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Australasian little grebe (*Tachybaptus novaehollandiae*) breeding on Whangarei sewerage wetlands, New Zealand, 2015–2017

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Abstract: Australasian little grebe (*Tachybaptus novaehollandiae*) was detected at the Whangarei sewerage wetlands at Kioreroa Road, in September–October 1996, and since 2012 has attempted to breed. Between October 2015 and April 2017, a pair of grebes produced 4 fledglings from 5 nesting attempts. Adults fed chicks for 26–29 days by diving in open areas with swamp lily (*Ottelia ovalifolia*). Fledglings began independent foraging between 19 and 26 days old. Fledglings were not seen at the site after reaching *c*. 55-days old. The young from late clutches left the natal site in March–April, 3 weeks after their parents were last detected there. The site was not used by any grebes in June and July.

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INTRODUCTION

The Australasian little grebe (*Tachybaptus novaehollandiae*) is a small recently self-introduced breeding wetland bird in New Zealand (Chance 1969; Checklist Committee 2010). The global estimated is between 25,000 and a million birds (Marchant & Higgins 1990). The current New Zealand distribution is centred on the Northland and Rotorua regions where there were estimated to be *c*. 100 individuals (Heather & Robertson 2015).

In New Zealand, Australasian little grebes use small permanent reed-surrounded and deep-edged wetlands for breeding (Chance 1969; Miller 1973; Lauder 1978; Marchant & Higgins 1990) and other wetlands in winter (Heather & Robertson 2015). In Australia, grebes use permanent wetlands and temporal lakes for breeding (Marchant & Higgins 1990). There is evidence of autumn and winter flocking, as well as movements associated with dry and wet seasonality (Marchant & Higgins 1990). Egg laying is asynchronous, and incubation is estimated at *c.* 23 days (Marchant *et al.* 1989). In some situations, the young remain at or near the nest for the first week (Marchant & Higgins 1990), while in others, chicks are active from hatching (Mo & Waterhouse 2015a). The number of breeding attempts can range from 1–3 times a year (Mo & Waterhouse 2015a), and at some sites the young of previous clutches help raise fledglings.

No pairs of Australasian little grebes have been reported throughout the breeding season in New Zealand, and the temporal use of habitat is undefined. In this study I gathered data on habitat use, breeding season duration, and fecundity of grebes, to ascertain whether the biology of Australasian grebes differs from that in Australia where the grebes in New Zealand are likely to have recently originated (Marchant & Higgins 1990).

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METHODS

Two groups of tertiary sewerage wetlands were developed along-side Kioreroa Road, Whangarei in 1990 (35.7446°S, 174.3247°E; Fig. 1A) as part of the sewerage treatment upgrade. The ponds were designed to capture solids and then allow discharge of treated water to the margin of the Limestone Stream mangrove system via aeration rapids. The eastern ponds at sea level were opened to the public, and signage at the entrance indicated that they were there to encourage wildlife viewing. The surround of the ponds was planted in native vegetation, but this only blocked wildlife from disturbance for <10% of the ponds between 1995 and 1998. However, marginal vegetation that died was not replaced. Over time wetland vegetation covered more of the ponds and giant cane (*Arundo donax*) developed on the southern side and hid the ponds from Kioreroa Road. By 2012 the ponds were very shallow, and in 2014 the Whangarei District Council upgraded the eastern pond system. The sludge was pumped into special bladders that were housed in the footprints of the original ponds (Fig. 1A). Shallow (less than 1 m deep) ponds were then reconstructed, and floating rafts of grasses were anchored in the ponds. Up until March 2015, the ponds remained weed free, and then beds of common swamp lily (*Ottelia ovalifolia*) developed from the western end of the main pond.

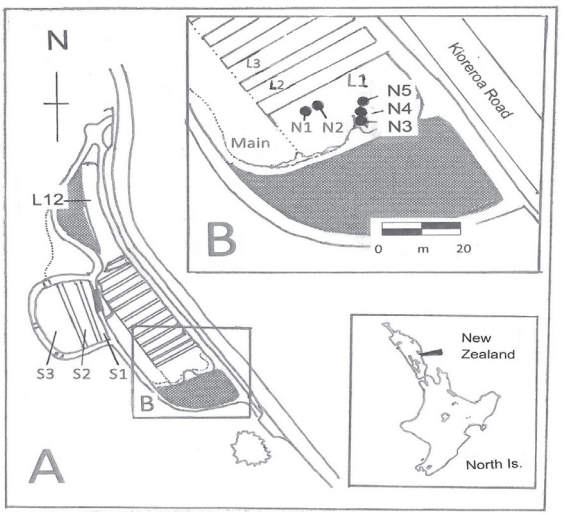

Figure 1. The Whangarei sewerage wetlands Kioreroa Road, Whangarei. The large pond is separated by floating wetlands between open areas of water (L1, L2…L12). The former smaller pond is now also separated into three areas by floating rafts (S1, S2, S3). The 5 nest sites used in pond L1 (N1–N5). Main = main linking pond. Shaded areas are parts of the original pond system that now enclose bladders and pond sediment.

The original ponds were monitored at intervals of 17–88 days, including 28 times during 9 November 1995 – 19 November 1998, to ascertain which birds were using them and the surrounding plantings (Fig. 2). They were then counted infrequently between 1999 and January 2014.

Intensive monitoring of the ponds re-commenced on 12 October 2015, when grebes were detected covering a nest, and continued until 30 August 2018. Visits were made on average every 3 days when nesting and fledglings were present, and every 7–14 days at other times (Fig. 2). Most visits took place between 1645 h and 1900 h and lasted between 20 and 50 minutes. A standard walk route followed each visit and the behaviour at detection of each grebe and the number, location, and breeding status of all the grebes were noted. A car was used as a hide to check on the incubation status of the birds between walk surveys.

During each survey between November 2015 and April 2016 at ponds L1 and Main pond (Fig. 1B), the duration of 12 dives was established to the nearest second. The location of the dive was also noted and collated as, i) along the margin of the pond, or ii)

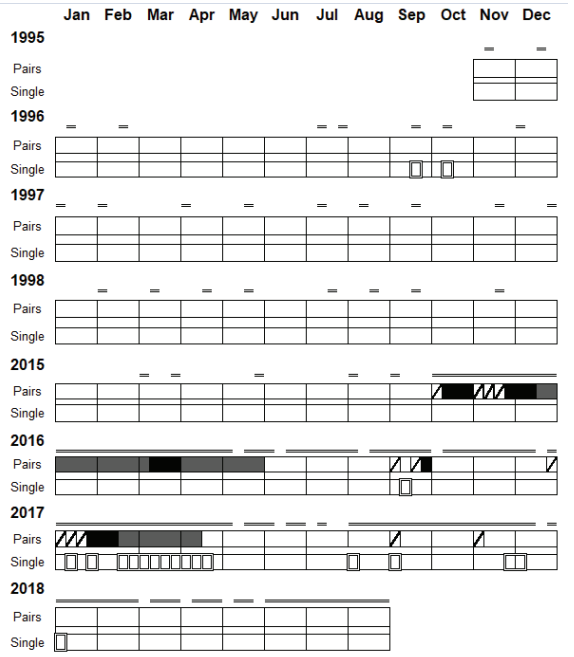

Figure 2. The time that the pairs of Australasian little grebes were present and breeding at the Whangarei sewerage wetlands. Parallel lines right of the year indicates the weeks the site was checked. Pairs; left hash = pair present (pre-breeding in some cases), black areas = incubation, grey areas = young present. Single; double lined square = solitary unpaired bird was present.

Table 1. Breeding status and parental care and fledgling behaviour of Australasian little grebe fledglings at the Whangarei sewerage wetlands in 2015–2017. Nest #, see Fig. 1B.

Incubation noted	Nest #	Date hatched	Age of fledglings (days)						
			Chick present	On backs of adults	First dive	Independent feeding	Given last warning calls	Last seen at the site	Young fledged
12 October 2015	N1	6 November 2015	-	-	-	-	-	-	-
11 November 2015	N2	19 December 2015	2	3-5	21-23	27-29	62-64	76-78	1
9 March 2016	N3	11 April 2016	2	-	23-27	23-27	19-23	55-59	2
22 September 2016	N4	26 September 2016	-	-	-	-	-	-	-
19 January 2017	N5	15 February 2017	2	8-12	8-12 & 26-28	16-18 & 26-28	30-33	58	1

within the pond. After April 2016 dive times were established throughout the pond system, to assess how adult dive times changed during the breeding season in the presence and absence of fledglings.

The walking track lacked cover and surveys were generally conducted from open ground besides trees. However, it was possible to observe from cover on some occasions. Vegetation was used as a hide on 21–22 December 2015, when the grebes and fledglings used pond S1 for foraging.

No birds were banded or could be individually distinguished by other means. The chronology of nesting portrayed assumes that the pair members were the same, due to the consistency of nest locations. The dates of hatching were estimated from the time adults were absent from the nest, and the likely incubation start dates (assuming *c.* 23 days incubation and asynchronous hatching; Marchant & Higgins 1990). The uncertainty in the age of the fledglings is indicated when discussing the times in development of behavioural interactions in this paper.

I noted the proportion of floating macrophytes and duckweed (*Lemna minor*) within the units of the wetland and grebe use of the parts of the ponds.

RESULTS

During monthly visits between August 1995 and November 1998, an Australasian little grebe was only detected on 15 September and 12 October 1996 (Fig. 2). More sporadic visits did not detect grebes again at this site between 1999 and 2013. However, Heather O'Brien (*pers. comm.* 2015) noted grebes on the small pond area (now ponds S1–S3, Fig. 1A) on 7 November 2012, and photographed two 10–14 day old young on the backs of adults on 22 January 2013. These young were not present 4 days later. One adult grebe was then seen at the ponds between 20 and 27 October 2013 (H. O'Brien *pers. comm.* 2015). No grebes were present on 15 January 2014, just before the ponds were re-configured.

Grebe presence and breeding success, October 2015 – June 2018

A pair of grebes used sites L1, Main, S1, and S2 between October 2015 and April 2017 (Table 1; Fig. 1&2). Grebes were not seen in the ponds with a full surface coating of duckweed.

Nests platforms of wet weed were constructed from the common swamp lily (*Ottelia ovalifolia*). The pair used 5 sites within 20 m of each other. Nests 1 & 2 were in the open water; nest 3 was connected to 12 emergent rush (*Scirpus* spp.) stems; nest 4 was between two small clumps of rushes and nest 5 was on the outer margin of the clumps of rushes (Fig. 1B). All sites were <5 m from the shoreline or rafts and gave the incubating bird 270–360° views of the surrounding habitat. Nest 2 was damaged in a storm on 2–3 October 2016. Nests 3 and 4 were accessible to pukeko (*Porphyrio porphyrio*), a potential egg/chick stealer (Mo & Waterhouse 2015b), and nest 5 was in the deepest water where it could be connected to rushes (Fig. 1B).

The 5 nesting attempts produced 4 young to independence (Table 1; Fig. 2). Two clutches (N1 & N4) were lost/deserted without hatching at *c.* 20 days (2 November 2015) and 7 days (29 September 2016). Young grebes were lost in 2 of the 3 clutches that hatched; 1 at *c.* 5 days old on 23–24 December 2015 (N2), and the other at *c.* 26 days old, on 12–13 March 2017 (N5, Table 1).

The pair of grebes was not seen between; 30 May 2016 and 11 September 2016, 28 September 2016 and 22 December 2016, and from 20 March 2017 to 31 August 2018. The absence from September to December 2016 (83 days) occurred after an unsuccessful breeding attempt. If these were the same birds then this period was long enough for the pair to have had bred elsewhere. However, no grebes were found in the neighbouring wetlands during any absence.

Single grebes were detected at pond L1 on 4 & 9 August, and 9 October 2017, and 2 grebes were seen there on 6 September 2017 (Fig. 2). However, no platform building occurred during those visits,

when macrophytes covered <5% of the three ponds that were not dominated by duckweed (L1, Main, S3). Macrophytes were only plentiful (*c.* 15% pond cover) in pond L1 from early November.

Two birds were seen on 6 September 2017 and 3 & 5 November 2017. A grebe constructed a small platform of macrophytes near the bridge in pond S1 between 3 and 5 November 2017, but the platform was lost when the wetland rose after rain on 19 November 2017. From this time, only single grebes were seen intermittently on ponds L1 (2 December 2017), S3 (20 November 2017) and S1 (15–16 November 2017, 6 January 2018; Fig. 2).

Pre-breeding and incubation

Before incubation the grebes foraged within vocal contact of each other but in separate parts of the wetland. No courtship feeding or courtship behaviour was seen during the mid-late afternoon visits.

Grebes were deemed to be incubating when they stayed on the nest or left the nest and covered it with vegetation. Incubation also coincided with the non-incubating adult giving *zit zit zit* calls (warning calls, Mo & Waterhouse 2015a) when it was disturbed (by the author). These calls were given throughout the time that fledglings were present, and especially when I appeared without notice and the warning calls of paradise shelduck (*Tadorna variegata*) were not heard (Table 1). The incubating bird generally stayed on the nest when I approached the area on foot (93.8% $n = 32$) and always remained on the nest when I stopped the car and used it as a hide ($n = 22$). The non-incubating bird was usually encountered diving for food (Table 3), but then stopped and stayed on the surface and preened or dived and disappeared into the vegetation.

The only time that the incubating bird was not found sitting tightly on the nest was during 18–23 February 2017 when chicks were present. No feeding was seen at the nest, even when the nest was observed from within my car.

Foraging and chick rearing

During the times where adults fed alone, either during the incubation period (mean = 17.2, SD = 6.3, $n = 134$) or when the adult was not a care giver (mean 16.0, $SD = 5.7$, $n = 174$), dive times were not significantly different (t (unequal variance) = 1.79, $df = 269$, $P>0.05$) and never exceeded 30 seconds. However, during these periods, there were differences in the duration of dives of adult grebes foraging near the shallower margins (mean = 10.8 seconds, $SD = 3.3$, $n = 26$) and middle of the main pond and pond L1 (mean = 17.4 seconds, SD = 6.1, $n = 118$; t (unequal variance) = -8.30, $df = 47$, $P<0.0001$).

Young grebes were always first detected off the nest. Very young fledgling moved over 70 m from the nest with adults during my first encounter with them. When there were two fledglings under 21 days old, they were first detected with both parents 60% of the time ($n = 10$) or were split between parents (40% of the time). Fledgling calls were heard up to 50 m away. Calls were given continuously when the fledglings were *c.* 3–8 days old. After this, and when fledglings were up to 26–29 days old, calls were only given once adults surfaced from dives. Fledglings were fed after 84.2% ($SD = 17.7$, $n = 8$ sample periods) of dives when between 3 and 17 days old. Adults reacted to the constant begging for food by occasionally chasing fledglings when they were between 12–28 days old.

Adult dive times before food delivery to their fledglings (mean = 6.6 seconds, $SD = 4.3$, $n = 204$) were significantly shorter than dive-times when food was not delivered (mean = 10.4 seconds, SD = 4.3, $n = 47$; $t = 5.60$, $df = 249$, $P<0.0001$). However, dive-times when food was not delivered to fledglings were still significantly shorter than dive-

Table 2. Dive times (seconds) of Australasian little grebe fledglings at the Whangarei sewerage wetlands in 2015–2017.

Age (days)	Dive times (seconds)				
	n	mean	*SD*	min	max
5-8	3	7.0	4.8	1	10
14-16	3	5.1	0.8	4	6
17-19	11	12.5	2.8	8	17
20-21	12	11.5	4.1	4	19
22-24	14	6.2	3.9	1	14
25-27	10	8.8	4.6	4	18
35-37	7	8.3	2.7	6	13
42-44	8	12.9	2.1	11	17
46-48	15	7.9	2.5	3	10

Table 3. Adult Australasian little grebe activity at first detection during the incubation and fledgling dependency periods, 2015-2017.

Activity	Nest phase	Fledgling phase
Dive for food	6	33
Dive to escape	0	4
Guard nest	0	2
Resting on nest	0	3
Swim to nest	0	6
Swim	3	11
Preen	0	4

times during the fledgling dependency period, but when parents fed alone (mean = 16.2 seconds, *SD* = 5.6, *n* = 47; *t* = 7.60, *df* = 96, *P*<0.0001).

The 4 fledglings raised to independence were first recorded foraging and diving independent of adults at 21, 19, 23, and 26 days old, respectively. When most day-to-day feeding of fledglings was over, adults still sought fledglings when they caught larger fish (*Gambusia affinis*).The foraging dives of fledglings before they left their natal site (mean = 9.2 seconds, *SD* = 4.1, *n* = 83) were significantly longer than those of their parents when they fed them from the same pools during the chick dependence phase (mean = 6.6 seconds, *SD* = 4.3, *n* = 203; *t* (unequal variance) = 4.87, *df* = 157, *P*<0.0001). However, the fledgling dive times were still significantly shorter than the foraging dive times of adults when they fed alone at these sites during the fledgling dependence period (*t* (unequal variance) = -11.1, *df* = 215, *P*<0.0001).

Disturbance

Adults generally resorted to swimming and feeding on the surface (22.7%, *n* = 75) or diving without food delivery (46.7%) when I disturbed them with fledglings. Food collected from the surface was seldom delivered to the fledglings (twice in 36 minutes), and disturbed adults with dependent fledglings recommenced diving for food within 10 minutes.

Fledglings mounted the backs of a parent when they were less than 12 days old. Mounting only occurred when both adults and fledglings were disturbed in open water, and when the fledglings could not reach vegetation cover without being seen. Observations from within vegetation cover on 21 December 2015, found that two 3–4 day old fledglings climbed onto a parent's backs when a human visitor appeared, and that the chicks remained there for 28 minutes, including 7 minutes after the visitor had left the site and after the paradise shelducks had ceased calling.

Fledglings could dive at 8–14 days old to escape detection, but did so rarely before 21 days old. Fledglings could stay submerged for 17 seconds when 19 days old (Table 2).

The duration of adult defence of fledglings exceeded that of food provision. The pair hastily swam/dived the 90 m of the main pond to the nest site, where the fledglings were present on my appearance on 19 and 21 January 2016, and when the fledglings were *c.* 32–34 days old.

Fledgling independence and movement

Fledgling presence only overlapped with incubation of the next clutch once, during March 2016 (Table 1; Fig. 2). The parents lived peacefully with their fledgling until it was 76 days old, and then the fledgling disappeared from the site before the next clutch hatched.

In late May 2016, 2 fledgling grebes departed from the pond when 55–57 days old, 23 days after their parents had gone. Similarly, in April 2017, the fledgling grebe was last seen at 58 days old, 24 days after the parent had gone. During all visits, no flights or wing flapping were seen by either adults or fledglings.

Fledgling grebes disappeared during autumn from the oxidation ponds just after major rainfall events (Table 4).

Non-paired adult interaction

A single adult grebe was seen on ponds areas S1–S3 (Fig. 1A) between 8 January 2017 and 5 April 2017, 7 times (28% of the visits), but was never seen concurrently with the pair or their fledglings (Fig. 2). The single grebe was more skittish that the paired

Table 4. Dates when, and circumstances in which, Australasian little grebe adults and fledglings left the Whangarei sewerage wetlands in 2015-2017.

Date of the last sighting	Date of large rainfall or wind event	In-flow to wetland	Movement
27 May 2016	Wind 28-30 May 2016	1.5 times higher than median rate	Loss of fledgling
26 September 2016	25 September 2016	2 times higher than median rate	Loss of nest
14 March 2017	9-12 March 2017	3 to 6 times higher than median rate	Loss of one breeding adult and fledgling
5 April 2017	4-7 April 2017	3.5 to 5.5 higher than median rate	Loss of single solo breeding adult
14 April 2017	12-14 April 2017	3 to 5.5 higher than median rate	Loss of fledglings and single unpaired adult

adults and generally dived and moved to cover on detection. It disappeared at the same time as the last fledgling of that breeding season (Table 4).

DISCUSSION

Australasian little grebes use the Whangarei sewerage wetlands seasonally. The macrophytes they make their nest platforms from die down in winter, but in spring they create habitats that are considered very suitable for grebes in Australia (Marchant & Higgins 1990). Grebes did not use the partitions of the wetland that were completely covered in duckweed. At Whangarei, the Australasian little grebes laid between late September and late/early March and during this time were capable of raising 2–3 broods each breeding season. This duration of breeding, and the potential number of clutches, are similar to those seen in the shallow wetlands in the floodplain and estuary systems on in northern New South Wales (Gosper 1981).

The fledgling behaviour and the timing of development were similar to that described in Australia; however, no fledgling overlap or helping by the young from previous clutches occurred. There is debate about the time chicks stay on the nest with some authors considering it can be a week, others a day (Marchant and Higgins (1990), and Mo & Waterhouse (2015a) did not record any occupancy of the nest. In Australia, there were also indications that the time spent by chicks on the nest varied between nesting attempts. In this study, parental on nest activity, and different fledgling size at first detection, indicated that at least one nest one chick stayed on or near the nest before the first detection. However, most of my records were collected in the afternoon, and it may be that mid to late afternoon is a poor time for understanding chick presence and its relationship with fledging. Marchant *et al*. (1989) considered the times that I visited the site were more likely to be the core times for foraging.

Parental care and foraging methods appeared to differ with habitat. In this study grebes did not use head submersion while swimming along the water surface, to find food. In the St. George region, southern Sydney, Mo & Waterhouse (2015a) reported that fledglings as young as 7 days old dived and foraged, which they attributed the combined effect of sibling rivalry and parental favouritism when they feed chicks. In some situations, food was delivered by adults flying back to fledglings and that large fish were beaten to pieces by adults on the surface of the water to feed fledglings. At Whangarei, some between-fledgling aggression occurred when fledglings were 7–10 days old, but in all cases, parents sought and fed both fledglings when they were the sole carer. There was no indication of any speedy transition to foraging independence by any fledgling. At Whangarei, the food delivered to chicks was very small, and no fish bashing or large fish delivery was seen. It may be that the ponds were too young for large fish to be present.

The timing to full development of fledglings, *c.* 8 weeks old, was similar to that reported from Australia (Marchant & Higgins 1990) and this time coincided with solitary fledglings leaving the ponds in the late autumn.

The foraging dive times were of similar duration to those in Australia (Ropert-Coudert & Kato 2009), but the maximum dive time of 30 seconds was far less than the 66 seconds recorded in Marchant & Higgins (1990). Adult foraging dives after which fledglings were fed were far shorter than other adult foraging times, suggesting that adults may feed underwater multiple times during their average dive. Consequently, it was surprising that the ponds were deserted by the adults in March–April in both years, when there was sufficient food for fledglings to continue development for a further 3 weeks, using significantly shorter dive times than the adults.

All the adults and the fledglings are assumed to have left the site by mid-autumn. Human disturbance can be ruled out as a source of these disappearances. The pair was sometimes disturbed multiple times each day by the local SPCA walking dogs there. The grebes gave distress calls when they saw dogs but remained on site and laid multiple clutches. My presence was a disturbance factor, but the grebes only stopping foraging dives temporarily and took fledglings onto their backs rarely.

Grebe movement coincided with periods after heavy rainfall, when the surrounding habitats were saturated, but when it appears the ponds were still suitable for foraging. The movements in autumn may be a normal part of the biology of this species. Flock formation occurs during autumn in Australia, and on the Aupouri Peninsula in Northland (Marchant & Higgins 1990; Heather & Robinson 2015).

In Australia, little grebes are known to travel up to 338 km (Marchant & Higgins 1990). If such movements are taking place in New Zealand, then the small population in Northland could be overwintering in a very few locations; know about many suitable and widely spaced breeding sites, and visit them regularly. Consequently, the movement of the pair from the ponds in September 2016 could well have been to another waterbody many kilometers away, and the flock on the Aupouri Peninsula could include breeding birds from all over Northland.

During the study period, 3 fledglings and

2 nests were lost. One nest platform was in the open and appeared to be destroyed by wind, and the other was vulnerable to pukeko. Swamphens and shortfinned eels (*Anguilla australis*) are also suspected problem predators for grebes in Australia (Mo & Waterhouse 2015a & b). Predation was suspected in this study, where a c. 26–28 days old fledgling (80% adult size) and a parent disappeared at the same time in mid-March 2017, and this was unlikely to be due to their movement from the area, because the fledgling could not fly.

In summary, the Australasian little grebe appears to visit the Whangarei oxidation ponds during the spring of most years, but its presence is temporary unless the site is used for breeding. The Australasian little grebe has previously only been recorded breeding in well vegetated marginal wetlands with steep edges in New Zealand (Marchant & Higgins 1990). This study has found that the breeding habitats used by Australasian little grebe in Northland are broader (Marchant & Higgins 1990) and include shallow wetlands with tapered edges and low grassland marginal vegetation. Generally, the dive times, laying times, and parental care behaviour is similar to that seen in Australia; as are the predation threats. However, adult grebe defence of young against pukeko (swamphens), and eels, was not seen (Mo & Waterhouse 2015a). The migratory nature of the species and the time that grebes are away from breeding sites in winter is similar to that in Australia (Marchant & Higgins 1990).

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