

Changes in Nankeen Kestrel *Falco cenchroides* breeding success at a nest-hollow after more than a decade

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Abstract. Observations of Nankeen Kestrels *Falco cenchroides* using a nest-hollow on agricultural land south-west of Sydney, New South Wales, over four breeding seasons (1998–2001) were previously reported by Starr *et al.* (2004a,b). In the present study, the same nest-hollow was monitored over three breeding seasons (2014–2016) more than 10 years later, when it was used each year, but only one chick was raised each year. This represents a notable reduction in breeding success from the 3–4 chicks that were raised each year in 1998–2001.

Introduction

Tree-hollows are an important habitat feature that provide refuge and breeding sites for a variety of wildlife (Gibbons & Lindenmayer 2002; Goldingay 2009). The Nankeen Kestrel *Falco cenchroides* is one of the few diurnal birds of prey that nest in tree-hollows where available (Aumann 2001; Olsen & Baker 2001). Nankeen Kestrels will also use disused nests of other birds, cliff-ledges, and even broken tops of ant-hills, sink-holes or mineshafts, artificial nest-boxes and buildings (Marchant & Higgins 1993; Olsen 2014). Breeding in this species is strongly seasonal (Bollen 1991; Paull 1991) and the same nesting site may be used repeatedly (Olsen & Olsen 1980a), although some observed changeover in mates (Olsen & Olsen 1980b) suggests different individuals using the site over multiple years.

Starr *et al.* (2004a) published observations of a pair of Nankeen Kestrels using a nest-hollow on an agricultural demonstration site, one of 15 species of diurnal birds of prey reported at this site (Starr *et al.* 2004b). The nest-hollow was located ~6 m above the ground in a live Forest Red Gum *Eucalyptus tereticornis* that had a crown height of ~28 m (Figure 1). Nankeen Kestrels used the nest-hollow each year from 1998 to 2001, raising three to four chicks per season (Starr *et al.* 2004b). The breeding cycle consistently occurred between September and December.

Here, I report on new observations of Nankeen Kestrels using the same nest-hollow more than 10 years later, with a specific focus on breeding success.

Study site and methods

The study site, the Elizabeth Macarthur Agricultural Institute is owned by the New South Wales Government and is situated ~70 km south-west of the Sydney Central Business District (Mo 2019). The property (1600 ha) comprises livestock paddocks and open woodland remnants on flat to gently sloping terrain between the Razorback Range and the Nepean River. Detailed descriptions of vegetation communities are provided by Ridgeway (2015) and Mo (2018). The nest-hollow is situated at the southern end of the site, >1 km from the nearest public road. After



Figure 1. The tree-hollow of a Forest Red Gum used annually by Nankeen Kestrels from at least 1998 to 2001 (Starr *et al.* 2004a,b) and 2014 to 2016 (present study). Note the metal sheeting applied to the tree-trunk; the section that has degraded is located on the opposite side of the tree, not visible in this photograph. Photo: Matthew Mo

the observations of Starr *et al.* (2004a,b), Institute staff installed metal sheeting around the tree-trunk to prevent Lace Monitors *Varanus varius* (a common local species; Mo 2019), from accessing the nest-hollow. By March 2014, when my observations commenced, several nails had given way, causing some of the sheeting to bend away from the tree-trunk. The nest-hollow was therefore again accessible to Lace Monitors and other non-volant predators.

From 2014 to 2016, I visited the nest-hollow between October and December on 15 occasions over the 3 years. During each visit, the nest-hollow was approached no closer than 50 m and was observed from a single post for the entirety of each observation period. Observation periods lasted 20–90 minutes. Frequency and duration of visits were kept to a minimum to avoid disturbing the Kestrels and causing nest abandonment. The number of adult and nestling Kestrels observed was recorded for each visit.

Differences in annual rainfall between 1998–2001 and 2014–2016 were analysed to identify possible correlation

with breeding success reported by Starr *et al.* (2004b) and the present study. Data were sourced from the Australian Bureau of Meteorology, primarily using weather records from the Menangle Bridge weather station, situated <2 km from the site. However, as rainfall data from this weather station were incomplete for 1998–2000, 2008 and 2011, data from the Camden Airport weather station (situated 8 km from the site) were used to fill these gaps.

Results

In the 2014 breeding season, I visited the nest-hollow on five occasions (Table 1). On 13 October, a pair of Nankeen Kestrels was observed leaving and returning to the nest-hollow. A nestling was first seen at the entrance of the nest-hollow on 28 November (Figure 2). During this observation period, one adult brought lizards (possibly *Eulamprus* sp.) to feed the nestling (cf. Olsen *et al.* 1979; Olsen 2014; Tsang *et al.* 2017; Debus 2019). The adult perched on a dead tree, 40 m from the nest-hollow, before returning to the nest-hollow (Figure 3). During food exchanges, no more nestlings appeared. One nestling was also observed on 17 December.

In the 2015 breeding season, I visited the nest-hollow on four occasions. On 29 October, one adult Kestrel was observed in the dead tree 40 m from the nest-hollow but it did not approach the nest-hollow any further during the 45-minute observation period. One nestling was observed on nest visits on 19 and 26 November and 17 December.

In the 2016 breeding season, I visited the nest-hollow on six occasions. Two adult Kestrels were seen investigating the nest-hollow on 4 October, and were in the nest-tree and surrounding trees on 26 October and 17 and

Table 1. Number of adult and nestling Nankeen Kestrels observed during 15 visits to the nest-site over 3 years (2014–2016). Dates for visits are given as day/month.

Visit	Observation period (minutes)	No. adults	No. nestlings
2014			
13/10	40	2	
17/10	20	1	
14/11	90	2	
28/11	25	1	1
17/12	30	2	1
2015			
29/10	45	1	
19/11	20	2	1
26/11	25	2	1
17/12	40	1	1
2016			
4/10	35	2	
26/10	20	2	
17/11	30	2	
24/11	90	2	
8/12	30	2	1
14/12	30	1	1



Figure 2. Nestling Nankeen Kestrel observed in the 2014 breeding season. Photo: Matthew Mo



Figure 3. Adult Nankeen Kestrel perched on a dead tree close to the nest-hollow with a lizard to feed to the nestling. Photo: Matthew Mo

24 November. One nestling was observed on 8 December, during which time an adult brought lizards to the nest. One nestling observed on 14 December was likely to be the same nestling. Even during food exchanges, there was no evidence of other nestlings.

Between 1998 and 2016, there were significant variations in annual rainfall in the region (Figure 4). Drier conditions in years such as 2001–2002, 2006 and 2009 were reflective of the Millennium Drought in south-eastern Australia, between 2001 and 2009 (Wong *et al.* 2009; van Dijk *et al.* 2013). During 1998–2001 when Starr *et al.* (2004b) monitored Nankeen Kestrels at the site, mean annual rainfall was 635 mm as the Millennium Drought progressively set in (cf. Horridge *et al.* 2005). In contrast, mean annual rainfall during the present study (2014–2016) was slightly higher (697 mm), although the number of chicks present was consistently lower than in 1998–2001.

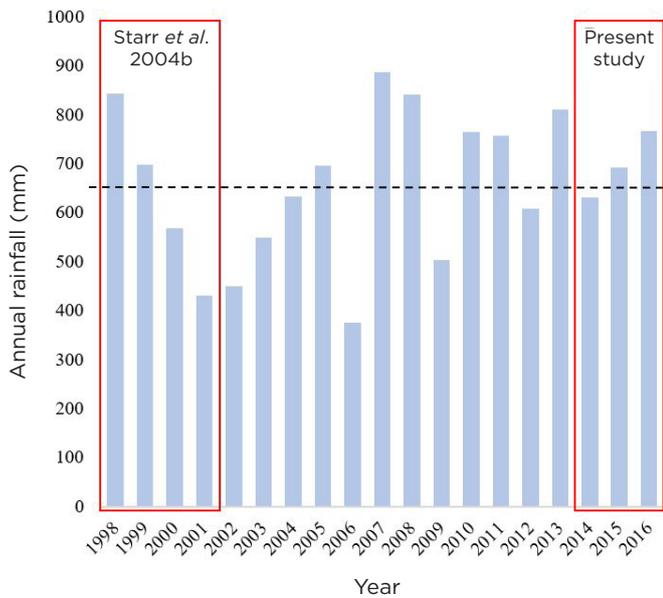


Figure 4. Annual rainfall in Menangle and Camden, recorded from the Menangle Bridge (2001–2007, 2009–2010, 2012–2016) and Camden Airport weather stations (1998–2000, 2008, 2011). Monitoring periods of Starr *et al.* (2004b) and the present study are labelled. The broken line represents mean annual rainfall during 1998–2016 (658 mm). Data source: Australian Bureau of Meteorology.

Discussion

Suitable tree-hollows for nesting can be scarce in agricultural areas, and this has been compounded by the severe rate of habitat destruction throughout eastern Australia since European settlement (Gibbons & Lindenmayer 2002). The present study site has been cleared for agricultural use for >150 years, with a more recent history of ring-barking (Mo 2018). Given the scarcity of tree-hollows at the site, it is not surprising that a particular tree-hollow would be used year after year, but it is surprising that the hollow was not usurped by other hollow-nesting species (Heinsohn *et al.* 2003; Olsen & Trost 2009), in any years.

Breeding success of the Nankeen Kestrels during 2014–2016 was substantially reduced from the 3–4 chicks raised per season recorded by Starr *et al.* (2004b) more than a decade earlier. Annual rainfall data suggest that environmental conditions should have been more favourable in 2014–2016 compared with 1998–2001, although it is also possible that prey availability had been impacted by the length of the Millennium Drought (van Dijk *et al.* 2013). The deterioration of the metal protective barrier on the tree-trunk possibly also lowered nesting success by enabling non-volant predators such as Cats *Felis catus*, Common Brushtail Possums *Trichosurus vulpecula* and Lace Monitors to again access the nest-hollow (cf. Olsen & Trost 2009; Guppy *et al.* 2017) although there is no evidence to identify predation as the cause of decreased breeding success. It is also important to note that the metal protective barrier was absent during the study conducted by Starr *et al.* (2004a).

In the time between 1998–2001 and the present study, there would also be some change expected in a living tree, which may alter the structures of tree-hollows. Tree-

hollows are continually altered by regrowth, natural decay, termite (Isoptera) activity and other biotic factors (Mattheck *et al.* 1994; Werner & Prior 2007; Lindenmayer & Wood 2010). Long-term studies of hollows used by Southern Boobooks *Ninox boobook*, for example, have shown that some hollows grow closed, and use by other hollow-nesting species have erosive effects on hollow structure (J. Olsen pers. comm.). Since monitoring by Starr *et al.* (2004b), it is possible that the tree-hollow used by the Kestrels had undergone changes that could have some effect on brood size.

The repeated use of the nest-site by Nankeen Kestrels indicates the suitability of the site. Elsewhere, circumstantial factors such as dry weather may cause Kestrels to leave an area (Debus 1985), as noted during droughts in the Northern Territory (Rix 1970) and Queensland (Whitmore *et al.* 1983). Managed agricultural areas such as the Elizabeth Macarthur Agricultural Institute are advantageous in that water resources are supplemented from mains supply, and the artificial habitats may benefit populations of Kestrel prey species such as rodents, lizards and insects (Starr *et al.* 2004a; Debus *et al.* 2007; Leach *et al.* 2015).

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