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THE SUNBIRD

Volume 27 No. 3 September 1997

HOW USEFUL ARE SMALL BUT LIGHTLY TREED SUBURBAN PARKS FOR FOREST BIRDS IN BRISBANE?

KIRSTI HUDSON, CARLA P. CATTERALL, SKYE MCNAMARA and MARK B. KINGSTON

ABSTRACT

Bird densities were assessed in eight sites within each of the following four habitat types within the southern suburbs of Brisbane: forest interior, forest edge, suburbs and suburban parks containing some eucalypts. Grey Fantail, Yellow-faced Honeyeater and White-throated Honeyeater (grouped together as "honeyeaters"), Magpie-lark and Noisy Miner were selected for study. Grey Fantails and honeyeaters were common in the forest interior but rare elsewhere; Magpie-larks were commonest in suburban areas; and Noisy Miners had higher densities in parks and forest edges than elsewhere. Differences in bird numbers counted in the morning versus late afternoon were not statistically significant. These results indicate that lightly treed parkland sites, lacking in understorey, support birds typical of suburbs or forest edges rather than forest interior or forest-dependent species.

INTRODUCTION

Previous research has demonstrated that many bird species are significantly affected by clearing and fragmentation of forest habitat and by urbanisation of the cleared areas. Some species increase their numbers in urban areas or at the forest edge, whilst others decline or disappear either as a direct consequence of the habitat loss, or as an indirect result of their interactions with species which have successfully adapted to edges and open spaces created by clearing (see for example Catterall *et al.* 1991, Recher & Serventy 1991).

Suburban landowners are often urged to plant native trees and shrubs in order to provide habitat for native birds, although research in some suburbs of Brisbane has clearly shown that, within an urbanised landscape, even well planted gardens close to remnant forest areas are not frequently visited by most forest birds (Catterall *et al.* 1989, 1991; Sewell & Catterall MS). It is also useful to know the extent to which urban parkland with retained native trees provides habitat for forest-dependent birds.

This study was designed to determine whether the densities of several species of bird differ significantly between the following four habitat types within the southern suburbs of Brisbane: forest interior, forest edge, suburbs and suburban parks. It was hypothesised, in particular, that parks characteristic of the suburbs surrounding the forest would not support the numbers and types of birds typically found in forest areas, but would be more similar to suburban areas and/or forest edges.

STUDY AREA AND METHODS

Study Sites

Data for the study were collected in the southern suburbs of Brisbane city, in and around Toohey Forest. Eight sites were chosen within each of four habitats, according to the following criteria.

i) Forest interior sites were located within the boundaries of Toohey Forest at least 0.25 km from the forest edge. Vegetation, aspect and other physical factors were kept similar at all of the sites. Toohey Forest is a relatively undisturbed, large forest remnant (approximately 600 ha) containing a mosaic of eucalypt woodland and open forest with a well developed understorey and shrub layer present.

ii) Forest edge sites were located along the boundary between Toohey Forest and residential suburbs, and were away from major roads. Minor roads and tracks within Toohey Forest were not considered to create edges.

iii) Park sites were chosen on the basis that they contained at least 25 medium to large trees including some eucalypts, had a cleared understorey, did not contain any houses or buildings, and were situated at least 0.25 km from remnant forest. Most selected parks were only a few hectares in area. The overall tree cover in the parks was substantially less than that in the forest or edge sites.

iv) Suburban sites were of medium housing density, on standard sized allotments in suburbs of a similar age. All had a moderate cover of trees and shrubs, and were at least 0.25 km from remnant forest.

Additionally, all were situated at least 0.5 km apart and at least 0.5 km from the nearest large water body. The two site types away from the forest were interspersed with one another to ensure that any differences were due to the site type rather than other confounding factors.

Bird Data

Each site was visited once in the morning between 6:30 and 9:30 am and once in the afternoon between 4:30 and 6:30 pm, on different days. Data were collected over five weeks between 20 March and 23 April 1995. An index of relative bird density was obtained within a transect of 200 m by 20 m at each site by two observers (K. H. and S. M.) who spent 20 minutes, beginning in the centre and walking away from each other until reaching opposite ends of the transect, while recording all birds seen. Birds that flew over or straight through the transect were excluded from the data analysis. The following species were selected for statistical analysis: Yellow-faced Honeyeater *Lichenostomus chrysops* and White-throated Honeyeater *Melithreptus albogularis*, grouped together as "honeyeaters"; Grey Fantail *Rhipidura fuliginosa*; Magpie-lark *Grallina cyanoleuca;* and Noisy Miner *Manorina melanocephala*.

A two-factor Analysis of Variance (ANOVA, Zar 1984) was used to test whether the density of each taxon varied according to either the habitat type or the time of day. When there was a significant ($P<0.05$) habitat effect, extended *t*-tests were used to test the significance of differences between each pair of habitat means. Pooling of the two honeyeater species was necessary to facilitate valid statistical analyses, and was considered justified for species with broadly similar habits that frequently occur together in mixed-species flocks within Toohey Forest (Catterall *et al.* 1991).

RESULTS

The effect of habitat was significant ($P<0.05$) for all types of bird tested (Fig. 1 and Table 1). Grey Fantails were common in the forest interior sites but rare elsewhere, and this difference was highly significant. The combined density of Yellow-faced and White-throated Honeyeaters (perhaps including a small proportion of White-naped Honeyeaters *M. lunatus*) showed a similar pattern, which was also statistically significant. Magpie-larks showed a contrasting pattern, being more common in suburban areas than in any other habitat type,

TABLE 1. Effect of habitat and time of day on bird density: ANOVA results. The morning and afternoon densities are across all habitats (S.E. is the standard error). See Fig. 1 for habitat means.

Bird species	Morning density mean	Morning density S.E.	Afternoon density mean	Afternoon density S.E.	ANOVA: probability (P) values Habitat (H)	Time (T)	H X T
Grey Fantai	0.7	0.30	0.7	0.32	0.0003	0.87	0.95
Honeyeaters	0.6	0.31	1.0	0.43	0.027	0.39	0.56
Magpie-lark	1.3	0.45	0.7	0.25	0.001	0.19	0.89
Noisy Miner	6.4	1.27	3.8	0.86	0.004	0.06	0.84

and typically seen foraging on the ground within these areas. The Noisy Miner, in groups of various sizes, was the most common of these species over all habitat types, and had significantly higher densities in parks and forest edges than in suburbs and forest interior sites.

The effect of habitat on bird density was consistent across both times of day, and there were no statistically significant differences ($P>0.05$) in density between the morning and afternoon sampling periods (Table 1). However, for both Noisy Miner and Magpie-lark, about twice as many birds were seen in the morning as in the afternoon (this was not statistically significant, although nearly so for the Noisy Miner, $P=0.06$).

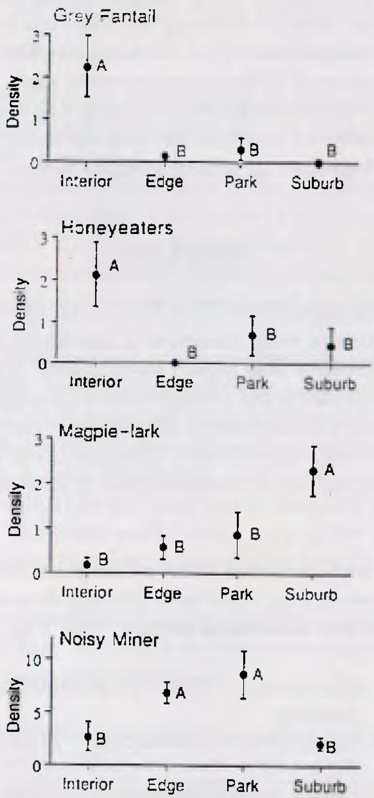

Fig. 1. Bird density (means of morning and afternoon, and standard error bars) in the four habitats. Points on each graph with the same letter (A or B) were not significantly different ($P>0.05$) from one another (extended *t*-tests).

DISCUSSION

Time of Day

Much research on the effect of time of day has focused on the detection of differences between hours within the morning, ignoring other times of day (Skirvin 1981), and has also frequently focused on the detection of singing individuals, in keeping with traditional northern hemisphere bird census methods (Robbins 1981). Individual species may show a variety of activity patterns, including little diurnal change (Robbins 1981, Arnold 1989, Leach & Watson 1994).

In the present study both the Noisy Miner and Magpie-lark showed a strong trend for more sightings in the morning hours than late in the afternoon, whereas no such trend was recorded for the Grey Fantail or the honeyeaters. Arnold (1989) similarly found little diurnal variation in frequency of sighting during winter transect counts for Grey Fantail and White-naped Honeyeater in Western Australia, and Evans *et al.* (1997) working in the same region as the present study, found no difference between morning and afternoon counts of Grey Fantails. In the present study, differences in local activity patterns resulting from variation in habitat type were considerably greater than those due to time of day. Counts along narrow transects which are based largely on sightings may be less affected by diurnal activity patterns than methods of assessing bird abundance which rely mainly on detecting vocalisations.

Bird Density Differences among the Four Habitats

The Grey Fantail, Yellow-faced Honeyeater and White-throated Honeyeater have been identified in previous studies as being dependent on native forest habitat and hence vulnerable to habitat loss and fragmentation, both in the Brisbane region and elsewhere (Catterall *et al*. 1989, 1991; Catterall & Kingston 1993). Previous work in the Brisbane area concluded that Magpie-larks were suburban or suburb edge species (Catterall *et al.* 1989, 1991), consistent with the findings of this study. There is a growing body of evidence that Noisy Miners increase in density where there is naturally sparse or artificially thinned woodland with grassy ground cover (Ford 1993), in small heavily grazed woodland remnants (Loyn 1987), in low density residential developments with an overstorey of remnant forest trees (Sewell & Catterall MS), and along forest edges (Catterall *et al.* 1991). In the present study, Noisy Miners were more abundant in the edges and wooded park sites than in forest interior and suburban sites.

The Conservation Value of Lightly Treed Suburban Parks

The results of this study supported our hypothesis that the areas of treed parkland would contain birds typical of suburbs or forest edges rather than forest interior species. There were, however, some patterns that would not be expected on the basis of typical feeding and movement habits. For example Magpie-lark did not frequent park and edge sites where open and grassy ground cover existed and should have provided a suitable feeding substrate. It is also difficult to explain on the basis of species' resource requirements the low densities of Grey Fantail and honeyeaters at edge sites, for these sites had a well developed understorey and forest canopy. These low densities could be a consequence of the interspecific aggressiveness of Noisy Miners (Loyn 1987, Catterall *et al.* 1991, Ford 1993), and it has been suggested that high Noisy Miner densities in Brisbane's western suburbs were the cause of low densities of many other species (Woodall 1995).

There are several possible explanations for the low abundance of the forest interior birds in these parks. (1) The sparse canopy and lack of understorey mean that there is a lack of suitable structure and substrates for foraging or insufficient cover from predators. However, Catterall & Sewell (MS), in studies in the same region, found that Grey Fantail densities were not reduced in habitats where the understorey had been removed, but Noisy Miner densities were not high. (2) Total habitat area is too small, even though the habitat structure is adequate. Area sensitivity is a well documented phenomenon in forest birds, although why it occurs remains poorly understood for many species, and many forest birds will use forest patches at least as small as 10 ha (Loyn 1987, Catterall *et al.* 1991, Sewell & Catterall MS). The habitat area associated with the parks in this study varied in size; most were only a few hectares, but some were also adjacent to other areas of natural or semi-natural habitat. (3) Forest birds might be excluded from (or avoid) the parks as a result of the high density and interspecific aggression of Noisy Miners. Evans *et al.* (1997) found that Noisy Miners had high densities in small (1-2 ha) remnants with understorey, and that Grey Fantails were very rare in these remnants. Some forest interior species might visit parks more often, in spite of the alterations to the habitat structure, if Noisy Miners were absent.

Both habitat area and adequate understorey are likely to be important determinants of the habitat value of parks. Many treed parks within urban Brisbane are only a few hectares in area, but whether they are too small for use by forest birds is at present unknown. The relative importance of habitat area and habitat structure within smaller remnants could be tested by comparing bird densities within treed but open parks and forest remnants of similar size. It is possible that tree species composition within the parks may also influence Noisy Miner density, and a future investigation could assess the extent to which a eucalypt overstorey may encourage Noisy Miners more than a rainforest or mixed tree species composition.

This study has shown that suburban parks, even if they contain mature eucalypts and other trees, are unlikely to provide useful habitat for forest-dependent birds. Further research is needed and there is considerable scope for urban planners to contribute to the development of this knowledge by experimentally altering the habitat structure in some of the open or lightly treed parks. This could include: increasing the variety of native tree genera and families; planting native shrubs to promote the development of an understorey; and repeating this within differently sized areas. Once such plantings have been established it would be a comparatively simple matter for bird observers to conduct systematic bird counts to evaluate the outcomes, provided that several examples of each situation are available. While not providing a substitute for conservation networks of larger forest remnants, Queensland's urban parks, if appropriately planted and managed, should be able to provide better wildlife habitat than they do at present.

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BREEDING DIET OF THE LETTER-WINGED KITE *ELANUS SCRIPTUS* AND BLACK-SHOULDERED KITE *E AXILLARIS* DURING A HOUSE MOUSE PLAGUE

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There have been few quantified studies of the diet of the Letter-winged Kite *Elanus scriptus*. Previous literature has emphasised the importance of native rodents, particularly the Long-haired Rat *Rattus villosissimus*, in the kite's breeding diet within its normal range in the eastern interior of Australia. However, the introduced House Mouse *Mus musculus* is important during extralimital (non-breeding) occurrences of the kite in irruption years, and in its breeding and non-breeding diet in central Australia during mouse plagues (see Baker-Gabb & Pettigrew 1982, Hollands 1984, Marchant & Higgins 1993). It has been suggested that the kite may be switching successfully to a diet of House Mice (Baker-Gabb & Pettigrew 1982), or that House Mice are a nutritionally inferior diet not permitting the kite's long-term persistence in extralimital areas nor successful breeding (Hollands 1984).

This paper documents the breeding diet of the Letter-winged Kite on the Darling Downs, Queensland, associated with a House Mouse plague over autumn-winter 1995. The diet of nesting Black-shouldered Kites *Elanus axillaris* from the same area was also examined and a brief comparison made. Pellets were collected opportunistically from beneath both nest and roost trees.

STUDY AREA AND METHODS

Letter-winged Kites had been breeding at a site within 10 km of Dalby (27°11' S, 151°16' E) in 1995. Structurally, the site resembled the kite's normal habitat further inland. The landscape at Dalby consisted of cropland and pasture dotted with single eucalypts or copses, and intersected by creeks lined with eucalypts. There were occasional densely foliaged small trees, Boonaree *Heterodendrum oleifolium*, Butterbush *Pittosporum phylliraeoides*, various wattles *Acacia* sp. and Beefwood *Grevillea striata*, 4-5 m high, scattered in paddocks.

A sample of Letter-winged Kite pellets (n = 201; total dry mass = 285 g)was initially collected by MTM, PJMcC and KMW on 16 September 1995 underneath two Poplar Box trees *Eucalyptus populnea*, being used for nesting, separated by 0.7 km. Three fledglings were roosting in one nest tree with two adult birds. The second nest contained three young yet to fly (but which did so during the following week), the adults being absent on the day of collection. The carcass of an advanced chick was found under each nest. Black-shouldered Kite pellets (n = 51; total dry mass = 83 g) were collected on the same day from under a recently abandoned nest tree, also a Poplar Box, less than 1 km from the Letter-winged

Kite nests. A separate site, within 3 km of the Letter-winged Kite nests, was inspected by SJSD on 23 September 1995 and a further sample of Letter-winged Kite pellets (n = 515; total dry mass = 970 g) collected beneath two Beefwoods being used as roosts by three kites, one adult and two juveniles. These kites were shown to SJSD by Messrs V. York Snr and Jr, who located the birds by radio-tracking one fitted with a transmitter. This site was within Dr J. Pettigrew's study area. Pellets were collected because dietary research by pellet analysis was not part of Dr Pettigrew's study. The birds observed by SJSD were well concealed in a Beefwood and would have remained undetected in daylight had the landholders not revealed their location.

Pellets were analysed by counting skulls and other skeletal parts, microscopic examination of fur, and comparison with reference material. The minimum number of mammalian prey individuals was determined by counting pairs of lower jawbones. Fragments of insects and spiders were identified by comparison with specimens held in the Queensland Museum. Pellets were mostly fresh and intact although a few were weathered and starting to disintegrate. At the time of pellet collection, the mouse plague was in decline with a small fraction of former numbers remaining (V. York Snr pers. comm. based on trapping results over time).

RESULTS

Attributes of the pellets examined are listed in Table 1. Analysis of the pellets showed that House Mice were the predominant prey item of both kite species (Table 2). Invertebrates, however, were found in the pellets of the Letter-winged Kites (Table 3). The contents of the pellets of both species ranged from fur only (invariably House Mice) to five identifiable individuals in a pellet (5 House Mice or 4 House Mice and 1 dunnart). Most commonly, one animal was found per pellet but frequently two, sometimes three and occasionally more. Adult and young mice were captured. There was no obvious relationship between pellet size and number of mice therein. The results for pellets collected by SJSD confirmed what

TABLE 1. Attributes of pellets from Letter-winged and Black-shouldered Kites examined.

Attribute	*Elanus scriptus*	*E. axillaris*
No. of pellets	716	51
Av. dry mass (g)	1.8	1.6
Pellet length (mm)	16-54	22-50
Pellet width (mm)	11-35	14-28
Av. no. vertebrates per pellet	1.2	1.1

Pettigrew (unpubl. data) had already determined for those particular kites by observation.

TABLE 2. Minimum number of individual prey items (percentage by number) represented in the samples of Letter-winged Kite and Black-shouldered Kite pellets.

Prey items	*Elanus scriptus*	*E. axillaris*
House Mouse	874 (99 %)	56 (100 %)
Sminthopsis sp.	1 (<1 %)	-
Skink sp.	1 (<1 %)	-
Invertebrates	7 (<1 %)	-

TABLE 3. Invertebrates found in Letter-winged Kite pellets.

Order	Family	min. no.	Identifiable remains
Araneae			
Opisthothelae			
Araneomorphae	Lycosidae[a,b]	1	cheliceral base
	Araneidae[a,c]	1	cheliceral base
Orthoptera	Acrididae[d] or Gryllacrididae[e]	3	mandibles
Coleoptera	Curculionidae[f]	1	elytrum, abdominal sternum
Mantodea[g]	?	1	ootheca (egg case)

a. Probable; b. Wolf Spider; c. Orb-weaver spider; d. Locust; e. Predatory Cricket; f. Weevil; g. Mantis.

DISCUSSION

Our sample confirms that the House Mouse is an important component of the Letter-winged Kite's diet during mouse plagues. Furthermore, it is apparent that the kites were breeding successfully on a diet almost exclusively of House Mice, in an extralimital area (also Pettigrew unpubl. data). It seems, therefore, that the House Mouse can sustain the intermittent (if not long-term) occurrence of the kite, though it may provide sufficient prey biomass only during plagues. The Letter-winged Kites were first reported, in print, from the area in April 1993 (Andrew & Eades 1993) and have been sighted periodically within a 10 km radius of the study site from that time until the present (August 1996). It is possible they were present throughout this period, rather than as part of an irruptive occurrence, but went undetected given the nature of the species and the lack of access to much of the region. The breeding event described in this paper is the second within the past 3 years, the first occurring in 1993.

In the week following the initial pellet collection at Dalby in 1995, there were unconfirmed reports to SJSD of Letter-winged Kites appearing at a mouse plague on the Liverpool Plains near Gunnedah, northern New South Wales. It appears, therefore, that dispersing kites readily key in on fresh outbreaks of mice. It would be interesting to monitor the kite's response to the apparently increasing scale and frequency of House Mouse plagues.

Comparison of the diet of breeding Black-shouldered Kites at a site less than 1 km from the two Letter-winged Kite nests examined, shows a similar use of plaguing House Mice for food. Previous studies (Hobbs 1971, Hayward & MacFarlane 1971, Baker-Gabb 1984, Campbell 1986) have shown House Mice to be an important prey item of the Black-shouldered Kite. During this study, the number of animals per pellet was essentially identical for both the kite species, as was pellet size and mass. The crepuscular/nocturnal hunting habits of the Letter-winged Kite and the diurnal/crepuscular hunting habits of the Black-shouldered Kite (Marchant & Higgins 1993) resulted in little difference in diet between the two species.

Baker-Gabb & Pettigrew (1982) suggested that an increased frequency of House Mice in the diet of the Letter-winged Kite in inland areas may influence its potential for increased competition with the Black-shouldered Kite. In the Dalby region, the Black-shouldered Kite is a common species, far outnumbering the Letter-winged Kite at any given time (MTM pers. obs.). Consequently, the former species would consume a greater biomass of available prey in the area. Given that House Mice were in plague proportions during the described breeding events, competition between the Letter-winged and Black-shouldered Kites for House Mice was not possible. Furthermore, several aspects of the ecology of the two species indicate that competition is unlikely even if food was in short supply. Letter-winged Kites occupy a specific habitat, viz. open, shrubby or lightly wooded grasslands of arid and semi-arid Australia (Marchant & Higgins 1993), whereas Black-shouldered Kites use almost all open habitats, particularly in temperate to semi-arid regions. Also, the Letter-winged Kite appears dependent on rodent plagues for its own breeding success whereas Black-shouldered Kites, although apparently rodent specialists (Baker-Gabb 1984), take a greater diversity of prey and are able to breed in non-plague periods (Marchant & Higgins 1993).

The results obtained in this study suggest that during times of mass prey abundance, these two kites can breed successfully in close proximity, consuming the same prey species. Once prey abundance decreases, rapidly in the case of a

declining plague, both the congenerics respond by dispersing, presumably to more productive hunting areas, thus restoring numbers of each species to what would be considered normal (i.e. the Black-shouldered Kite remaining a common species but with reduced numbers and the Letter-winged Kite, a scarce, extralimital species in the area in any case, remaining in only very small numbers or absent completely). Indeed, numbers of both Black-shouldered and Letter-winged Kites in the study site dropped dramatically after they finished breeding and after House Mice had decreased in abundance (MTM pers. obs.).

One aspect of the event at Dalby gives cause for concern for raptors, in particular the Letter-winged Kite, in agricultural areas, namely the mass poisoning of mice and possible secondary effects on them and other birds. House Mice plagued on the Darling Downs in the autumn months of 1995 (Chambers *et al.* 1996) and were the subject of sanctioned broadscale aerial baiting (200 000 ha) by grain laced with strychnine in August/September 1995 (J. Harris and D. Seton pers. comm.). According to local information, the strychnine was applied after the mouse plague was in severe decline and was therefore a futile exercise in control of that plague (V. York Snr pers. comm. based on trapping).

Although not threatened nationally or regionally, the Letter-winged Kite is identified as a species of national conservation concern (Garnett 1993). Furthermore, it is identified as a "major decreaser" in the Western Division of New South Wales (Smith *et al.* 1994). Unnecessary additional mortality should therefore be avoided, if possible, and mouse plagues should be countered with more ecologically sound strategies, if economically viable. Such strategies should use knowledge of the factors precipitating plagues (see Strahan 1995) to avoid conditions conducive to build-up of mouse numbers; encourage the use of 'raptor-friendly' rodenticides such as coumatetralyl (Racumin® by Bayer, see Olsen 1995) at pre-plague stages of the mouse population cycle; and provide raptor foraging perches in treeless, rodent-infested areas (e.g. Kay *et al.* 1994). Chambers *et al.* (1996) suggested that the targeting of refuge habitats of mice during non-plague periods (e.g. fencelines and grassy verge areas, subject to change periodically) may also effect some measure of mouse control, therefore employing less poison over the total affected area. Consequently, a decreased impact on predator species such as the Letter-winged Kite would be expected.

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IS THE SARUS CRANE UNDER THREAT IN AUSTRALIA?

G.R. BERULDSEN

ABSTRACT

It is now thirty years since the Sarus Crane was first added to the Australian list. Very little information has been published on the species since then, and, in the view of the author, some of the material that has been included in Marchant & Higgins (1993) is misleading and requires rearranging. The author is also concerned that there may one day arise a threat to the continued existence of this species in Australia and that this issue be raised and discussed.

INTRODUCTION

Cranes almost world-wide have been under pressure, particularly with habitat loss, and great effort has been expended in some countries on habitat preservation (Archibald & Swengel 1985). This habitat loss pressure led to the disappearance of the Brolga *Grus rubicunda* from some of its former range in Australia and to the extinction of the Sarus Crane *G. antigone* in much of its South-east Asian range, from India to the Philippines. Even the apparently sustainable western populations of the especially large nominate form in India and Nepal are far from healthy. Specifically, at a site in Nepal where there were 1-7 birds per km^2 in 1993, only 4.5% of individuals were juveniles (Suwal 1994); and at Bharatpur in northern India, 18 dead birds in 1988-90 were found in crop fields where aldrin-treated wheat was recently sown (Vijayan 1991).

In the early 1980s Queensland National Parks and Wildlife Service officers collected 60 Sarus Crane eggs from the south-eastern Gulf country and sent them to the International Crane Foundation for eventual reintroduction of the species to South-east Asia. In February 1984 the then National Parks Minister announced the collection of these eggs, saying, "Thousands of sarus cranes were breeding along the Gulf of Carpentaria this year and the collection of eggs posed no threat to the fully protected Australian Crane" (*Courier Mail*, 23 February 1984). Schodde (1988) separated Australian birds as the subspecies *gilliae*, which is smaller then the endangered *sharpei* of South-east Asia. Is this small form of the Sarus Crane in Australia really doing well?

ORIGINAL REPORTS

On 13 October 1966, H.B. (Billy) Gill, E.E. (Eric) Zillman and F.T.H. (Fred) Smith observed some cranes near Glenore Crossing, Norman River, 25 km south of Normanton on the South-eastern Gulf of Carpentaria, that they noted were 'different'. The next day at Wards Lake, 6 km west of Burketown, to the west of Normanton, they saw two more of the 'different' cranes. These 'different' cranes were ultimately identified by these observers as Sarus Cranes and a new species was added to the Australian list (Gill 1969). But where had they come from and how long had they been here? On 29 July 1967, less than a year later, Bruce Cook reported having seen 20 Sarus Cranes at Willets Swamp, 6 km south-west of Atherton, over 480 km east of Normanton (Bravery 1969).

Since 1967 there have been regular reports from the Atherton Tableland, with a few as far south as Ingham, other reports from the centre and east coast of Cape York, and occasional reports from the Top End of the Northern Territory and the Kimberley region of Western Australia. But now, 30 years later, there has been no general expansion of the range of this crane in Australia. They still occur in similar numbers on the Atherton Tableland, arriving usually about July and departing sometime after Christmas, with no breeding records for that area. There are still reports from central and eastern Cape York, the Northern Territory and the Kimberley, but the main breeding population continues to be confined to the wetlands of the south-eastern Gulf region and the west coast of Cape York.

The closely related Brolga is found over most of the northern and eastern halves of Australia as far south as south-western Victoria and south-eastern South Australia. Having in mind that the Brolga and the Sarus Crane share the same habitat in the Gulf country, and on the Atherton Tableland, one is left to contemplate the sudden discovery of Sarus Cranes in 1966-67 followed by no apparent further expansion in their range. Perhaps they were always in the wetlands of the south-eastern Gulf and western Cape York, going unnoticed until 1966 when three astute observers took a second look at some 'Brolgas'?

IDENTIFICATION

At a casual glance, and certainly at a distance, the two species are very similar and one has to look carefully or get a close look in the non-breeding season to see the red collar and the pink legs of the Sarus Crane. In the breeding season, in my experience, the red of the head and the collar of the Sarus Crane becomes much brighter and develops a gloss, while the legs change from pinkish to bright shiny red. But then of course the legs are hard to see, for the birds are usually found in well-grassed areas or in swamps where one's view of the legs is either fully or partially hidden. In their original report, Gill, Zillman and Smith say "A cursory distant view of the birds, both flying and standing, had given the impression that they were Brolgas. ... at the time we took the birds to be an undescribed form of *G. rubicunda*". One has to wonder how many previous birdwatchers did just that, with what is a relatively common bird, and failed to follow up, unlike these three diligent observers who went to the Melbourne

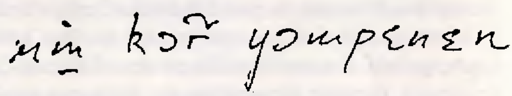
Zoo then later went back to Normanton to confirm their observations.

On the matter of their calling (trumpeting), Hugh Lavery in Frith (1976) says that the call is different and readily distinguishable from that of the Brolga. I have never found this to be so. In fact I have never been able to readily distinguish the trumpeting of Brolgas from the trumpeting of Sarus Cranes. Gill, Zillman and Smith share that view, saying "no obvious differences in trumpeting call" (Gill 1969). If one listens to tape-recordings of the trumpeting of these two species (*A Field Guide to Australian Birdsong, cassette 3 - Bird Observers Club*) it is difficult to pick a difference, bearing in mind that the tapes are not a comprehensive record of all the trumpeting calls of the two species.

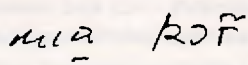
OBSERVATIONS

In 1977, subsequent to a response to an enquiry about cuckoos, the author was told that the Aborigines at Aurukun, on the west coast of Cape York, have a separate name for the Sarus Crane or, as they called it in English, the Red-legged Brolga (J. von Sturmer pers. comm.). Hereunder, in the handwriting of von Sturmer, are the two names, written by von Sturmer on 3 February 1977. The first name is the aboriginal name for the Red-legged Brolga or Sarus Crane as we know it, and the second name is the Aboriginal name for the Brolga. The O is an open O and the R is a trilled R.

Red-legged Brolga



Brolga



The fact that the Aborigines had a separate name for what they called the Red-legged Brolga seems to the author a good indication that the species had been in the area for a long time, probably many generations. J. von Sturmer went on to tell the author that the local Aborigines regarded the flesh of the Red-legged Brolga as much superior to the flesh of the Brolga.

In the late 1800s, Normanton was a trading post with a population of some 500 and a "floating stream of visitors constantly going to and fro" (Gunn 1995), yet there are few reports on the birds of that area. In fact that remained the situation until the mid 1900s. However, in 1857, Mr T.A. Gulliver reported Yellow Chats *Epthianura crocea* from Normanton (Serventy 1982), so there was someone in the area interested in birds and someone who knew the significance of his Yellow Chat observation. Nevertheless there appears to be no record by Gulliver of Brolgas or Sarus Cranes from an area where both are now reasonably common. Perhaps Brolgas were too common a bird at the time and he did not see the need to report them, or perhaps also, like others, he did not notice the difference between the two cranes or thought that they were just two colour phases of the one species.

In the years 1987, 1988 and 1989, the author had the opportunity on a number of occasions to speak with 'old-timers' at Normanton and to sit and listen to their stories, so learning that they knew of the Red-legged Brolga, as they called it, in their early years (1920-1930). It was apparently thought by some locals at the time that this Red-legged Brolga was simply a fully mature male Brolga.

DISCUSSION

It seems likely that the Sarus Crane may always have been a resident species in the wetlands of the south-eastern Gulf and the west coast of Cape York, and that these are the only parts of Australia which suit its breeding requirements. If this were not the case then why are there no breeding reports from the Atherton Tableland, the Northern Territory, the Kimberley or other parts of Cape York? On the matter of breeding, the current literature is, in my opinion, rather confusing. In Marchant & Higgins (1993) there is a heading 'Distribution and Population', with a sub-heading (page 482) 'Breeding'. Under that sub-heading there appears the following comments: "Strathgordon and Strathmay, adult with juvenile, 1 July 1981 (Aust. Atlas); Coen Airstrip, one pair, 23 Oct. 1981 (Aust. Atlas); Karumba, two adults and one immature, 11 Aug. 1978 (Aust. Atlas)". I submit that none of these are records of breeding for the areas indicated. For instance the record sheet for Coen (record no. 99776) says: "2 adults plus 2 immature fully grown young".

A further comment in Marchant & Higgins (1993), under the heading 'Breeding' on page 483, can, in my opinion, be misleading. The text says "mean laying date of first egg, 22 Jan", without any comment. The Sarus Crane breeds in the wet season and needs suitable wet season conditions. In the Gulf and western Cape York, wet seasons are notoriously fickle, both in the months in which they commence and in the volumes of rainfall (see schedule of rainfall hereunder, courtesy Bureau of Meteorology, Queensland). It can be seen from this schedule that 'the wet' sometimes commences as early as November (1973) or as late as February (1991), and occasionally fails to develop (1982). These variations have a dramatic effect on the preferred nesting habitat of the Sarus Crane, so that January cannot be relied upon to be the mean egg-laying period.

Under the heading 'Movements' in Marchant & Higgins (1993) there is a statement: "... congregate in flocks soon after chicks fledge in Apr-May; flocks

Bureau of Meteorology
Listing of Monthly Rainfall for Normanton

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
1966	0.0	0.0	0.0	10.9	31.0	31.1	105.5	168.4	138.5	4.6	0.0	72.4	
1967	0.0	0.0	0.0	0.0	42.0	47.3	298.6	194.9	55.7	89.4	38.6	0.0	
1968	1.8	0.0	0.0	0.6	1.8	33.8	120.9	140.3	162.3	0.0	6.1	4.6	
1969	4.3	0.0	0.0	7.1	20.5	221.4	51.2	92.8	174.2	51.6	0.0	0.0	
1970	0.0	0.0	15.1	1.3	2.5	163.5	47.0	254.6	255.5	82.6	22.3	0.8	
1971	0.0	0.0	0.0	19.5	16.0	132.1	268.3	325.2	248.7	0.0	0.0	3.0	
1972	0.0	0.0	0.0	10.9	67.4	38.3	186.4	317.9	150.3	21.7	0.0	0.8	
1973	0.0	0.0	63.3	0.0	232.4	231.0	965.1	288.9	358.8	0.0	1.8	0.0	1974
1974	0.0	14.2	14.4	0.0	4.3	204.0	215.1	251.8	53.8	16.5	0.0	0.0	Flood
1975	0.0	0.0	12.0	70.8	17.7	236.0	494.2	481.5	71.7	0.0	1.6	0.0	
1976	0.0	0.0	0.0	0.1	7.9	192.0	168.0	385.1	245.5	101.9	0.8	0.0	
1977	0.0	0.0	0.0	28.0	68.7	98.1	225.9	84.0	13.5	11.8	0.3	0.6	
1978	10.1	0.0	10.0	1.8	49.4	36.1	246.8	335.3	296.5	39.6	0.4	0.0	
1979	0.0	0.0	0.0	0.9	0.1	142.8	219.6	251.3	108.4	23.6	3.4	0.0	
1980	0.0	0.0	0.0	2.8	25.2	135.5	545.0	166.2	35.0	27.6	36.2	5.2	
1981	7.0	0.8	0.0	12.5	43.2	130.6	81.4	140.8	177.2	12.0	0.0	0.6	
1982	0.0	0.2	0.0	0.0	1.4	79.4	42.0	41.2	212.2	77.4	34.4	0.4	
1983	0.0	0.0	0.0	0.2	22.4	61.2	288.4	246.2	152.4	3.2	0.0	0.4	
1984	1.6	0.0	0.0	0.2	25.2	81.0	145.2	183.6	220.2	4.6	0.0	41.4	
1985	4.4	0.0	0.0	24.0	66.5	101.2	228.4	131.2	24.2	46.8	16.0	0.4	
1986	3.6	0.0	10.6	78.8	26.2	147.9	155.5	204.2	135.2	34.0	0.0	0.0	
1987	0.8	0.0	1.4	3.9	72.6	167.2	61.6	173.4	3.7	7.2	0.6	0.0	
1988	0.0	0.0	2.6	0.0	33.1	319.7	61.6	268.1	263.0	14.1	0.6	0.6	
1989	0.0	0.0	0.0	6.8	98.4	140.8	47.8	11.6	257.6	49.3	25.0	53.0	
1990	5.7	0.0	0.0	0.0	20.0	44.9	844.7	509.6	11.2	30.0	0.0	0.0	1991
1991	0.0	0.0	0.0	2.8	20.0	66.8	72.9	213.5	74.0	0.0	13.0	0.0	Flood
1992	0.0	0.0	6.2	23.0	6.2	157.3	135.1	311.4	100.2	0.0	0.0	0.0	
1993	21.8	0.0	0.0	0.0	132.3	144.6	254.7	66.6	166.6	0.0	0.0	0.0	
1994	0.4	0.0	0.0	0.0	93.7	124.4	147.2	228.0	149.2	0.0	6.8	0.0	
1995	0.0	7.6	0.0	2.8	34.1	40.2							

then disperse". That accords with my experiences, and the likelihood is that the Strathgordon, Strathmay and Coen sightings were after dispersal from Gulf wetland breeding areas and are not breeding records in their own right. Unfortunately they go further, still under the sub-heading 'Breeding' (p.482), and refer to "population and range expanding". It seems to me that the whole of this paragraph should be positioned directly under the heading 'Distribution and Population' and not under the sub-heading 'Breeding', for the comments have nothing whatever to do with breeding.

Blakers *et al.* (1984) make the statement: "Since its recognition in Australia the Sarus Crane has spread rapidly and the population appears to be still expanding". The author has serious doubts that this is in fact the case. Certainly there has not been the rapid expansion that occurred with the Cattle Egret *Ardea ibis* (see Blakers *et al.*, 1984). It seems more likely that the Sarus Crane had simply been overlooked, as had the Hall's Babbler *Pomatostomus halli* and the Grey Grasswren *Amytornis barbatus*, until an astute observer took a second look and became curious, as did Gill, Zillman and Smith (Gill 1969).

If one looks at the early records of the Sarus Crane (Bravery 1969, Gill 1969) one finds the following:

Oct 1966	:	First siting near Normanton, Gulf of Carpentaria
Jul 1967	:	20 then 23 reported at Atherton Tableland
Aug 1968	:	85 reported at Atherton Tableland
Jul 1969	:	34 reported at Atherton Tableland
Sep 1969	:	72 reported at Atherton Tableland
Aug 1970	:	350 reported at Atherton Tableland

Although these figures do indicate a rapid rise in numbers the author is nevertheless of the opinion that the figures only represent correct identification and stimulation of interest in a bird not long on the Australian list. If that were not so, one would have expected a significant increase in numbers and a significant expansion of range in the 26 years since 1970, and that has not occurred. There are no published reports that would indicate such a rise, especially not the rapid rise evident in the above figures.

It is the author's experience that the Sarus Crane is much more particular with its selection of a nesting site than is the Brolga. Generally speaking, although nesting habitats are superficially similar, the Sarus Crane seems to prefer surrounding cover, in particular trees, in their chosen swamp or wetland, whereas the Brolga is much more likely to select wide-open areas. For instance, in February 1996 two Sarus Crane nests were located from a helicopter, one at the base of a tree in knee-deep water and the other in the shade of a tree, again in water. Both nests held a single egg that appeared when tested in the water to have been partly incubated. Walkinshaw (1973) reported that 27 of 34 nests were by the trunk of a tree or in the shade of a tree. It is also the author's experience, at least outside the breeding season, that when disturbed, the Sarus Crane is much more likely to walk away amongst the trees or bushes than to fly off as does the Brolga. The Sarus Crane has an extraordinary ability to keep a tree of bush between it and an observer, making photography very difficult.

CONCLUSION

If it is the case that the Sarus Crane has a relatively small preferred breeding area then diligence will have to be exercised to ensure that these areas are not affected, especially by alteration to the preferred wetlands or the draining of or excessive irrigation from the rivers that feed those wetlands (the Nicholson, Albert and Leichhardt Rivers in the west, east to the Flinders and Norman Rivers, then north to the Gilbert, Staaten, Mitchell, Edward and Archer Rivers). Another threat may well come from the spread of the introduced Rubber Vine *Cryptostegia grandiflora* that is smothering parts of the south-eastern Gulf region. If the Rubber Vine were to overrun the swamps in which the Sarus Crane prefers to breed then there could well be a risk to their continued existence in Australia.

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THE BEHAVIOUR OF POWERFUL OWLS *NINOX STRENUA* IN REDWOOD PARK, TOOWOOMBA

PATRICK J. McCONNELL

INTRODUCTION

Redwood Park is 197 ha of bushland situated below the escarpment of the Great Dividing Range on the eastern outskirts of Toowoomba. The park contains a diversity of vegetation types ranging from open forest to semi-notophyll vine forest. Vine forest occupies about 30% of the park, which is dissected by Gatton Creek.

The Powerful Owl *Ninox strenua*, classified as rare (Garnett 1992), was first recorded in the park on 10 October 1976 by R. Hobson. An individual bird was seen perched along Gatton Creek near the entrance to the park. Pairs, individual birds and young have been recorded regularly until January 1995. Redwood Park is one of two locations along the Toowoomba escarpment where Powerful Owls have been found. The other location is Glen Lomond Park where a single bird was heard on 22 March 1991 by R. Hobson and P. McConnell.

METHODS

Information has been obtained from newsletters of the Toowoomba Bird Observers from October 1976 to September 1996 and from observations by the author from August 1982 until September 1996. Pellets were collected for diet analysis on two occasions by the author (10 October 1993 and 10 January 1995), on two occasions by C. Dollery (29 August 1993 and 16 September 1993), and on one occasion by R. Hobson (6 August 1992). Ten pellets were collected in all. Prey items were identified from bones, with comparisons made with specimens at the University of Southern Queensland's reference collection. Other dietary information was obtained from observations of the birds holding prey at daytime roosts. In all, over 100 trips have been made into the park by the author, including more than 20 spotlighting forays. On most occasions, two 50 watt, 12 volt spotlights were used for one and a half to three hours.

All vegetation types were sampled, with emphasis being placed on the vine forest and adjacent open forest areas near known roost sites. However, ten trips were made to the more open forest areas away from known roost sites.

RESULTS

In all there have been 31 sightings of the Powerful Owl within Redwood Park. These included 16 by the author and 15 by other members of the Toowoomba Bird

Observers (Table 1). There was no date recorded for one of these sightings.

TABLE 1. Monthly sightings of Powerful Owls in Redwood Park.

Month	J	F	M	A	M	J	J	A	S	O	N	D
No. of sightings	4	1	2	3	0	1	1	3	0	6	3	6

Breeding

The Powerful Owl's nest has never been found in Redwood Park. Adults have been recorded roosting together on three occasions. On one occasion, on 10 April 1993, an adult male and adult female were observed roosting approximately 40 cm apart on the same branch, 11 m above ground level. This behaviour indicates that breeding is imminent (Holland 1991, McNabb 1996). Eggs are usually laid during the period from mid-May to mid-June (Holland 1991, Pavey *et al.* 1994). Young were seen in 1984, 1992, 1993, 1994 and 1995, with juvenile birds being observed on seven occasions from early October to early January. In all cases where breeding occurred only one young was observed and all young have been of adult size with varying amounts of down. A juvenile bird was found dead on 19 October 1993 by D. Gaydon.

Roosting

Powerful Owls are known to use numerous roost sites (Pavey *et al.* 1994). The birds at Redwood Park have never been known to use the same roost site for extended periods of time, and at least eleven different sites have been found. The greatest distance observed between roost sites is 1100 m and roosting has been observed from ground level (a juvenile bird) to approximately 15 m up. The lowest an adult bird has been seen roosting is 3 m. The many large, emergent eucalypts in the thicker gullies do not appear to be used, birds apparently preferring the lower trees with thicker foliage. Roosting has always been observed in the thicker gullies in the vine forest and never in the open forest areas nearby. Of thirty dated observations, only five were during the period from May to September.

On one occasion, in August 1993, a bird fitting the description of a Powerful Owl was observed by a bushwalker to fly out of a small cave (C. Dollery pers. comm.). On inspection, on 26 August 1993 and 16 September 1993, six pellets were collected from this cave. John Young, a wildlife consultant specialising in nocturnal birds, verified these as Powerful Owl pellets. The cave is 70 cm high, 120 cm wide and 100 cm deep. A juvenile was observed roosting on top of this cave on 22 November 1993 (R. Roberts and N. Thompson pers. comm.).

Diet

Details of diet were determined from the contents of the ten pellets collected from under roost sites and in the cave. Prey items included Black Rat *Rattus rattus* (five), Yellow-footed Antechinus *Antechinus flavipes* (two), bandicoot sp.(one), Common Brushtail Possum *Trichosurus vulpecula* (immature) (one), Squirrel Glider *Petaurus norfolcensis* (one) and Pied Currawong/Australian Magpie (one). Prey remains held by the owls at daytime roost sites included Australian Brush-turkey *Alectura lathami* (immature) (two), Common Ringtail Possum *Pseudocheirus peregrinus* (one)and Grey-headed Flying-fox *Pteropus poliocephalus* (one). On several occasions Powerful Owls have been recorded approximately 350 m outside the park in suburban back yards (R. Viljoen pers. comm.). Prey may at times be caught here.

Spotlighting in the park produced the following mammal sightings (within the range of the Powerful Owl's diet): Yellow-footed Antechinus, Northern Brown Bandicoot *Isoodon macrourus*, Long-nosed Bandicoot *Perameles nasuta*, Koala *Phascolarctos cinereus*, Common Brushtail Possum, Mountain Brushtail Possum *Trichosurus caninus*, Common Ringtail Possum, Fawn-footed Melomys *Melomys cervinipes*, House Mouse *Mus musculus*, Black Rat and Grey-headed Flying-fox. Squirrel Gliders have never been seen while spotlighting. Northern Brown Bandicoot and Common Brushtail Possum were the most common mammals seen.

DISCUSSION

Paired roosting behaviour and observations of fledged young would indicate egg laying around early June. Lavazanian *et al.* (1994) mention that adults are more difficult to find in autumn. This is certainly the case at Redwood Park, where only eight of the thirty dated observations were during the cool April -September period.

In all cases where breeding has been recorded only one young has been observed. The remains of an immature bird found in a creek bed on 19 October 1993 may well have been the young bird of the previous year. The age of the remains confirmed that it was not the young of 1993, and if it had been from the 1991 season the remains would not still have been in the creek bed due to rain that year. The latest month in the breeding season that a young bird has been observed in the park was January.

Observations of the diet of Powerful Owls at Redwood Park are limited. Prey varied in size from Yellow-footed Antechinus to Common Ringtail Possum, immature Common Brushtail Possum and immature Australian Brush-turkey. Pavey *et al.* (1994), in a detailed analysis of the diet of Powerful Owls at Mt. Coot-tha, did not record Black Rat, Yellow-footed Antechinus or any bandicoot species as prey items. Black Rat and Long-nosed Bandicoot have been recorded by Chafer (1992).

The work of James (1980), Lavazanian *et al.* (1994), Pavey (1994), Pavey *et al.* (1994) and Tilley (1982) clearly indicates that ground dwelling prey is rarely taken. The small amount of dietary data obtained from the Redwood Park birds indicates that ground dwelling prey may be more important here than at these other sites. Black Rat, Yellow-footed Antechinus (a semi-arboreal species) and bandicoots are rarely taken by Powerful Owls elsewhere, and at Redwood Park this may have been in response to feeding a young bird in drought conditions when arboreal prey may have been scarce.

Work done by Pavey *et al.* (1994) led to the inference that Powerful Owls hunt in suburbs adjacent to forested areas as well as the forested areas themselves. A Powerful Owl observed on several occasions by R. Viljoen perched and called in his yard which is adjacent to Redwood Park. The Powerful Owls at Redwood Park may also hunt in suburban areas near the park where roadkill data (P. McC. pers. obs.) show Common Ringtail Possum, Common Brushtail Possum and Northern Brown Bandicoot to be common.

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A SECOND RECORD OF A PAPUAN SPECIES OF PARADISE-KINGFISHER IN TORRES STRAIT AND ITS RELEVANCE TO THE DISSEMINATION OF JAPANESE ENCEPHALITIS

STEPHEN GARNETT and RANDAL SMITH

In February 1978 a paradise-kingfisher *Tanysiptera* sp. with a white breast was seen on Darnley Island in eastern Torres Strait after a period of strong north-westerly gales (Draffan 1978). It was identified as a Common Paradise-Kingfisher *T. galatea* but the record was not accepted by the RAOU Records Appraisal Committee (Anon. 1988) on the grounds that the species is largely sedentary in lowland rainforests (Bell 1980) and that, despite the weather, the bird could have been brought to Darnley Island by Papuan fishermen and released (R.D.W. Draffan pers. comm.). It is also remotely possible that the bird was a Little or Aru Paradise-Kingfisher *T. hydrocharis* from which the Common Paradise-Kingfisher differs only in size and for which there are a small number of records from southern New Guinea (Beehler *et al.* 1986, Fry & Fry 1992). This note reports a second record of a white-breasted paradise-kingfisher from Torres Strait, which suggests that the first record was likely to have been the result of natural vagrancy.

At sunrise on 15 March 1993 a paradise-kingfisher with a white breast was sighted by the second author on Stephens Island, an island of 53 ha in eastern Torres Strait, 55 km from Papua New Guinea and 25 km from Darnley Island. The island is, like Darnley, volcanic in origin and largely covered with evergreen coastal scrub dominated by Indian Almond *Terminalia catappa* and Coconut *Cocos nucifera*. Clear views were obtained of the bird which was perched for 2-3 minutes 20 m away on a low vine hanging horizontally across an unused path. A pink bill, white breast, blue upperparts and long tail feathers were noted. At the time of the sighting the wind had been blowing from the north or north-west. There had been no visits from Papuan fishermen in the previous 15 months. It is highly unlikely that the kingfisher would have been overlooked had it been present for that long. The bird was not seen again, suggesting that it had either flown on or died.

This second record of a white-breasted paradise-kingfisher on Australian territory was in the same region of Torres Strait and at the same time of year as the first, 14 years previously. This suggests that these paradise-kingfishers do indeed occur as vagrants on Torres Strait islands during the wet season when winds blow from the north-west.

The observation is also relevant to the transmission of disease from New Guinea into Australia. In March 1995 an outbreak of Japanese Encephalitis occurred on several islands in Torres Strait (Hanna *et al.* 1995). Both mosquitoes and birds, principally herons, can be vectors for the disease and there has been debate about its most likely source in Australia (Bell *et al.* 1995). The record of a wind-blown rainforest kingfisher on Stephens Island, where the Japanese Encephalitis was also recorded (M. Bell pers. comm.), suggests that it is also possible for mosquitoes to be blown there from New Guinea. Given the scarcity of active bird migrants, particularly herons, landing on Stephens Island (Draffan *et al.* 1984), and the occurrence of the disease only in the northern islands of Torres Strait (J. Hanna pers. comm.), mosquitoes are thus the most likely vector of the disease during the 1995 outbreak.

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