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IDENTIFICATION OF NEST PREDATORS WITH REMOTE CAMERAS AND ARTIFICIAL NESTS IN EXTENSIVE OLD-GROWTH WOODLAND OF SOUTH-WESTERN AUSTRALIA

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Four major nest predators, in a large block of relatively undisturbed woodland in south-western Australia, were identified by remotely triggered cameras at artificial nests: Brushtail Possum *Trichosurus vulpecula*, Grey Currawong *Strepera versicolor*, Red Wattlebird *Anthochaera carunculata* and Grey Shrike-thrush *Colluricincla harmonica*. Each species' predatory impact was influenced by different localised factors. Brushtail Possums were important predators in a tourist village situated within the woodland and at one woodland site. The Grey Shrike-thrush disturbed camera-nests across all woodland sites, but were not detected in the village, at camera-nests or in censuses. Red Wattlebirds were more abundant where numerous eucalypts flowered simultaneously and disturbed camera-nests at those sites. Grey Currawongs only disturbed camera-nests before they undertook a home range shift that corresponded with their own nesting. The theft of nest material (approximately one third of all events) highlighted the fact that existing nests may be important to nesting birds as a source of nest material and that the theft of this material may be an under-estimated cause of nest failure.

INTRODUCTION

Nest predation is considered the major cause of nest failure in open nesting passerines (Lack 1954; Skutch 1966; Ricklefs 1969; Martin 1992) and often goes unwitnessed despite its high frequency of occurrence (Skutch 1966; Major and Gowing 1994). The majority of observations are limited to daylight hours although the presence of observers is likely to deter some predators and may attract others to nest sites (Major 1990, 1991). Nocturnal predation is somewhat overlooked (Major 1991; Laurence *et al.* 1993; Laurance and Grant 1994). Remotely triggered cameras have become a popular tool to identify nest predators because they help overcome these problems (Picman 1987, 1992; Major *et al.* 1996; Sieving and Wilson 1999; Berry 2002).

Predator identification is an important step in understanding how conservation management might proceed as it is crucial to know what species to manage. The Grey Shrike-thrush *Colluricincla harmonica* was identified as a significant nest predator in south-eastern Australia, by utilizing remote photography (Major *et al.* 1999; Berry 2002). In south-western Australia, there has been no study of bird nest predators using remotely triggered cameras and the identity of nest predators continues to be largely speculative.

The aim of this study was to identify nest predators in a continuous block of relatively undisturbed woodland, the Dryandra Woodland, and at a small tourist village within this woodland. Dryandra Woodland holds an almost full complement of bird species for the region, including those lost from remnants of the central wheatbelt of Western Australia (Recher and Davis 1998). It also retains remnant populations of animals that have been extirpated from the region. Mammalian species extinct elsewhere on the mainland have been re-introduced to the Dryandra Woodland (Friend and Thomas 1994; Friend *et al.* 2001), although the dingo *Canis familiaris dingo* is not present. Foxes have been controlled since 1982 (Friend 1990), and surveys for cats using call and scent lures have shown that they are not abundant in the woodland (Friend and Thomas 1994). This site provides an opportunity to identify nest predators in an area where the original woodland dynamics are largely unchanged.

STUDY SITE AND METHODS

The Dryandra Woodland is located about 160 kilometres south-east of Perth on the western side of the wheatbelt of Western Australia. It comprises a series of large woodland fragments, which are separated by agricultural land and scattered over an east-west distance of approximately 35 kilometres: the total area is approximately 27 000 hectares (Department of Conservation and Land Management 1995). The woodland is characterized by Powderbark Wandoo *Eucalyptus accedens* on the upper slopes, with Brown Mallet *E. astringens* and Wandoo *E. wandoo* on the lower slopes and valleys — powderbark and wandoo woodland make up approximately 50 per cent of the total area (Coates 1993; Department of Conservation and Land Management 1995).

All woodland cameras were positioned in wandoo woodland, which had a grassy and herbaceous understorey with scattered *Gastrolobium* and *Astroloma* spp. shrubs. One camera was positioned in the tourist village, within the garden of the caretaker's residence, to detect if different predators would be identified there. The village, situated 3.5 kilometres from the nearest bitumen road, consists of eight larger and two smaller cottages, a dormitory complex that can accommodate larger groups, an open field and a row of approximately 150 mature pine trees, which separate the open field from the cottages. The tourist village has a Brown Mallet plantation on three sides and an open grassed paddock on another. The side of the village adjacent to old-growth woodland is narrow (approximately 100 m) and forms part of the home range of a social group of Australian Magpies *Gymnorhina tibicen*.

Two camera set-ups were deployed for 256 camera days at 15 locations within the woodland during the breeding seasons of 2003 and 2004. Woodland sites were chosen in the lower parts of the landscape dominated by wandoo woodland where most birds were detected breeding.

The camera apparatus consisted of a Ricoh 35R brand (35 mm) automatic camera, with a built-in flash. The camera was housed in a clear plastic container, which had a circular hole cut in its side to avoid

obscuring the lens. The camera was connected to a micro-switch at the nest by wires, which were taped to the nest tree and covered with litter where they crossed the ground. The cameras were not deliberately disguised, although their exposure varied with cover from tree branches. All cameras were considered to be visible to birds. Cameras were mounted in the field using boss-head and burette clamps. The set-up generally followed that described by Berry (2002), except that the micro-switch was positioned outside the nest with a lightweight extension arm inserted through the side of the nest, which triggered the camera if the egg was removed. The extension arm had a small spoon-shaped end to place the egg on. The nest seemed natural in appearance with a single Common Quail *Coturnix coturnix* egg placed inside. Cameras were set between five and seven metres from the nests. The camera rolled on automatically and could take multiple pictures of each disturbance event each time the micro-switch was depressed provided that film was available. The status of the film was checked daily, notes were taken and the film replaced as necessary. Processed photographs were analysed from a week to a month later. They were then matched to field notes to confirm the date of each photograph. Individual disturbance events represented by a series of pictures were differentiated from a sequential series involving the same species by the patterns of shade and the background weather conditions of each photograph.

Four types of nests were used in the camera set-ups — three natural nest types and an artificial nest. The three natural nest types used were Willie Wagtail *Rhipidura leucophrys*, Western Yellow Robin *Eopsaltria griseogularis* and Restless Flycatcher *Myiagra inquieta*, which had been collected in 2002 from within the Dryandra Woodland. The artificial nest consisted of coconut fibre matting, which was cut and sown into a distinct cup-shape. All nest types were attached to a branch or fork with a single thin wire strand. Nests were placed in the field similarly to the natural nests previously detected. Nests that had been damaged by storms and/or by the theft of nest material were replaced as required.

Nests were placed at specific locations for periods ranging from 3 to 36 days (mean 17 days; SE 3.1 days). Nests were checked daily for damage to the nest itself, egg and camera set-up. Nests were regarded as depredated if the egg had been taken, partly consumed, or the nest had been completely removed. Eggs were replaced in nests after they were depredated and this may have allowed animals to learn there was a recurrent reward at the set-ups. Thus there is a lack of independence between each event, which precludes any statistical analyses.

The theft of nest material was concluded from a photograph or series of photographs where the 'predator' was pulling material from the nest. Theft of nest material without egg predation was concluded when nest material, but not the egg was taken. Predation of the egg is assumed at nests where a photograph of the predator was taken and the egg was missing.

RESULTS AND DISCUSSION

Eleven species were photographed involving 76 disturbance events (Table 1). The four most frequently photographed species were Brushtail Possum, Grey Currawong *Strepera versicolor*, Red Wattlebird *Anthochaera carunculata* and Grey Shrike-thrush. The three former species were the most frequently detected predators at woodland and village locations while the Grey Shrike-thrush was only detected at woodland locations.

The egg was depredated from 59 nests and nest material was taken from 23 nests. Both egg and nest material were taken from 6 nests: twice by Australian Magpies, twice by Grey Currawongs and once each by the Grey Shrike-thrush and Yellow-plumed Honeyeater *Lichenostomus ornatus*. In total, eight species were photographed taking nest material from artificial nests (Table 1).

Predators

In eastern Australia, the ubiquitous presence of the Pied Currawong *Strepera graculina* has been proposed as a possible explanation for the current decline of open-nesting songbirds (Recher 1972; Matthews *et al.* 1999; Fulton and Ford 2001). The Pied Currawong undertakes a seasonal shift in home range (Wimbush 1969; Bass 1989), and changes its diet to incorporate the eggs and nestlings of other birds when raising its own young (Prawiradilaga 1996; Wood 2000; Fulton and Ford 2001). Comparatively little is known of the Grey Currawongs diet and movements. To date they have been recorded only irregularly as predators of eggs and nestlings (Van Bael and Pruett-Jones 2000; Higgins *et al.*, in press). In this study, Grey Currawongs were identified as important nest predators in the Dryandra Woodland. However, they only depredated camera-nests before they commenced their own breeding. They moved away from the tourist village midway through September and did not return until their young had fledged, despite the reliable food available from tourists at the village (unpubl. data). The Grey Currawong also exhibited a shift away from roadsides during their breeding season along a nearby highway (unpubl. data). In addition, they did not nest in the low-lying areas of the landscape where the greatest concentration of passerines nested (unpubl. data) and may not pose a threat to the bird species that nest in these areas. More detailed studies of this species are needed to assess its importance as a nest predator, particularly in smaller remnants where it may be unable to shift its home range. Conversely, the Grey Currawong may itself be threatened by the scarcity of larger

TABLE 1

Species identified at camera-nests. Predation and theft of nest material events and occurrences within woodland and village habitats. The sum of egg predation and theft of nest material may be greater than the overall total predation, because both may occur at a single disturbance event.

Species	Habitat			Egg predation events	Theft of nest material events	Both
	Woodland	Village	Total			
Brushtail Possum *Trichosurus vulpecula*	11	9	20	20	0	0
Grey Currawong *Strepera versicolor*	10	7	17	17	2	2
Red Wattlebird *Anthochaera carunculata*	8	4	12	6	6	0
Grey Shrike-thrush *Colluricincla harmonica*	9	0	9	9	1	1
Yellow-plumed Honeyeater *Lichenostomus ornatus*	4	0	4	2	3	1
Willie Wagtail *Rhipidura leucophrys*	4	0	4	0	4	0
Australian Magpie *Gymnorhina tibicen*	1	2	3	2	3	2
White-browed Babbler *Pomatostomus supercilosus*	3	0	3	0	3	0
Australian Raven *Corvus coronoides*	1	1	2	1	1	0
Restless Flycatcher *Myiagra inquieta*	1	0	1	1	0	0
Singing Honeyeater *Lichenostomus virescens*	0	1	1	1	0	0
Totals	52	24	76	59	23	6

remnants, as their range has contracted in association with clearing for agriculture in south-western Australia (Storr 1991; Saunders and Ingram 1995; Abbott 1999).

Grey Shrike-thrushes have been characterized as insectivores that take a large proportion of their prey from the ground (Ford and Bell 1981; Brooker *et al.* 1990; Recher and Davis 2002), but they were identified as the most widespread predator of camera-nests in the woodland, although they were not recorded at camera-nests in the tourist village. During three years of monitoring, Grey Shrike-thrushes were not recorded in censuses in the tourist village despite being commonly recorded at all eleven locations throughout the woodland (unpubl. data). Grey Shrike-thrushes were also observed at four nest-disturbance events across the woodland (Fulton, in press) and were additionally observed raiding a Rufous Tree-creeper's *Climacteris rufa* nest (Gary Luck, pers. comm.). The Grey Shrike-thrush is not considered an open-country species (Howe 1984; Berry 2001), although some birds have been reported foraging in open paddocks (Berry 2001). This later finding contrasts with other studies by Major *et al.* (1999) who found they were common in linear remnants but not in adjacent farmland and, Fulton and Majer (in press) who found them restricted to a small remnant avoiding open country and a recently cleared area. Ford and Bell (1981) only recorded them in natural woodland and not in disturbed areas, while Howe (1984) only detected them in larger forest fragments. These reports indicate that Grey Shrike-thrushes are linked to larger and higher quality remnants. In contrast, they have been commonly recorded nesting in and around houses (Higgins and Peter 2002; Stevens and Watson 2005), although Stevens and Watson reported that continuous forest occurs up to 50 metres from a homestead where Grey Shrike-thrushes had their nests. At Dryandra Woodland, Grey Shrike-thrushes only nested in the low-lying areas of the landscape along with the greatest concentration of open nesting passerines (unpubl. data). As such they may place substantial predation pressure on woodland species that nest there. More detailed studies of the Grey Shrike-thrush are required to assess its predatory significance.

Brushtail Possums have been widely reported as nest-predators (Brown *et al.* 1993; Brown *et al.* 1996; Luck 2003). In this study, Brushtail Possums were the most frequently recorded predator of camera-nests. However, most of the predation events associated with this predator were recorded in the caretaker's garden and at a single camera location in the woodland. At the woodland location a single possum may have learnt that the egg would be replaced each night; this possum appears to be the same individual, which occurs in successive photographs. In the village, possums are regularly fed by tourists and have become habituated to finding food around the cottages. In addition, boxes providing roosts have been attached to most of the cottages and these probably help maintain a higher abundance of possums in the village. It seems likely that their predatory pressure will be higher in the village, because of the supplemental feeding and more evenly spread throughout the woodland, although individual possums may exploit the higher abundance of nests available in low-lying areas of the landscape during the birds' breeding season.

The Red Wattlebird has been previously reported as a nest predator, in Western Australia (Brown and Brown 1986). In this study, Red Wattlebirds took nest material as frequently as eggs from camera-nests, and were identified as important predators in both the woodland and the village. They nested prolifically around the village in 2004, when many exotic eucalypts were in flower and they were common in mallet plantations, where most trees flowered synchronously. Their aggregations at the synchronous flowering of *Eucalyptus* spp. concentrated their numbers locally within the Dryandra Woodland, which in turn corresponded to their detection as predators at camera-nests.

The Australian Magpie and Australian Raven *Corvus coronoides* were infrequent nest predators. The former was habituated to the village where their social groupings were larger than elsewhere in the woodland (Fulton, in press). Two out of three occurrences of magpie predation were in the village and all three were associated with the theft of nest material. The other event was recorded in an area adjacent to the village where the same group of magpies commonly foraged. Village magpies have been recorded depredating juvenile White-naped Honeyeater *Melithreptus lunatus* and Brown-headed Honeyeater *M. brevirostris*, near the camera position in the caretakers garden (Fulton, in press). Birds from this social group of magpies are likely to continue to depredate nests and other birds in and around the village. One camera was set up within 20 metres of an Australian Raven nest within the woodland. This camera returned only a single predator photograph, a Red Wattlebird, from 32 days of exposure. It may be that the presence of nesting Australian Ravens deterred other would be predators from this camera location. The Restless Flycatcher and Singing Honeyeater *Lichenostomus virescens* were recorded only once each at camera nests and may be opportunistic and infrequent nest predators.

The theft of nest material

Willie Wagtails and White-browed Babblers *Pomatostomus supercilosus* took only nest material. The Willie Wagtails took nest material from re-used Willie Wagtail camera-nests while White-browed Babblers took nest material from re-used Western Yellow Robin nests both from within their foraging territories. No adults were present to defend the artificial nests and birds may have regarded them as abandoned nests or simply a source of nest material. Both White-browed and Chestnut-crowned Babblers *Pomatostomus temporalis* have previously been reported as nest predators (Carter 1924; Brooker 1998; Van Bael and Pruett-Jones 2000). However, during this study, Rufous Treecreeper, Yellow-plumed Honeyeater, Red Wattlebird and Australian Magpie were observed taking nest material from active nests of other birds (Fulton, in press).

Approximately one-third of the photographs in this study recorded the theft of nest material without egg predation. The comparative frequency of the theft of nest material to egg predation indicates that it is important to nesting birds. The magnitude of the theft of nest material was unexpected given how rarely it has been recorded in the literature, although anecdotally many passerine species have been reported stealing nest material. Ley *et al.* (1997) described the theft of nest material, by ten honeyeater species and six

other passerine species, from active and inactive nests, in eastern Australia. Rowley and Russell (2002) reported that Yellow-plumed Honeyeaters took nest material from active (under construction) Blue-breasted Fairy-wrens *Malurus pulcherrimus* nests on three occasions, at Dryandra Woodland. Brown and Brown (1986) observed other small species stealing nest material from active nests of the Yellow-rumped Thornbill *Acanthiza chrysorrhoa*, which included thefts by con-specific ex-helpers. The nests disturbed in this study lost some or their entire nest material to eight different passerine species. The variety of woodland birds detected stealing nest material from active and inactive nests indicates that the phenomenon is likely to be widespread.

The predators identified by cameras in this study behaved differently and were associated with specific habitat factors. Various explanations have been proposed in relation to predators and processes operating within fragmented habitats. Chalfoun *et al.* (2002) conducted a meta-analysis of nest-predator studies in fragmented habitats, and they concluded that predator responses were complex, specific to each taxon and context dependent. For example, the bark type associated with the age and type of trees affected the ability of Rat Snakes *Elaphe obsolete* to climb trees and therefore their ability to depredate arboreal nests (Mullen and Cooper 2002). Tewksbury *et al.* (1998) found greater nest predation in forested habitats over fragments in an agricultural matrix, which corresponded with the presence of an important nest predator, the Red Squirrel *Tamiasciurus hudsonicus*. Similarly, Brooker and Brooker (2001) found greater nest predation in larger remnants and higher nest success in smaller woodland remnants in the Western Australian wheatbelt, and concluded that small fragments may be unsuitable for predators that require a large territory.

Australian forest and woodland landscapes are naturally variegated in that they form a continuous mosaic of natural patches that differ in the physical and chemical properties of their soils and consequently their avian assemblages (Barrett *et al.* 1994; Abbott 1999). The results herein, from continuous old-growth woodland, indicate that a collection of predators is important and that their effects are likely to be patchy depending on local circumstances. Therefore, conservation efforts need to be customized according to the species of nest predator that is primarily responsible for local nest mortality and to the local factors that encourage nest predation.

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ERRATA

Errors were printed in the paper by Greg P. Clancy in Volume 30(1) of Corella, March 2006. The errors occurred in Table 2: Number and duration of visits to Osprey nests in Clarence Valley, 1991-1996. This table is reprinted below.

TABLE 2

Number and duration of visits to Osprey nests in Clarence Valley, 1991–1996.

Year	Total Hours	Number of visits	Number of visits per nest
1991	21.8	9	Iluka (1), Serpentine (1), Yamba (1), Woodford Is. (2), Lawrence (2), Swan Crk (1), Wooli (1).
1992	28.5	6	Serpentine (1), Woodford Is. (1), Lawrence (2), Swan Crk (1), Wooli (1).
1993	42.2	55	Woodford Is. (15), Kings Crk (9), Lawrence (18), Swan Crk (7), Wooli (6).
1994	17.6	26	Woodford Is. (8), Kings Crk (8), Lawrence (9), Swan Crk (1).
1995	35.5	16	Woodford Is. (8), Kings Crk (1), Lawrence (7).
1996	67.4	60	Woodford Is. (23), Munro's Lane (22), Lawrence (15).
Totals	213	172	Iluka (2), Serpentine (2), Yamba (1), Woodford Is. (57), Kings Crk (18), Munro's Lane (22), Lawrence (53), Swan Crk (9), Wooli (8).