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CHANGES IN THE RELATIVE ABUNDANCE OF RAPTORS AND HOUSE MICE IN WESTERN NEW SOUTH WALES

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In western New South Wales, the relative abundance of both diurnal birds of prey and house mice was monitored at frequent intervals over a three-year period. The abundance of mouse-eating raptors was positively correlated with that of house mice, and these birds appeared to be responding to changes in mouse abundance. This suggests that the role of birds of prey should be considered in future control strategies for rodent pests.

INTRODUCTION

Recently, it has been demonstrated that raptors (birds of prey) are able to regulate house mouse *(Mus domesticus)* populations in rural Australia, at least when mouse numbers are low to moderate (Sinclair *et al* 1990; Kay *et al* 1994). As part of an investigation of the biology, ecology and control of house mice in and around irrigated summer crops in western New South Wales, we undertook a three year live-trapping survey of house mice in a variety of habitats associated with this agricultural system. To gain a more complete understanding of this ecosystem, changes in the relative abundance of diurnal birds of prey were also included as part of the study. Because of increasing concerns regarding the use of rodenticides in agriculture, it is becoming increasingly important to examine, and where possible enhance, the potential of 'natural' control agents for pest species.

This paper presents data on changes in the relative abundance of diurnal raptors along a permanent riparian transect situated in the center of this irrigated cropping system, and compares these to changes in mouse abundance for those raptor species whose diet includes house mice. We also compare the abundance of diurnal raptors along part of the route travelled to the mouse survey sites which included little (reduced) irrigated summer crop landuse with that found for the riparian transect.

STUDY AREA AND METHODS

The mouse survey sites were located near Trangie (31°59′S, 147°57′E; altitude 215 m) in the Macquarie Valley, New South Wales, where various summer crops are irrigated from the Macquarie River (see Kay *et al.* 1994 for details).

Trapping and Abundance Indices For House Mice

The live-trapping censuses used permanent trap grids which generally comprised 24 Elliott traps, in a 4 × 6, 2 × 12 or 1 × 24 pattern with 10 m spacing providing an effective trap area of approximately 0.24 ha. However, on some occasions at the beginning and end of these surveys, trap grids were bigger with 50 to 100 traps at 10 m spacings. Trapping was undertaken for three consecutive nights every 4–6 weeks for the 13–14 sites surveyed. When comparing mouse abundance between trap sessions, the proportion of traps with captures was averaged for each site, and an index of abundance was calculated for each session using a frequency-density transformation (Caughley 1977).

Relative Abundance of Raptors

The raptor surveys were conducted using road transect counts from September 1989 to July 1991. The advantages and disadvantages of road counts are discussed by Fuller and Mosher (1987). The same two counters (LET and BJK) were used throughout the surveys. Counts were made by eye and recorded using Bird of Prey (BOP) recording sheets provided by David Baker-Gabb. Stops were made to confirm bird identity (with binoculars if necessary), but any 'new' sightings at such times were excluded.

Diurnal birds of prey were surveyed along a permanent transect in the center of our mouse study site, and along the highway between Dubbo and the field sites near Trangie. The permanent riparian transect (Austin/Twynam — 54 km) in the centre of the mouse survey area was approximately equally distributed on the north and south sides of the Macquarie River. These counts were made between 0900 h and 1700 h. Two routes were used for the Dubbo to Trangie/Study Site transect: 1 — via Dubbo, Narromine and Trangie (64 km and 19% of the DTSS counts), and 2 — via Dubbo, Narromine and then along the Macquarie River direct to the field sites which were 16 km north of Trangie (total length 77 km and 81% of the DTSS counts). Counts along this transect were conducted between 0900 h and 1230 h on the outward journey and 0900 h and 1700 h on return.

Changes in the relative abundance of Laughing Kookaburras *(Dacelo novaeguineae)* should be influenced less by changes in mouse abundance than mouse-eating raptors, and the former species was therefore included in all counts as an 'out group'. In addition, all raptors and kookaburras observed while working in the study area, but excluding those sighted on the permanent transects, were recorded separately as 'other observations'.

Counts were standardized to birds seen per 100 km. Each time a transect was traversed on either the outward or return trip, it was considered a separate count. Means were calculated for each transect for each season using all survey data collected for each calendar month.

RESULTS AND DISCUSSION

Changes in Mouse abundance

The mouse surveys were conducted from March 1989 to June 1991 and involved almost 30 000 trap nights over three summer crop seasons which resulted in 3 568 mice being caught at least once. Mouse abundance in all habitats generally peaked around March/April (autumn) in each year and then declined to relatively low levels by the end of spring. Mouse numbers were also considerably greater in 1990 than any other year (Fig. 1). Winter abundance of mice (37 mice per 100 trap nights; adjusted) was also relatively high in 1989.

Changes in Raptor Abundance

Ten species of raptor were observed during the surveys (Table 1). Australian Kestrels *Falco cenchroides* (48.5%), Black-shouldered Kites *Elanus notatus* (32.5%) and Brown Falcons *Falco berigora* (9.0%) accounted for 90 per cent of all observations with a further seven species being observed at relatively low frequencies (Table 1). There was one diurnal record for a Southern Boobook Owl (*Ninox novaeseelandiae*). No additional species were recorded during our daily activities at the study site (other observations — Table 1), indicating that we were seeing all

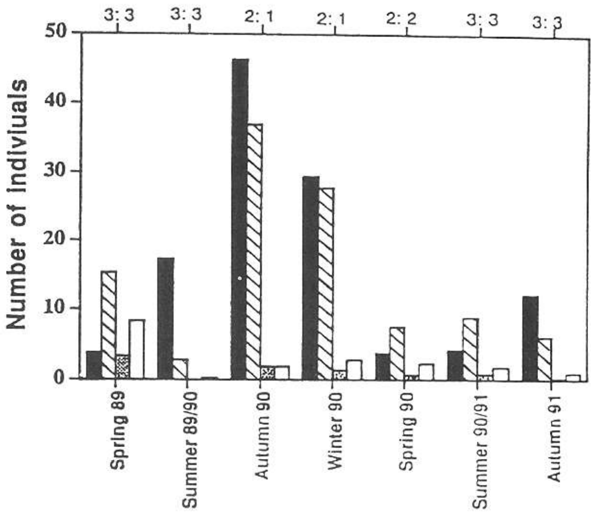

Figure 1. *Changes in the relative abundance of house mice,* Mus domesticus *(indexed as adjusted numbers per 100 trap nights), diurnal birds of prey, and Laughing Kookaburra's (birds per 100 km) observed over the three year survey period at the mouse study area.* Legend: solid, *house mice;* striped, *raptor species known to feed on house mice (Australian Kestrel, Black-shouldered Kite, Brown Falcon, Black Kite, Australian Hobby, Black Falcon);* stippled, *other non-mouse-feeding diurnal raptors (Swamp Harrier, Little Eagle, Wedge-tailed Eagle, Australian Hobby, Peregrine Falcon);* clear/open, *Laughing Kookaburras. Data are means with the number of months used for each season shown at the top of the graph for house mice and birds, respectively. Depending upon climatic conditions, for mice there were between 13 and 20 sites trapped each month. For birds, each month included at least one outward and return journey census.*

species of diurnal raptors present when travelling the permanent transects. Australian Kestrels, Black-shouldered Kites and Brown Falcons were also the most recorded birds of prey during road counts for a 13 month period, commencing in December 1979, in the Murrumbidgee Irrigation Area of New South Wales (Davey and Fullagar 1986), which is approximately 350 km south-west of our study site.

The abundance of mouse-eating raptors generally followed that of house mice on the study area (Fig. 1). Considering the mouse-eating species only (indicated in Table 1; Barker and Vestjens 1979) for the Austin/Twynam riparian transect in the centre of our mouse trapping sites, there was a positive correlation between the number of raptors seen and mouse abundance ($n = 16$, $R^2 = 0.42$, $P < 0.01$). There was no correlation

TABLE 1

The number and percentage of each species observed for the two transects; Dubbo to Trangie (77 or 64 km, depending upon route) and the Austin-Twynam transect (54 km). Other observations, recorded near the irrigation blocks throughout each trip but excluding those for the transects, are also shown. *= Species known to eat mice.

Species	Dubbo/Tran n	%	Aust/Twynam n	%	Other Obs n	%	Total n	%
Survey period	Sep. 89–Jul. 91		Oct. 89–Jul. 91		Nov. 89–Jul. 91			
Swamp Harrier *Circus approximans*	2	0.7	1	0.4	3	0.4	6	0.5
Black Kite* *Milvus migrans*	5	1.8	9	3.5	30	4.2	44	3.5
Little Eagle *Hieraaetus morphnoides*	1	0.1	0	0	5	0.7	6	0.5
Wedge-tailed Eagle *Aquila audax*	4	1.4	10	3.9	17	2.4	31	2.5
Black-shouldered Kite* *Elanus notatus*	102	36.8	77	30.3	224	31.6	403	32.5
Black Falcon* *Falco subniger*	3	1.1	7	2.7	9	1.3	19	1.5
Brown Falcon* *Falco berigora*	15	5.4	23	9.1	74	10.4	112	9.0
Australian Kestrel* *Falco cenchroides*	140	50.5	124	48.8	336	47.4	600	48.5
Australian Hobby *Falco longipennis*	0	0	1	0.4	1	0.1	2	0.2
Peregrine Falcon *Falco peregrinus*	0	0	0	0	1	0.1	1	0.1
Unidentified Raptor	4	1.4	2	0.8	9	1.3	15	1.2
Total Raptors	276	—	254	—	709	—	1 239	
Kookaburra* *Dacelo novaeguinea*	69	—	57	—	101	—	227	

between the abundance of house mice with that of Laughing Kookaburras ($n = 16$, $R^2 = 0.03$, $P > 0.5$) or other diurnal raptors ($n = 16$, $R^2 = 0.00$, $P > 0.8$) (Fig. 1). The abundance of Kookaburras and other diurnal raptors remained relatively static throughout the survey period, fluctuating from 0 to 10, and 0 to 6 birds per 100 km respectively.

The Dubbo to Trangie transect was included in the surveys for comparison between areas with and without extensive irrigated summer crop landuse. This transect commenced some 100 km east from the mid-point of the Austin/Twynam transect, and for much of its length (approx. 45 of 77 km), it did not include areas surrounded by irrigated summer crops. Furthermore, throughout our survey period, economic losses attributed to house mice were mainly restricted to irrigated summer crops in western New South Wales Twigg unpubl. data). The total autumn abundance of diurnal mouse-eating raptors for this transect was less than that of the Austin/Twynam transect ($\chi^2 = 17.81$, d.f. = 1, $p < 0.0005$), as peak abundance for the Dubbo/Trangie transect occurred later in the winter months (Figs 1 and 2). The maximum in mean abundance of these raptors was also much less on the Dubbo/Trangie transect (21 birds per 100 km) compared to that of the Austin/Twynam transect (37 birds per 100 km). These trends support the suggestion (Davey and Fullagar 1986) that in western New South Wales mouse-eating species respond to changes in mouse abundance. The mean abundance of the mouse-eating species in winter 1990 was similar between the two transects (Figs 1 and 2). The total abundance of mouse-eating species observed during the 1990 autumn and winter surveys for the Austin/Twynam transect was also similar ($\chi^2 = 0.77$, d.f. = 1, $p > 0.40$).

Whether the above observations represent a real change in abundance, as reported for Black-shouldered Kites in Victoria (Baker-Gabb 1984), or differences in activity or sightability could not be ascertained. Observations were often greater in the cooler months of our surveys (Figs 1 and 2). There was also a major episode of flooding over much of Western New South Wales in autumn/winter 1990, with extensive flooding at our sites. While the short-term effects of these floods on mouse abundance were minimal (Twigg and Kay 1992), they restricted access to the Austin/Twynam raptor transect and our trapping grids for some sampling periods, and these floods may have also influenced the sightability and activity of birds of prey at this time.

House mice have been reported to constitute 95 per cent and up to 19 per cent of the diet of Black-shouldered Kites and Brown Falcons, respectively, at Werribee, Victoria (Baker-Gabb 1984). Barker and Vestjens (1979) also indicate the importance of house mice in the diet of the three most abundant species we observed. It has been suggested that some raptor species do respond to mouse plagues (Haywood and MacFarlane 1971; Hobbs 1971; Davey and Fullagar 1986), but these studies generally lacked direct information on mouse abundance and/or on the abundance of raptors when mice are scarce. If raptors are responding to changes in mouse abundance as our and other studies suggest (Davey and Fullagar 1986; Sinclair *et al* 1990; Kay *et al* 1994), then the question arises as to whether they can regulate mouse populations sufficiently to be effective biological control agents. Given the current trend away from the use of chemicals in agriculture, utilizing birds of prey as natural control agents for house mice has much appeal (see Kay *et al* 1994).

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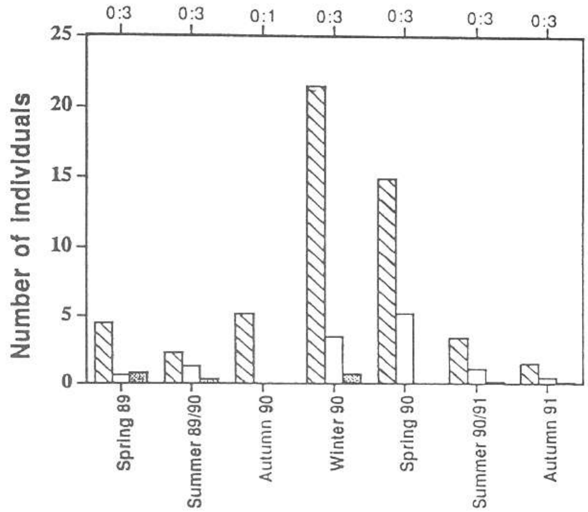

Figure 2. *Changes in the relative abundance of diurnal birds of prey and Laughing Kookaburras (birds per 100 km) for the Dubbo to Trangie transect (approx. 70 km) outside the mouse study area. Legend as for Figure 1.*

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