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EFFECTS OF DAM SIZE ON WATERBIRDS AT FARM DAMS IN SOUTH-EAST QUEENSLAND

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Waterbirds were counted on 10 farm dams (1.2 to 25 × 10^3 m^2 maximum surface area) in south-east Queensland on 20 days from May 1980 through October 1982. Dams were 10 to 30 years old. Seventeen species (3 960 observations) of openwater birds and 14 shoreline species (224 observations) were observed. More than 2.3 individuals of each of Australasian Grebe, Pacific Black Duck, Grey Teal, Hardhead and Eurasian Coot were observed per dam per day, but only 0.3 individuals of Black-winged Stilt, the most numerous shoreline species.

Number of species increased linearly with logarithm of maximum surface area of dams, implying that a maximum area of at least 10 000 m^2 was necessary to consistently attract most of the common waterbird species of the region and that few additional species occurred as area exceeded 10 000 m^2. Number of individuals increased linearly with increase in maximum surface area: one individual was observed for each 260 m^2 of maximum water surface. Numbers of species were also correlated, less strongly, with maximum depth.

INTRODUCTION

Sub-coastal southern Queensland and northern New South Wales have a rich diversity of waterbirds (Gosper 1981; Woodall 1985; Leach and Hines 1987). The richness of one dam, Minden Dam, was attributed to both the diversity of aquatic habitat and its ability, through permanence, to function as a local refuge when nearby shallower dams and ephemeral swamps dried (Leach and Hines 1992). Minden Dam was excavated over 100 years ago for community needs. Many farm dams in south-east Queensland are smaller; most are less than half its age. Furthermore, farm dams are usually in grazed paddocks, with livestock having unrestricted access. These factors may limit their value as waterbird habitat (e.g. see Braithwaite 1975).

The main aim of this study was to determine the influence of size of farm dams on their waterbird populations. A subsidiary aim was to determine whether newer farm dams attracted as rich a waterbird fauna as Minden Dam.

METHODS

Dams

Waterbirds on 10 farm dams within 12 km of Minden, south-east Queensland (27°33'S, 152°33' E) were monitored (Table 1).

Dams were representative of many newly constructed, or substantially enlarged, with availability of bulldozers from about 1950. All were accessible from minor roads. Six (M1 to M6) were in the 10' Grid Square centred on Marburg and the remainder (L1 to L4) in the one to the west, encompassing Laidley.

Climate, soils, vegetation and land use of the Marburg district are described by Leach and Hines (1987, 1992). Briefly, climate is sub-tropical with 70 per cent of the 780 mm mean annual rainfall falling in October through March. The fertile clay soils which occupy much of the landscape originally supported softwood scrub vegetation but it has mostly been cleared for pastures and crops.

The dams were excavated 10 to 30 years before the survey. The 'L' dams were about 10 years more recent than 'M' dams and their catchments also included greater proportions of infertile solodic soils. Catchments were mostly pastures grazed by cattle and horses, precluding development of shoreline vegetation. Trees were sparse. L2 abutted woodland and M5 was in a steep sided gully, ensuring some shelter. Bulrush *Typha* sp. covered one third the area of L1. L4 was always turbid from clay in suspension.

Total rainfall during the survey (2 102 mm) was 4 per cent above average and depth of water in dams always exceeded 40 per cent of maximum depth, which was visually estimated to the nearest metre.

Observations

Birds were counted on each dam on 20 days from May 1980 through October 1982. Counts were at 4 to 11-week intervals. M1 to M6 were counted between 0735 and 1050 h and L1 to L4 between 1015 and 1500 h. Most counts were completed within 5 mins. Vernacular and scientific names follow Schodde *et al.* (1978).

TABLE 1

Maximum surface area and maximum depth of dams and land use in their catchments.

Dam	Area $\times 10^3$ m^2	Maximum depth m	Catchment[a]	Remarks[b]
M1	2.5	3	P	T
M2	4.7	4	P	T
M3	2.8	2	P	T
M4	7.8	3	P + C	TT
M5	4.7	3	P	TT
M6	25.0	5	P	TT
L1	1.2	2	P	T
L2	1.9	3	P	SG
L3	11.2	5	P	T
L4	7.5	5	P	T

[a]P — pasture; C — Cultivation.

[b]Vegetation within 50 m of dams included sparse trees (T) or open clumps (TT) of mainly *Acacia* spp. other than Brigalow *Acacia harpophylla*, or open Spotted Gum *Eucalyptus maculata* woodland (SG).

Data analyses

Analyses were confined to *waterbird* species, i.e. excluding Cattle Egret, Masked Lapwing and Plumed Whistling-Duck which are predominantly *terrestrial-feeding* species.

Similarity Indices (SI) were calculated using the formula:

SI = 2c/(a + b), where 'a' is the number of species on one dam, 'b' the number on another and 'c' the number common to both.

Correlation and regression analyses were used to examine relations of numbers of individuals and species of all waterbird species, and their constituent *open-water* and *shoreline* species, to dam size (maximum surface area and maximum depth). Logarithmic transformations were also analysed, because species-area relations are usually logarithmic (Krebs 1985). Observations from the northern (main) section of Minden Dam (Leach and Hines 1992) were used in some analyses.

RESULTS

Thirty-one species of waterbird (4 184 observations) and three terrestrial-feeding species (3 586 observations) were seen (Table 2). Plumed Whistling-Duck was only seen at three dams, but it was over three times as numerous (3 337 observations) as Pacific Black Duck, the next most numerous species.

Australasian Grebe and Pacific Black Duck were on all dams and another five open-water species were on six or more dams (Table 2). Australasian Grebe, Pacific Black Duck, Dusky Moorhen and Eurasian Coot were observed on all days and another four species on over half of them. No shoreline species was present on all days or at all dams, but White-faced Heron, Royal Spoonbill and Black-winged Stilt were observed at both more than half the dams and on more than half of the days.

The mean number of individuals per dam per day exceeded 0.5 for eight open-water species, and exceeded 2.0 for five of them (Table 2). In contrast, the highest mean for a shoreline species was 0.31 (Black-winged Stilt).

From 5–12 open-water species, and 3–11 shoreline species, were observed at each dam (Table 3). Two to six open-water species, but usually no shoreline species, each contributed 5 per cent or more of the individuals at each dam. Dam M6 attracted eight or more open-water species on seven days and never less than five. In contrast, the four smallest dams attracted nil to four open-water species.

It took 12–20 counts to observe the full complement of species for each dam, with indications that accession of species was continuing even after 20 counts at three 'L' dams (Fig. 1). The number of species reached 90 per cent of their eventual total on the two largest 'M' dams three counts earlier, on average, than on the two largest 'L' dams. Numbers of open-water species reached 90 per cent of their eventual total five counts ahead of attainment of the same proportion for shoreline species.

Dams M2, M4, M5 and M6 supported more individuals when water levels were falling in the first year than through summer–autumn of 1981–1982 when levels rose. Numbers on M2, M6 and L3 increased substantially when levels fell in winter 1982.

The mean abundance of open-water individuals was highest on M6 and lowest on M1 (Table 3). The largest count was 238, on M6. In contrast, no more than 25 individuals were seen on any day at five dams. Mean numbers of shoreline individuals varied from 0.2–3.9, with never more than 10 at a dam.

Similarity Indices for all pair combinations of dams M2, M4, M5 and M6 were high, with M4 and M6 most similar (0.78). In contrast, M3 and L4 had lowest similarity (0.27) and M3 had low similarity with all other dams.

TABLE 2

The number of dams and days on which a species was observed and mean numbers of birds of each species per dam per day.

Species	Dams	Days	Mean	SE[a]
Open-water species:				
Australasian Grebe	10	20	2.45	0.24
Australian Pelican	2	4	0.03	0.01
Darter	1	1	0.005	—
Little Black Cormorant	6	15	0.60	0.12
Little Pied Cormorant	8	14	0.16	0.03
Wandering Whistling-Duck	1	1	0.05	—
Black Swan	2	1	0.02	0.01
Pacific Black Duck	10	20	5.03	0.73
Grey Teal	7	19	3.52	0.84
Australasian Shoveler	1	2	0.04	0.02
Pink-eared Duck	2	9	0.15	0.05
Hardhead	5	19	2.33	0.52
Maned Duck	3	10	0.92	0.35
Cotton Pygmy-Goose	1	1	0.005	—
Dusky Moorhen	8	20	0.97	0.17
Eurasian Coot	8	20	3.47	0.50
Comb-crested Jacana	3	10	0.07	0.02
Shoreline species:				
Pacific Heron	3	5	0.03	0.01
White-faced Heron	8	11	0.11	0.02
Great Egret	3	5	0.03	0.01
Intermediate Egret	7	9	0.07	0.03
Glossy Ibis	1	1	0.005	—
Sacred Ibis	5	5	0.03	0.01
Straw-necked Ibis	4	5	0.11	0.05
Royal Spoonbill	8	14	0.09	0.02
Yellow-billed Spoonbill	5	5	0.03	0.01
Purple Swamphen	4	8	0.06	0.02
Red-kneed Dotterel	2	5	0.07	0.03
Black-fronted Plover	5	10	0.13	0.03
Black-winged Stilt	7	14	0.31	0.06
Latham's Snipe	3	5	0.06	0.03
Other (terrestrial-feeding) species:				
Cattle Egret	7	11	1.08	0.38
Plumed Whistling-Duck	3	13	16.69	6.04
Masked Lapwing	7	11	0.17	0.04

[a]SE — Standard Error of Mean.

Numbers of individuals of all waterbird species, open-water species and shoreline species were significantly correlated with maximum surface area of dams ($P < 0.001$) (Table 4). From 92–94 per cent of variation was accounted for by differences in maximum area (Fig. 2). Numbers of shoreline individuals were significantly correlated with maximum depth ($P < 0.05$), but the linear regression accounted for only 54 per cent of variation.

Numbers of species were best correlated with maximum surface area after logarithmic transformations (mostly $P < 0.001$), although coefficients were smaller than corresponding coefficients for numbers of individuals (Table 4, Fig. 3). Linear regressions on the logarithm of maximum area explained 73 per cent and 83 per cent of variation in numbers of open-water and shoreline species, respectively. Numbers of species were more strongly correlated with

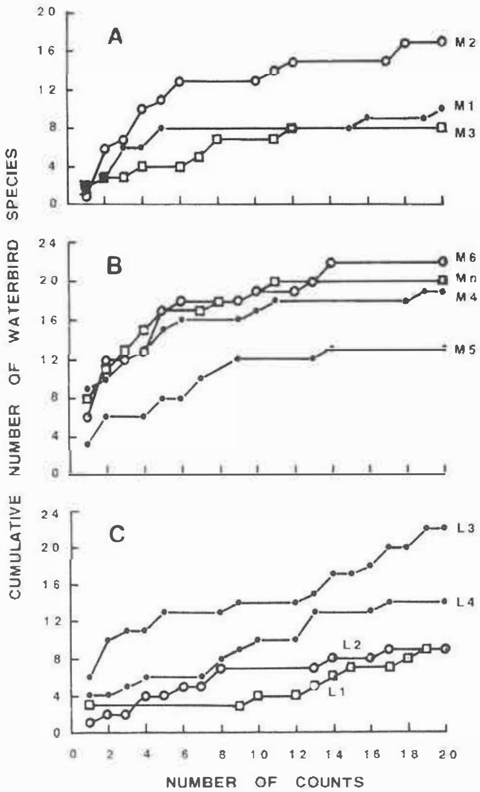

Figure 1. *Accession of waterbird species in successive counts of (A) Dams M1 to M3; (B) Dams M4 to M6 and Minden Dam (Mn); and (C) L1 to L4.*

maximum depth (mostly $P < 0.01$) than were numbers of individuals; linear regressions had small positive intercepts and explained about the same proportion of variation as those on maximum area.

Values of correlation coefficients were not changed when results from Minden Dam were included in analyses with those from the present survey.

DISCUSSION

The farm dams attracted over 60 per cent of freshwater species seen in 12 annual counts over 15000 km^2 of South-east Queensland (Woodall 1985), or over five years in the Richmond Valley of North-eastern New South Wales (Gosper 1981). The number of species was similar to that observed on 'small' water bodies on the New England Tablelands (Ambrose and Fazio 1989) and marginally less than that for water bodies of the Namoi Valley, New South Wales (Broome and Jarman 1992), even though the number of counts, or the area of water surveyed, or both, were much larger in both surveys than in the present study. These comparisons confirm that together the farm dams were rich in waterbird species. Additionally, some attracted large flocks of terrestrial-feeding Plumed Whistling-Duck and Cattle Egret, possibly only to roost.

Influence of dam size on waterbird populations

Correlations between numbers of species, or individuals, and dam size were commonly highly significant even though there were differences between dams in patterns of use over the 20 counts, emphasising the overriding importance of dam size. Regression analyses suggested one waterbird individual was observed for each 260 m^2 of maximum area in dams. This density is similar to the *maximum* (1 individual per 180 m^2) for 'small' dams on the New England Tablelands (Ambrose and Fazio 1989) and at least an order of magnitude greater than for other dams (Ambrose and Fazio 1989) and larger lagoons (Briggs 1977; White 1987). Densities were also similar to the average for natural wetlands and higher diversity artificial water bodies in the Namoi Valley (Broome and Jarman 1983), but five times as large as those for wetlands along the Paroo River in inland New South Wales (Maher and Braithwaite 1992).

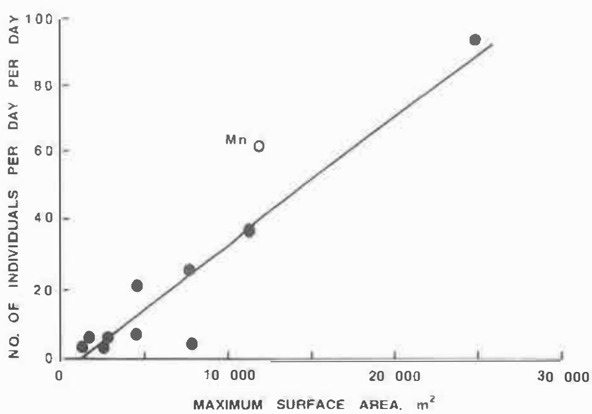

Figure 2. *The relation between mean number of individuals of waterbird species in each count (N) and maximum surface area (A) of dams. The regression $N = 0.0038A + 5.77$ ($r^2 = 0.93$, $P < 0.001$) is shown. Mean for counts at Minden Dam on the same days (Leach and Hines 1992) is labelled 'Mn'.*

TABLE 3

Numbers of species and individuals observed at each dam.

	Dam									
	M1	M2	M3	M4	M5	M6	L1	L2	L3	L4
OPEN-WATER SPECIES										
No. of species:										
Total	5	10	5	10	8	11	5	5	12	7
Abundant[1]	3	4	3	5	6	5	4	4	6	2
No. of individuals:										
Mean	2.0	21.4	5.2	24.9	7.1	90.1	2.7	6.4	34.8	3.3
SE	0.83	4.64	1.58	5.08	1.58	13.15	0.48	1.19	7.08	1.06
SHORELINE SPECIES										
No. of species:										
Total	5	7	3	9	5	11	4	4	10	7
Abundant	1	0	0	0	0	0	1	0	0	2
No. of individuals:										
Mean	0.6	0.7	0.4	1.0	0.4	3.9	0.6	0.2	2.4	1.2
SE	0.28	0.29	0.21	0.32	0.20	0.71	0.20	0.12	0.65	0.48

[1]Abundant species are those contributing 5 per cent or more individuals on each dam.

Rate of accession of species was strongly determined by dam size, generally reaching an asymptote earliest at large dams. Slower rates at 'L' dams than at 'M' dams of similar size, indicates that factors such as age, catchment fertility and water turbidity may also have influenced rates. Faster accession of open-water species than of shoreline species indicates that the dams are a continuing resource for the large population of the former species while they are used only opportunistically by small populations of the latter.

The number of species reached an asymptote at about 22 at 10 000 m^2 maximum area, although more counts are required within the range 10 000–30 000 m^2 to confirm this relation. Even though the number of species would probably increase with additional counts, e.g. 10 more were observed in all 128 counts at Minden Dam (Leach and Hines 1992) than in the 20 counts included in Fig. 1, the area at which the number reaches an asymptote may not necessarily change.

Increase in maximum depth mainly correlated with number of species, presumably providing more habitats. However, because effects of depth and area were confounded, the indication that dams shallower than 2 m supported few waterbird species was in part a consequence of their small areas — a nearby ephemeral wetland that covers 100 ha when flooded is rich in waterbird species although usually less than 1 m deep (G. J. Leach, unpubl. data). The importance of maximum depth may also have been reduced because rainfall was sufficient to maintain water levels at 40 per cent or more of maximum.

High Similarity Indices for several pairs of 'M' dams probably reflected both their larger size and location in the more fertile catchments. Human disturbance at M3, through location 150 m from a homestead and especially affecting shoreline species, may have contributed to low similarity with other dams — small size *per se* was not a major factor.

Comparison of farm dams with the long-established Minden Dam

The total number of species (34) observed on the farm dams (69×10^3 m^2 of maximum water surface) in 20 counts was the same as in 128 counts over eight years at Minden Dam (12×10^3 m^2) (Leach and Hines 1992). The number of species observed at Minden Dam on the same days as the farm dams were censused was the same as at the richest farm dams, but there were more individuals

TABLE 4

Correlations between waterbird populations and size of dams.

	Pearson correlation coefficients[a]	
	Area m^2	Depth m
No. of individuals		
All species	.962***	.601
Open-water species	.960***	.594
Shoreline species	.967***	.735*
No. of species		
All species	.810**	.772**
Logarithms[b]	.910***	.772**
Open-water species	.711*	.712*
Logarithms[b]	.853**	.720*
Shoreline species	.848**	.803**
Logarithms[b]	.912***	.800**

[a]Coefficients are significant at *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

[b]Correlations with the logarithms of area and depth.

per unit area (Fig. 2). Patterns of accession of species at Minden Dam and the largest farm dam (M6) were similar (Fig. 1) suggesting that long existence and habitat diversity may have counteracted the twofold difference in maximum surface area. Thus, although 100-year old Minden Dam does not attract more species per unit of sampling (area × surveys) than the newer farm dams, it attracts them for a greater proportion of surveys, in turn reflecting consistent diversity of aquatic habitats.

Conclusions and implications

The number of individuals observed at farm dams in the Marburg District increases linearly with increase in maximum surface area to at least 30 000 m^2, but the number of species reaches an asymptote at a smaller area. A maximum surface area of at least 10 000 m^2 when full is needed to support the main local species. Maximum depth was less important for number of individuals than area, possibly because rainfall maintained high water levels.

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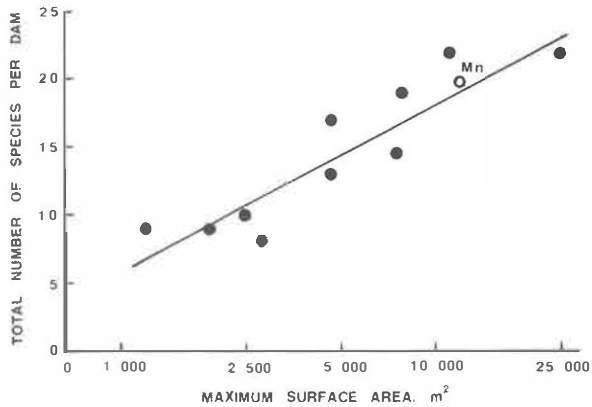

Figure 3. *The relation between total number of waterbird species on each dam (S) and the logarithm of maximum surface area (A). The regression* $S = 5.4011 \, Log_e \, A - 31.52$ ($r^2 = 0.83$, $P < 0.001$) *is shown. Mean for counts at Minden Dam on the same days (Leach and Hines 1992) is labelled 'Mn'.*

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