0	<0.01
	1966–1967	47	53.5	4.7	Timbillica	2009 –2010	64	26.9	4.0	<0.01
						2010–2011	69	33.7	4.6	<0.05
						2011–2012	79	34.7	4.0	<0.05
						2012–2013	120	20.2	2.8	<0.01
	1967–1968	45	55.0	12.2		2009–2010	64	26.9	4.0	NS
						2010–2011	69	33.7	4.6	NS
						2011–2012	79	34.7	4.0	NS
						2012–2013	120	20.2	2.8	<0.05
	1968–1969	43	69.0	6.6		2009–2010	64	26.9	4.0	<0.01
						2010–2011	69	33.7	4.6	<0.01
						2011–2012	79	34.7	4.0	<0.01
						2012–2013	120	20.2	2.8	<0.01
	1969–1970	52	62.3	10.7		2009–2010	64	26.9	4.0	0.01
						2010–2011	69	33.7	4.6	NS
						2011–2012	79	34.7	4.0	<0.01
						2012–2013	120	20.2	2.8	<0.01

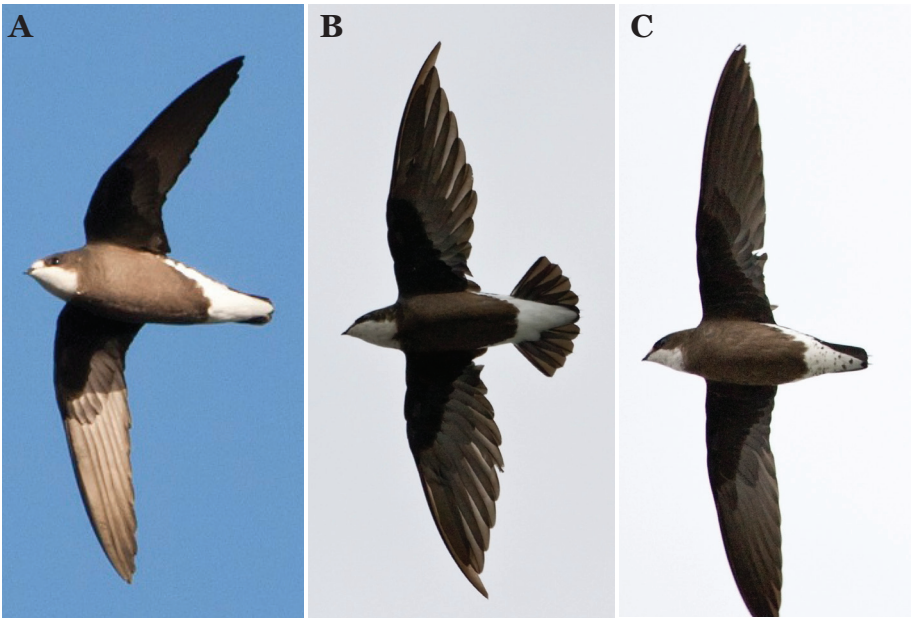

Figure 1. White-throated Needletail. (A) Adult flying in clear sky, Wynnum, south-eastern Queensland, 9 March 2008. (B) Adult, Woologoolga, north-eastern NSW, 22 December 2009; note that p8 (second primary from outer edge) is not fully grown, indicating that the bird is in a late stage of moult. (C) Juvenile, Woologoolga, 22 December 2009. Photos: Mat & Cathy Gilfedder

a significant drop in the mean number of birds sighted per day in the four states where most Needletails occur during the non-breeding period—Queensland, NSW (including the ACT), Victoria and Tasmania. The mean numbers of birds sighted per day in SA for the two periods were not significantly different, although the sample size may be too small to identify a change in this region, which is on the edge of the Needletail's range. It might also be that Needletails visit these marginal areas only in poor or good seasons, again highlighting the need for a larger sample.

Australia-wide trends

The Australia-wide trends in mean numbers of White-throated Needletails per day are shown in Table 4. The pooled Australian data (with 1901–1950 considered a single period for comparison: see Methods) show an apparent decline in mean numbers per day in each decade after 1950, but there are no significant differences between sequential pairs of decades (e.g. 1961–1970 versus 1951–1960). That each decade after 1950 shows a progressive decline in the mean number of Needletails seen per day does, however, provide a good indication that the decline over time is real. A Spearman Rank Correlation shows a significant decline (r = 0.964, P <0.05) in mean numbers of Needletails observed per day over the whole period 1901–2010.

Table 4. Australia-wide trends in mean number of White-throated Needletails seen per day between 1901–1950 and 2001–2010. In the table, *n* = number of days that Needletails were recorded, S.E. = standard error, *P* = probability of a decline in the period for the row indicated compared with the preceding period (*t*-test), NS = no significant probability of decline.

Years (July–June)	*n*	*Mean*	*S.E.*	*P*
1901–50	319	176	52.0	
1951–60	1764	195	46.6	NS
1961–70	6882	108	4.2	NS
1971–80	1912	102	4.6	NS
1981–90	1030	60	8.2	NS
1991–2000	2405	49	4.1	NS
2001–10	6280	46	1.8	NS

Table 5. Australia-wide trends in mean number of White-throated Needletails seen per flock between 1901–1950 and 2001–2010. In the table, *n* = number of flocks recorded, S.E. = standard error, *P* = probability of a decline over the whole period as determined by Spearman Rank Correlation.

Years (July–June)	*n*	*Mean*	*S.E.*	*P*
1901–1950	342	170	48.8	
1951–1960	2241	164	37.3	
1961–1970	9746	76	2.8	
1971–1980	3239	59	2.5	
1981–1990	733	70	11.4	
1991–2000	2173	49	4.5	
2001–2010	6389	42	1.7	<0.01

In addition to the tests in Table 4, these data for White-throated Needletails were also grouped into flock sizes as opposed to numbers seen per observer per day (see Table 5). This analysis using Spearman Rank Correlation again indicated a significant decline ($P < 0.01$) in the mean flock size observed each decade.

Discussion

The results from the three local Victorian sites, the state-by-state comparisons and the Australia-wide comparisons all indicate a significant decline in numbers of White-throated Needletails over time.

The data for each of the sites when treated as a unit spanning several years (Table 1) show a statistically significant decline in numbers of White-throated Needletails and are also supported by a significant decline for 30 of the 35 individual yearly comparisons (Table 2). This supports the notion that the decline for the remaining five yearly comparisons, although not significant, does not preclude the notion of an actual decline. Three of these yearly comparisons showing non-significant declines are from Maramingo Creek in 1967–1968 (when there was a high standard deviation, and therefore high standard error, contributing to such results; the original data indicate that on two very hot days there were two very large flocks of Needletails drinking from the creek, followed by very small flocks except for two close to the average size).

Local areas are easier to study because fewer personnel are required, but declines in numbers of White-throated Needletails in local areas may mean little if those areas have been so modified that the resultant reduction in the birds' food supply forces the Needletails to forage elsewhere. The suburban Melbourne sites have been modified by large reductions in orchards and native vegetation, and so the decline there could be expected. However, the outer Melbourne and eastern Victorian sites have not had significant habitat change according to the observers from the original surveys, so declines there are more likely to indicate a declining population of Needletails. As these sample sites are 400 km apart, the validity of the declines seen there is strengthened.

This consensus of a decline is supported by the data from each state (except SA), including states in which the White-throated Needletail is relatively common (Queensland, NSW), and so discounts suggestions that Needletails have not declined in some states and/or that they may have just moved to different parts of the eastern coast of Australia.

Whether White-throated Needletails are declining in any particular region is not as important as what is happening to the total population and, at an Australia-wide level, the data clearly show that the total population has been in decline since 1950 (Tables 4–5). The analysis of pooled data for Australia shows a decline in mean numbers of Needletails observed per day of 74% between 1901–1950 and 2001–2010. This is a larger decline than the 49% between the time periods for the two Atlases of Australian birds, comparing 1977–1981 and 1998–2002 (Barrett *et al.* 2003). Significant declines in flock sizes are also evident since 1950. Because this part of the study covers the total wintering population of Needletails (excluding vagrants to New Guinea and New Zealand), it should raise concern for the future of the migrating portion of the species, if the population continues to decline.

If the decline reported here is real, why do some observers anecdotally feel that White-throated Needletails are not in decline? I believe that it is because some observers are in regions where Needletails have concentrated because of

concentration of invertebrates (especially insects) resulting from changing rainfall patterns. Most observers supplying data directly to me comment that the numbers of Needletails have declined locally. By collecting and analysing data from all of Australia, as has been done in this study, it is possible to overcome regional and seasonal variations to derive a more accurate assessment of the total population. This assessment shows clearly that this species is in significant decline, so what is causing the decline of Needletails in Australia?

Why are White-throated Needletails declining in Australia?

There are several possible reasons for the apparent decline in numbers of White-throated Needletails in Australia. Much forest and woodland has been permanently cleared from eastern Australia in the last 50–100 years (Bradshaw 2012) and modified through other practices, including changed grazing and fire regimes, which result in loss of roosting sites and reduction in the abundance of invertebrates upon which Needletails feed. The loss of roosting sites in forests resulting from forestry activities may be another cause of decline. For example, a forested ridge in Queensland that had been used as a roost by Needletails in 1991–1992 was subsequently logged and the birds were not using the site as a nocturnal roost 2 years later (MKT pers. obs.). The logging methods used in Australia mean that there are always forested ridges not far from cleared ridges and the birds can use these for roosts.

Although permanent clearing of forests and woodlands has probably reduced the abundance of White-throated Needletails in those areas, availability of food resources in existing Australian forests is apparently not a limiting factor. In forests in Victoria and NSW, where ant (Hymenoptera: Formicidae) and termite (Isoptera) alates are sometimes abundant during summer, sometimes no Needletails have been observed feeding on them during observations from a vehicle over stretches of 70–80 km (MKT pers. obs.).

The use of insecticides, particularly organochlorines, is another possible cause of decline of White-throated Needletails, either through a decrease in the abundance of invertebrates (Needletails feed mostly on insects) from wide use of insecticides or from secondary poisoning by insecticides accumulated as sublethal doses in their prey. Termite alates are a preferred food of Needletails, and various insecticides are used to control termites and cockroaches (Rose 2005). Tawny Frogmouths *Podargus strigoides* in Sydney and Melbourne regularly die from ingestion of organochlorines in their insect prey (Rose & Eldridge 1997), and many adult and chick Laughing Gulls *Leucophaeus atricilla* in Texas, USA, were killed by parathion sprayed on a cotton field 3 miles from their colony (White *et al.* 1979). Other causes of mortality in White-throated Needletails appear to be of little consequence, e.g. collisions with power-lines, branches or telephone-lines (only six published incidents in Australia; e.g. Noonan *et al.* 1963; Pescott 1966), lighthouses (14 reports in Australia; Draffan *et al.* 1983), or conspecifics (two reports in Australia; Wheeler 1960). Hull *et al.* (2013) recently found 11 Needletails had collided with wind-turbines at two windfarms in north-western Tasmania over a 10-year period up to 2010. There appear to be no reports of collisions of

White-throated Needletails with aircraft in Australia, but the US Federal Aviation Administration (2008) reported 93 aircraft collisions with swifts, of at least three species, over 17 years.

Besides land-clearing, none of these factors appears likely to result in the decreases in abundance of White-throated Needletails observed in Australia. The cause appears to lie beyond Australia: possibly the most important factor influencing numbers of Needletails in Australia, and elsewhere, is the increase in clear-felling of the taiga forests of Siberia. These forests are the breeding regions of a large proportion of the Needletails that migrate to Australia for the boreal winter (Lobko-Lobanovski 1956; Lyuleeva 1991; Surmach 1994), and are bordered by the treeless tundra to the north and treeless grasslands of Mongolia and China to the south, neither of which is suitable for breeding of Needletails. White-throated Needletails breed in the deep hollows of two species of conifers and three deciduous trees that grow in the taiga forests (Lyuleeva 1991).

The problem of illegal logging of Siberian forests is severe (Newell *et al.* 2000; Crowley 2005; Smirnov *et al.* 2013) and has increased dramatically since the break-up of the USSR. The problem is recognised by Russia and governments of other countries, with the USA and Russia working together to attempt to combat the depletion of the Siberian taiga forests (US–Russia Civil Society Partnership Program 2012). Lebedev (2005) examined increases in Siberian logging between 2001 and 2005 and found softwood exports to China increased 15 times in the 5 years preceding 2002, and suggested that some analysts estimate that at least 50% of Russian ash and oak timber going to China was logged illegally. Lebedev (2005) also stated that there are now three–five times as many logging companies operating in Siberia and the Russian Far East as during Soviet times, and there are many unregistered small operations supplying an increasing amount of timber to the market (especially China).

Investigations by the British Broadcasting Corporation (BBC 2008, 2009a) reported illegal logging of >2 000 000 m^3 of timber a year from Siberian forests, and that the region could be stripped of timber reserves in 5 years, although later (BBC 2009b) it was estimated that the Siberian forests—'the largest forest on the planet'—would be destroyed in 20–30 years. The World Wildlife Fund (2011) stated that 'Illegal and uncontrolled cutting of larch is a major issue all over Russia. Overall, illegal logging rates have reached 50% in the Russian Far East', with Russia losing ~$US1 billion per year to illegal logging, which restricts money available for good harvesting practices

The problems for White-throated Needletails from logging of the taiga forests are possibly twofold. Firstly, the loss of forest habitat results in a reduction of invertebrate food for swifts and other insectivores, such as the Siberian Tit *Parus cinctus*. The Siberian Tit's breeding success is higher in natural forests than in managed forests (Virkkala 1990), with increased success attributed to the lower abundance of invertebrates in managed stands than in natural stands (Petterson *et al.* 1995). This reduction in food supply for Needletails and other invertebrate-feeders is probably exacerbated by the short growing season and extreme cold of the taiga compared with the parts of Australia over which Needletails feed. For

example, I constantly observe many insects (and Needletails feeding on them) over recently logged regrowth sectors in Beenak and Tarago State Forests and recently burnt forest in the nearby Bunyip State Park in Victoria (MKT pers. obs.). When breeding, however, Needletails, also need to find enough food for two–seven young (Lyuleeva 1991).

The second and more major likely impact on White-throated Needletails is the targeting of old and mature trees (i.e. those with hollows suitable for breeding). The trees remaining in logged forests are typically thin and lack such hollows (BBC 2009; Smirnov *et al.* 2013). Smirnov *et al.* (2013) specifically mentioned that the encroachment of illegal logging into riparian forests threatens bird species such as Blakiston's Fish Owl *Bubo blakistoni* that nest in the cavities of massive poplar *Populus*, elm *Ulmus* and ash *Fraxinus* trees.

White-throated Needletails are known to nest only in isolated hollows in large-diameter stumps (2–9 m tall), broken tree-trunks or hollow branches in large trees (14–20 m tall), or woodpecker holes that open into tree-hollows (Lobko-Lobanovski 1956; Neufeldt & Ivanov 1960; Surmach 1994; Yonekawa & Kawabe 1994). Suitable nest-sites are usually found at the edge of clearings in the forest (such as natural clearings caused by fires) or at the edges of forests or in wind-breaks, and it is thought that a cleared area is needed adjacent to nesting sites for adults to make their landings and take-offs (Yonekawa & Kawabe 1994). Reports that Needletails nest colonially in fissures in cliff-faces (Le Souëf 1907; Yamashina 1941; Harber 1955; Kiyosu 1978), which might have provided some hope for the nesting success of the species, are now considered erroneous (Collins & Brooke 1976; Surmach 1994; M. Hotta *in litt*. 2010).

Cavity-nesting birds, such as the White-throated Needletail, are among the groups most sensitive to the alteration of forest structure (Scott & Oldemeyer 1983; Imbeau *et al.* 1999, 2001). Large, old and decaying trees, which are used for nesting, are often among the first to be removed in managed forests (Wesolowski & Tomialojc 1986; Aulén 1988; Blume 1990; Stenberg 1990; Pechacek 1995). Furthermore, the trees of the taiga forests of Siberia grow very slowly (Schulze *et al.* 2005; de Blij *et al.* 2011), and hollows suitable for nest-sites take a long time to develop.

Swifts in general are long-lived birds (Tarburton 1987; Chantler & Driessens 1995) and so, for their size, White-throated Needletails are also probably long-lived, and there may be a lag between a decrease in breeding or breeding success and a detectable decrease in numbers in Australia. Identification of juveniles (see Figure 1) in Australia would provide an indicator of annual breeding success, as has been done for 30 years for some waders (e.g. Minton *et al.* 2011). Juvenile White-throated Needletails are distinguished from adults by: (1) the tips of the white undertail-coverts being 5–8 mm short of the tip of the rectrices (in adults they fall 0–3 mm short of the tip of the rectrices); (2) small, dark-brown fringes (1–4 mm wide) to the white feathers of the vent and under-tail coverts, giving a scaly appearance [some adults have fine (<1 mm wide) dark fringes in very fresh plumage]; (3) juveniles have worn primaries, and do not show moult of the wing-feathers, in the period August–April, when they are in Australia (adults begin their

moult of primaries in this period); and (4) juveniles have more pointed tips to the primaries, most evident on the inner primaries (those of adults are more rounded) (Higgins 1999). Note, however, that these differences are discernible only in the hand or with good photographs, thus limiting the ability for analysis of age in the field.

It is also possible that some larger flocks of White-throated Needletails still reported in Australia may originate from breeding populations other than the declining populations of Siberia. In addition to Siberia, migratory populations of White-throated Needletails breed on Sakhalin and the Kuril Islands, in Korea, north-eastern China and on Hokaido in Japan (Ptushenko 1951; Higgins 1999). White-throated Needletails that breed in the Himalayas are considered to be resident there all year (Baker 1927). If migratory populations other than those originating in Siberia do occur in Australia, these birds may remain together and in the one region, and thus not show changes in abundance in Australia.

Halting the loss of old-growth taiga forest should be a high priority for the conservation of the White-throated Needletail. A strategy that might help partially mitigate the problem caused by the destruction of nesting habitat could be provision of nesting boxes or artificially hollowed tree-trunks. These have been used in Sweden by Common Swifts *Apus apus*, which, unlike populations of that species in central Europe, would not nest under roofs after nest-trees had been logged (Leidgren 1985; J. Holmgren pers. comm. 2009). If the amount of logging and/or the short growing period in the White-throated Needletail's main breeding area (the Taiga) is also impacting on the Needletail's food supply, then it is all the more important to preserve either enough total forests or enough mature trees to provide the invertebrates that are required by breeding Needletails. In the Taiga, their food consists largely of parasitic wasps and small bumblebees (Hymenoptera), ladybirds (Coleoptera), and mayflies (Neuroptera) (Lyuleeva 1991). However, it appears that the forests are not always as important a source for food while the Needletails are breeding: Lyuleeva (1991) recorded that in Siberia Needletails also feed over meadows, bogs, lakes and rivers, which are often >1 km from their nests. It is not known whether Needletails feed over these wetlands because they have always done or because food is in short supply over the forests.

From my observations, the warmer climate of the Australian forests does not seriously affect the supply of flying invertebrates after logging or forest fires, and White-throated Needletails still spend most of their time feeding over those forests. Considering the concerning decline in numbers of Needletails over several decades, there is an urgent need for systematic surveys of the species in Australia, as well as in their breeding grounds of northern Asia and in the flyways. There is almost no current research on the species in their breeding grounds. In addition, collecting data from a wider range of windfarms would be useful to determine the impact of these on Needletails compared with other species.

Chantler (1999) considered the White-throated Needletail not to be threatened at a global level, and BirdLife International (2014) currently classifies it as of Least Concern. Its listing under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* is for its migratory status

rather than as a threatened species. Garnett *et al.* (2011) considered the Needletail to be of Least Concern in Australia, and it is only in Victoria where the species is formally classified as being of conservation concern (Vulnerable: DSE 2013). Considering the documented declines in the population in Australia, a revision of the conservation status of this species at state, national and international levels may be warranted.

Conclusion

The results of this study show that the White-throated Needletail is in significant decline in Australia and has been since at least 1950. This decline has been shown at three local Victorian sites, in each Australian state where Needletails winter, and by comparing all Australian data as a single unit. This means that the decline is real, and that any anecdotal observations to the contrary must be either very local or not real. Small numbers of Needletails do die while in Australia, but the main cause of their decline appears to be the increasing destruction of their breeding grounds in Siberia. Conserving old-growth forest within the boreal breeding grounds is likely to be the most effective way of halting the decline in the species. It may be possible to partly offset the loss of mature forest by creating artificial hollow stumps or by the provision of large nest-boxes on the Northern Hemisphere breeding grounds but it is not known if Needletails would use them, and this would be successful only if there were sufficient food for the birds within flying distance. In addition, whether such a program could be carried out on a scale large enough to maintain the species is not known.

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