CHANGES IN THE WATERBIRDS AND OTHER BIOTA OF LAKE YUMBERARRA, AN EPISODIC ARID ZONE WETLAND

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ABSTRACT

Lake Yumberarra is a small freshwater lake (151 ha) in the Currawinya National Park in southwestern Queensland. During 1995-2003 it held water much of the time in two filling-drying cycles, one initiated by riverine flood water and the second by local runoff. Water in both was clear, alkaline and generally fresh, but became saline as it dried. Zooplankton comprised 27 crustaceans and a few rotifers with the copepod Boeckella triarticulata dominant. Numbers were greatest soon after filling and in each spring and least towards drying. At least 44 taxa of macroinvertebrates inhabited the littoral zone, with hemipterans and chironomids dominant. Waterplants, chiefly Myriophyllum verrucosum, grew abundantly in the first half of each filling cycle. A limited fish fauna inhabited the lake, with carp present only in the first cycle. The lake was used extensively by 59 species of waterbirds, with four foraging groups dominant at different times probably reflecting fluctuating abundance of their food resources. Breeding in the lake was not widespread, nor was the lake used much by migratory waders, unlike some other wetlands in the Paroo. Its unusually high species richness and bird densities means the lake is important for feeding and maintaining waterbird diversity in an arid landscape.

INTRODUCTION

Australia’s large arid zone has a surprising number and variety of wetlands, none more so than in the Paroo catchment of northwest New South Wales and southwest Queensland. Unlike many wetlands elsewhere in the arid zone, the vast majority of the Paroo’s waters are fresh (Kingsford et al. 2004) and moreover, on a decadal scale often have water in them (e.g. Timms 1997a, 1997b, 1998a, 2001a). The salient features of these wetlands are summarised in Timms (1998b, 2001b, In Press), with details in Timms 1993, 2001a, 2002, Kingsford & Porter 1994; Kingsford 1999a, Timms & Boulton 2001, Hancock & Timms 2002, and Seddon & Briggs, 1998. The environmental factors most influencing biological communities in these wetlands are water regime, turbidity and salinity (Timms & Boulton 2001).

Given their extent, variety, generally favourable water regime, and food resources, these wetlands are important for waterbirds (Kingsford et al. 1994, Kingsford & Porter 1994, 1999). These largescale studies concentrate on lakes >1000ha, but smaller waterbodies often also support many waterbirds (Lawler & Briggs 1991, Timms 1997a) and some like Lake Yumberarra have as many species as the larger ones (McDougall & Timms 2001). Almost all studies on arid zone waterbird
Changes in the waterbirds and other biota assemblages are either annual censuses (the annual aerial survey of waterbirds) or censuses over two-three years (Kingsford & Porter 1994, Kingsford et al. 1994) or studies over a short filling period (<1 year) (Timms 1997a; Chapman & Timms In Press). There are few long term studies over many years on a complete filling-drying cycle over variable weather patterns governed by El Nino-La Nina cycles. Work has focused on saline waterbodies (Timms 1993, 1998c, in Press) and also on clay pans (Hancock & Timms 2002, Timms 2002) and creek pools (Timms 2001c), but little has been reported on the freshwater lakes (Timms 1999, 2001a). This paper focuses on a small freshwater lake, L. Yumberarra, in the middle Paroo. It fills every few years and then slowly evaporates over the next few years. It is an episodic hydrological regime with water more often present than not. The aims of this paper are to characterise the limnological features of the lake during a nine year period (1995-2003) encompassing two filling-drying cycles, and to assess waterbird usage of the lake during the second filling-drying cycle from 1998-2002.

The Study Site

Lake Yumberarra (151ha) is a triangular-shaped lake in the Currawinya National Park, near Hungerford southwest Queensland (28°53’S, 144°19’E) at the edge of the Paroo floodplain (Timms 1997b). It would have formed initially as a floodplain backswamp and has deepened by wind action removing fine-grained sediment to a fringing lunette dune on the eastern shore. When water reaches the fringing blackbox trees (Eucalyptus largiflorens) it is 3.4m deep, but overfilling can flood about 170ha to 3.8m deep. Floodwater enters from the northeast corner (as in January 1995) via a distributary channel of the Paroo and exits via this channel and another to the south (see Fig. 2 in Timms 1999). The lake is also connected by a broad channel in the northwest corner to Lake Karatta, from which it may receive water (as in July and September 1998) or pass water onto Karatta from the Paroo. The shoreline at 200-400cm above lake bottom (ALB) is sandy on the eastern and southwestern shores and somewhat stoney on the northern shore; the extensive flat floor is grey mud. The lake has segmented unevenly (Lees 1989) by spit growth in the southeastern quarter (Fig. 1), so that between 150 and 250cm depth there is a partially cut-off bay in this quarter. There are well developed sandy beaches on the eastern arm of this spit at 150-250cm ALB and less extensive beaches in the northwest corner at 160cm and 250cm ALB.

Figure 1: Bathymetric map of Lake Yumberarra.
When the water level is at the tree line, maximum length is 1950m, maximum width 1150m, lake volume 2.95x10^6 m^3, mean depth 1.7m, and length of shoreline ca 5800m (length difficult to determine as three corners of lake connect to wide channels) (Fig. 1). An absolute hypsographic graph (Fig. 2a) was used to determine the area at any observed depth for calculation of waterbird densities. Because of the presence of a semi-isolated southern bay when levels lay between 150 and 250cm depth, shoreline length is between 5500 and 5800m at all depths greater than...
150cm (Fig. 2b). This means a relatively constant shoreline length over a wide range of water levels from 150 to 340cm lake depth. Generally the width of shallow water (<20cm deep) for waders was roughly 10m, but up to 200m as the lake shrunk beyond the 50cm contour.

**METHODS**

The lake was mapped when dry in December 2002 using a dumpy level across numerous transects arranged as two wagon wheels with spokes 30° apart at each end of the lake and eight parallel ones at 150m apart in between and linked up the centre of the lake by a transect along the axis of the lake.

The lake was visited about every three months from January 1995 to November 2003 to determine some physicochemical parameters and sample zooplankton and littoral organisms. On each visit, lake depth was recorded variously from five graduated staffs over time, each placed in the lake at various points according to the prevailing lake level and used for many months; eventually their heights above the lake bottom were surveyed when the lake dried. On each visit, a surface water sample about 50m offshore was immediately measured for temperature with a mercury thermometer, and for pH with a HANNA HI8924 pH meter. Turbidity was measured on site with a standard Secchi disc. Total dissolved solids (TDS) was determined later by gravimetry on the water sample with turbid water allowed to settle for months in a sealed container.

Zooplankton were collected with a net of mesh size of 159µm mounted on a pole with a rectangular aperture of 30 x 15cm. It was trawled for a minute over a distance of ca 10m in water at about 30-70cm deep usually 50-100m from the shore. The contents were preserved in formalin. In the laboratory species were identified, relative abundance was established by counting the first 200 individuals and scanning the whole collection for rare species and adding them as 0.1% of the total. This is a quick and reliable method of assessing relative abundance, though it may overestimate rare species (R. Shiel, pers. comm.). Absolute abundance was determined as the settling volume of the collection in a measuring cylinder after a standard time of 10 minutes.

A similarly constructed net but with mesh size of 1mm was used to catch littoral invertebrates. This was swept through water 5-30cm deep near the shore for a total of 15 minutes (usually 5 x 3 minutes, accordingly as the net clogged). Animals caught were examined in a white tray and assigned an order of magnitude, r = 1 individual, x = 2-10 individuals, xx = 11-100 individuals, xxx = 101 – 1000 individuals, and xxxx = 1001-10,000 individuals. Data were simplified by averaging on a log scale with the number of ‘x’’s converted to integers. This coarse method provides a rapid assessment, with detailed analyses of samples showing it caught ca 80% of the species present at the time of sampling and that log abundances were reliable.

Fish were caught sometimes in the littoral net or in opera house yabbie traps set for an hour or two to catch Cherax crayfish. These traps were not employed regularly.

Waterbirds were counted from July 1998 to October 2002 with binoculars and a spotting scope at various time intervals, usually every one or two months, but up to four months as the
lake dried. Counts were always early to mid morning and from the eastern shore. From February 2002, counts were repeated the next day with very little overall difference (±5% of total numbers and species richness). Other observations on species present were made between trips.

RESULTS

Physicochemical features

Monthly rainfall in the study period was erratic, with major falls in January 1995, January, April and July 1998, November and December 1999, May and November 2000, followed by little rain 2001-2002 (Fig. 3). The dry lake filled in January 1995 largely from Paroo floodwater plus some local runoff and then dried by December 1997 (Fig. 4). The next filling began with the April 1998 rainfall, but only filled in July 1998 from local runoff. The heavy falls during 1999 and 2000 extended the fill period so that the lake was greater than two metres deep for three years, but the drought of 2001 to 2002 dried it by October 2002 (Fig. 4). During 2003 there was 197mm rainfall, but the lake remained dry, so 2003 is not considered further.

TDS (≈ salinity) ranged during the study from 346mgL⁻¹ to almost 14000mgL⁻¹ but reached 114000mgL⁻¹ when the lake was only a few centimetres deep (Fig. 3). Generally the lake was fresh (<3gL⁻¹) at depths >1.4m. Depth and salinity were significantly negatively correlated (r = -0.8697, p<0.001). The minimum winter water temperature recorded over the years was 10.7°C and the maximum summer temperature 32.8°C. Lake water was clear with Secchi disc readings averaging 56 ±36cm, except for a few months after filling with turbid water and when less than a metre deep and often wind-stirred. Water was alkaline, ranging between pH 8.2 and 10.3 and averaging 9.3 ±0.6.
Aquatic plants

The dominant species present was *Myriophyllum verrucosum* Lindl.; *Lepilaena bilocularis* Kirk, *Chara* spp and *Nitella* sp also occurred. In the first filling cycle plants were most dense in the spring of the second year, while in the second filling cycle they were most dense in the spring and summer of 1999 and sparse after November 2000. By late summer each year the beds of macrophytes were shrouded with filamentous green algae.

Zooplankton

At least 27 species of crustaceans were recorded (Table 1), with the copepod *Boeckella triarticulata* dominant and other copepods, *Calamoecia canberra*, *C. lucasi*, *Microcyclops* spp. and the cladoceran *Daphnia angulata* common for extended periods. Blooms of the limnetic rotifers *Asplancha seiboldi*, *Brachionus calyciflorus*, *B. plicatilis*, *B. urceolatis* and *Keretella australis* occurred during the study period. Many crustacean species were littoral strays (e.g. *Macrocylops* sp., *Macrothrix carinata*, *Alona* spp., *Celsinotum* sp. while other truly limnetic species were present only briefly and as a small proportion of the total (e.g. *Daphnia lumholtzi*, *Ceriodaphnia cornuta*, *Diaphanosoma unguiculatum*).

The two filling periods had similar species compositions and proportions (Table 1), but cyclopod copepods were notably more common in 1995-97 and *Daphnia angulata* in 1998-2002. The cyclopoid peaks coincided with the longer hyposaline stage in the first fill and the *Daphnia* peaks with a long, ‘deep’ freshwater stage in the second fill. The waxing and waning of species was rarely repeated seasonally or during the two filling-drying cycles. Exceptions included *Calamoecia canberra* which was common only during initial turbid periods and saline species (*Microcyclops* sp. b, *Daphniopsis queenslandensis*, and the ostracods, *Diacypris* sp., *Mytilocypris* and *Trigonocypris*) most noticeable when salinity exceeded 3gL⁻¹. The
Changes in the waterbirds and other biota

Table 1: Zooplankton in Lake Yumberarra 1995-2002.

highest salinities tolerated by freshwater species were *Daphnia angulata* and *Macrothrix carinata* to 4.9gL⁻¹, and *Boeckella triarticulata* and *Cyprinotus* sp.to 7.1gL⁻¹.  

In the second filling cycle, settling volumes (≈ biomass) were greatest in August to October 1999 (peak of 67ml per minute collection in August), usually greater than 10ml during 1998 and 1999 and less than 5ml during 2000-2002, except for peaks in the springs of 2000 (26ml) and 2001 (8ml). Fluctuations in the first filling cycle were not so marked, with a maximum of 29ml in the first spring (October 1995) and each spring thereafter and generally less than 5ml throughout.

**Littoral invertebrates**

At least 44 species of invertebrates were caught in the littoral zone of Lake Yumberarra during 1995-2002 (Table 2). Chironomids were incompletely studied and identified, as were some odonatans and watermites. The dominant taxa were *Micronecta* sp. and *Anisops gratus*; *Tasmanocoenis tillyardii*, *Xanthoagrion erythronem*, *Agraptocorixa eurnome*, *Ag. parvipunctata*, *Anisops calcaratus* and chironomids were also common at times. Some seasonality...
| Species                                      | 95-97 (13 collections) | 98-02 (16 collections) |
|----------------------------------------------|------------------------|------------------------|
|                                              | records | range | mean | records | range | mean   |
| Mytilocypris splendida (Chapman)            | 4       | 1-4   | 1    | 1       | >0.1  |
| Trigonocypris globulosa De Deckker          | 4       | 0.1-4 | 0.5  | 1       | >0.1  |
| Cherax destructor Clark                      | <0.1    | 3     | 0.1-1| 0.3     |
| Cloeon sp.                                  | 1       | 3     | 0.1-2| 0.2     |
| Tasmanocypris tillyardi (Lestage)           | 4       | 0.1-2 | 0.2  | 8       | 0.1-2 | 0.6   |
| Austrolestes annulosus (Selys)              | <0.1    | 2     | 1    | 0.1     |
| Xanthoagriom erythroneurum Selys            | 4       | 1-2   | 0.4  | 6       | 1     | 0.4   |
| Diploacoides spp.                           | <0.1    | 3     | 0.1-1| 0.1     |
| Hemianax papuaensis (Burmeister)            | 2       | 0.1   | <0.1 |
| Hemicordulia tau (Selys)                    | 2       | 0.1-1 | 0.2  |
| Orthetrum cadedonicum (Brauer)              | 2       | <0.1  | 0.1  |
| Micronecta spp.                              | 13      | 2-4   | 2.9  | 14      | 2-4   | 2.8   |
| Agraptocorixa eurnome Kirkaldy              | 7       | 1-3   | 0.7  | 8       | 0.1-2 | 0.3   |
| Agraptocorixa hirtfons Hale                 | 2       | 0.1-1 | 0.3  | 3       | 0.1-1 | 0.2   |
| Agraptocorixa parvipunctata Hale            | 4       | 1-2   | 0.6  | 4       | 1-2   | 0.4   |
| Anisops calcaratus Hale                     | 4       | 1-2   | 0.6  | 8       | 0.1-2 | 0.5   |
| Anisops gratus Kirkaldy                     | 9       | 1-4   | 1.6  | 10      | 1-3   | 1.1   |
| Anisops thienennanni Lundbald               | 3       | 1-2   | 0.3  | 6       | 0.1-1 | 0.3   |
| Oecetis sp.                                 | 1       | <0.1  | 1    | <0.1    |
| Notolina sp.                                 | 1       | <0.1  | 1    |
| Trilectides australicus Banks               | 3       | 1-2   | 0.3  | 5       | 0.1-1 | 0.3   |
| Allodesess bistreitus (Clark)                | 2       | 0.1-1 | <0.1 | 4       | 0.1   | <0.1  |
| Antiporus giberti Clark                     | 1       | <0.1  | 6    | 0.1-2   | 0.5   |
| Berosus approximamus Fairmaire              | 2       | 0.1   | <0.1 | 1       | <0.1  |
| Berosus macumbensis Blackburn               | 2       | 0.1   | <0.1 | 1       | <0.1  |
| Berosus nutans MacLeay                      | 1       | <0.1  | 1    | <0.1    |
| Enochrus eyrens (Blackburn)                 | 3       | 0.1-1 | 0.1  |
| Halipus fuscatus Clark                      | 1       | <0.1  | 1    |
| Limnoxenus macer (Blackburn)                | 3       | 0.1   | <0.1 | 5       | 0.1-1 | 0.2   |
| Antiporus larvae                            | 2       | n/a   | 4    | 0.1-1   | 0.3   |
| Berosus larvae                              | 5       | n/a   | 6    | 0.1-1   | 0.1   |
| Chironomus sp a                             | 4       | 0.1-1 | 0.5  | 4       | 0.1-1 | 0.2   |
| Chironomus sp b                             | 2       | 0.1   | <0.1 |
| Cryptochironomus griseidorum Keiffer        | 3       | 0.1-1 | 0.5  | 5       | 0.1-1 | <0.1  |
| Dicrotendipes sp.                           | 5       | 0.1-1 | 0.5  | 3       | 0.1-1 | <0.1  |
| Polypedilum nubifer Skuse                   | 4       | 0.1-1 | 0.2  | 6       | 0.1-1 | 0.3   |
| Unidentified chironomids                    | 6       | 0.1-1 | 0.3  | 5       | 0.1-1 | 0.5   |
| Unidentified ceratopogonid Diptera          | 4       | 0.1-1 | 0.3  | 3       | 0.1-1 | 0.1   |
| Unidentified tabanian Diptera               | 1       | <0.1  | 1    | <0.1    |
| Unidentified pyralid Lepidoptera            | 3       | 0.1-1 | 0.1  |
| Arrenurus spp.                              | 5       | 0.1-1 | 0.2  | 2       | 0.1-1 | 0.1   |
| Diplodontus spp.                            | 1       | <0.1  | 1    | <0.1    |
| Elyias spp.                                 | 4       | 0.1-1 | 0.3  | 3       | 0.1-1 | 0.1   |
| Hydrachna spp.                              | 3       | 0.1-1 | <0.1 | 1       | <0.1  |
| Limnesia spp.                               | 1       | <0.1  | 1    |

Table 2: Littoral Invertebrates in Lake Yumberarra 1995-2002. (Numbers in log scale, e.g. 1 = up to 10 individuals per collection; see text for details)
and phenological changes were evident during the filling-drying cycles, but are not considered here. As the lake aged and became saline during each filling, species richness reduced to a few core species, mainly the hemipterans, and the large ostracods, *Mytilocypris splendida* and *Trigonocypris globulosa*; all survived salinities to 14 g L$^{-1}$, but none were present at 114 g L$^{-1}$.

**Lower vertebrates**

Mosquito fish (*Gambusia holbrooki*), Bony Herring (*Nematalosa erebi*) and Spangled Perch (*Leiopotherapon unicolor*) were caught incidentally in the pond net and yabby traps from a few months after filling till mid 2001. Carp (*Cyprinus carpio*) were present in the 1995 fill, but was not encountered in the 1998 fill. The tortoise *Emydura* sp. was seen throughout the study period and 18 skeletons were found as the lake dried in 2002.

Amphibians were not studied, but little or no breeding occurs in the lake as no tadpoles were ever caught in the pond net.

**Waterbirds**

Fifty-nine species of waterbirds were seen in the lake 1998-2002, though 11 of these were encountered only once (Table 3). The most persistent species (>20 occurrences) were Black Swan, Grey Teal, Hardhead, Hoary-headed Grebe, Eurasian Coot, Black-winged Stilt and Masked Lapwing, and the most numerous species in order of mean abundances were Eurasian Coot, Grey Teal, Pink-eared Duck, Hoary-headed Grebe, Black Swan and Hoary-headed Grebe. Other persistent species (>15 occurrences), but in much lower numbers were Pacific Black Duck, Australasian Shoveler, Australian Pelican, Black-fronted Dotteral and Silver Gull.

Momentary species richness was least at first filling (11 species) and when almost dry (four species), with at least 20 species present for almost all of the time the lake held water (Fig. 5). Peak richness of 38 and 36 species were reached in January 1999 and March 2001 respectively. Density of waterbirds fluctuated markedly with greatest values May to December 1999, low values January to September 2000, and higher values as the lake dried (Fig. 5). The maximum bird count of 11,517 was in December 1999 (115.2 birds per ha).

Fifteen species bred on the lake: Black Swan, Pacific Black Duck, Grey Teal, Pink-eared Duck, Australasian Grebe, Hoary-headed Grebe, Great Crested Grebe, Darter, Rufous Night Heron, Dusky Moorhen, Eurasian Coot, Black-winged Stilt, Black-fronted Dotteral, Red-capped Plover and Whiskered Tern. Small numbers were involved (<10 pairs) and all breeding occurred in 1999 and/or 2000 when the lake was full or nearly so. The Australian Pelican probably bred in the previous filling cycle as judged by old nests on the island in the northwest corner.

The four major foraging groups (Kingsford & Porter 1994) had different patterns of variation in abundance over the five year existence of the lake (Fig. 6). Ducks were the least variable from year to year with greatest numbers early in the filling cycle peaking in the second year. Waders were similar, but peaked in the first year. Like the ducks their numbers were lowest in the middle stages of the cycle. The number of waders per unit length of shoreline values was highest as the lake filled and dried (Fig. 7). By
Table 3: Waterbirds on Lake Yumberarra 1998-2002. ^ Taxonomic order follows Christidis & Boles 1996.

Table 3 continued next page
| Species | Foraging groups | records n=23 | mean count | SE | 1998 n=2 | 1999 n=8 | 2000 n=5 | 2001 n=4 | 2002 n=4 |
|---------|-----------------|-------------|------------|----|--------|--------|--------|--------|--------|
| Royal Spoonbill *Platalea regia* | pw | 4  | 2.3 | 1.5 | 0 | 4 | 0 | <1 | 4 |
| Yellow-billed Spoonbill *Platalea flavipes* | pw | 13 | 8.2 | 3.9 | 5 | 4 | 18 | 1 | 13 |
| White-bellied Sea Eagle *Haliaeetus leucogaster* | h | 1 | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 |
| Brolga *Grus rubicundus* | h | 4 | 0.4 | 0.2 | 2 | <1 | <1 | 0 | 0 |
| Australian Spotted Crake *Porzana fluminea* | h | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Purple Swamphen *Porphyrio porphyrio* | h | 1 | 0.3 | 0.3 | 0 | 1 | 0 | 0 | 0 |
| Black-tailed Native Hen *Gallinula ventralis* | h | 7 | 29.0 | 15.6 | 0 | 82 | <1 | 4 | 0 |
| Dusky Moorhen *Gallinula tenebrosa* | h | 3 | 0.3 | 0.2 | 0 | 0 | 1 | 0 | 0 |
| Eurasian Coot *Fulica atra* | h | 21 | 1190.3 | 453.7 | 18 | 2922 | 207 | 610 | 97 |
| Latham’s Snipe *Gallinago hardwickii* | w | 4 | 0.3 | 0.2 | 0 | <1 | 0 | <1 | <1 |
| Black-winged Stilt *Himantopus himantopus* | w | 19 | 72.9 | 30.7 | 250 | 39 | 0 | 92 | 119 |
| Red-necked Avocet *Recurvirostris novaehollandiae* | w | 13 | 25.0 | 13.1 | 150 | 25 | <1 | 13 | 7 |
| Red-capped Plover *Charadrius ruficapillus* | w | 19 | 9.7 | 2.7 | 5 | 10 | 5 | 19 | 9 |
| Black-fronted Dotterel *Euryornis melanops* | w | 5 | 3.1 | 2.0 | 0 | 9 | 0 | 0 | 0 |
| Red-kneed Dotterel *Erythrogonys cinctus* | w | 21 | 14.0 | 2.6 | 4 | 23 | 6 | 16 | 10 |
| Masked Lapwing *Vanellus miles* | w | 2 | 0.2 | 0.1 | 0 | 0 | 0 | <1 | <1 |
| Banded Lapwing *Vanellus tricolor* | w | 18 | 13.7 | 5.3 | 60 | 15 | 2 | 7 | 8 |
| Silver Gull *Larus novaehollandiae* | pw | 3 | 4.3 | 2.6 | 0 | 12 | 0 | 0 | 0 |
| Gull-billed Tern *Sterna nilotica* | pw | 10 | 4.8 | 2.3 | 0 | 2 | 0 | 19 | 5 |
| Caspian Tern *Sterna caspia* | pw | 13 | 27.3 | 9.0 | 25 | 24 | 65 | 15 | <1 |
| Whiskered Tern *Chlidonias hybridus* | pw | 2 | 0.1 | 0.1 | 0 | <1 | 0 | <1 | 0 |
| Clamorous Reed-warbler *Acrocephalus stentoreus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | <1 | 0 |
| Little Grassbird *Megaleurus gramineus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | <1 | 0 |

Table 3 Cont.: Waterbirds on Lake Yumberarra 1998-2002. ^ Taxonomic order follows Christidis & Boles 1996. * seen at the lake, but not during a bird count
Figure 5: Species richness and density of waterbirds on Lake Yumberarra 1998-2002.

Figure 6: Variation in yearly average abundance of the major foraging groups in Lake Yumberarra 1998-2002.
contrast piscivores were most common in the third and fourth years (Fig. 6). The herbivores were the most variable year to year with a major peak in the second year and minor peak in the fourth year.

Almost every species had individual variations on the group themes. Some, like the Black-tailed Native Hen, Australasian Shoveler and Silver Gull were most common soon after filling declining in numbers during the drying phase. Hardhead and Frecked Duck increased during the drying phase, while some were common at the beginning and end (e.g. Grey Teal, Red-necked Avocet). A common pattern was peak abundance in the second year, seen in Black Swan, Pink-eared Duck, Hoary-headed Grebe, Black-tailed Native Hen and Eurasian Coot. Most piscivores peaked in numbers in the third and fourth years (e.g. Great Crested Grebe, Little Pied Cormorant, Little Black Cormorant) the Australian Pelican and Glossy Ibis peaked earlier. Many species were absent during filling and particularly during the final drying stage (Table 3, Fig. 5).

Six species of international migratory waders were seen on Lake Yumberarra during 1998-2003: Red-necked Stint, Sharp-tailed Sandpiper, Latham’s Snipe, Black-tailed Godwit, Common Greenshank and Marsh Sandpiper. None were common (<100, see Table 3), though some were on nearby Lake Wyara (A. McDougall, unpublished data).

DISCUSSION

Lake Yumberarra has a more propitious water regime than many Paroo freshwater lakes (e.g. Kaponyee Lakes (Timms 1999), most of the Paroo overflow lakes (ANCA, 1996)), though some Paroo lakes are nearly permanent (e.g. Lake Numalla (Timms 1999) and Mullawoolka Basin among the overflow lakes (Kingsford et al. 2004). Other physiochemical features are similar to other inland waters, though atypically Yumberarra’s waters are clear and the pH is elevated (>9).

Dense beds of macrophytes grow in Lake Yumberarra in spring and summer of the first and/or second year of filling (see also McDougall &
The main species in Yumberarra are *Myriophyllum verrucosum*, *Lepilaena bilocularis*, *Chara preissii* A. Br., *Chara globularis* Thuill and *Nitella sonderi* A. Br (J. Porter, pers. com.). The only lakes in the middle Paroo with such dense beds of macrophytes are the hyposaline/mesosaline lakes, Wyara (Kingsford & Porter 1994) and Bulla (B. Timms, unpublished data).

At least 72 invertebrate taxa have been recorded (Table 2 & 3), making Yumberarra one of the more species-rich freshwater lakes in the Paroo (Timms & Boulton 2001). Its dominant species are typical of arid zone freshwater lakes, both in the Paroo (Timms & Boulton 2001) and beyond in the Coongie Lakes (P. Hudson pers. com.). In the local context, it is interesting that shrimp, crabs and carp were absent in the 1998-2002 fill (Table 2), probably because water was sourced locally and not from the river. Yabbies and three species of fish were present, so either they survived the dry phase in late1997-early 1998 in an inflowing local stream or dam. Many species of invertebrate were only occasionally present in small numbers (Table 2 & 3). These included a few planktonic species (*e.g.* *Daphnia lumholtzi*, *Ceriadaphnia cornuta*) which bloomed elsewhere in the Paroo (B. Timms, unpublished data).

Compared to other waterbody types in the area (Timms & Boulton 2001), Yumberarra had no large branchiopods (probably due to the presence of fish), fewer beetles (little detritus for habitat/food) and more odonatans (abundant aquatic plants and bottom mud provided a suitable habitat), and also more ephemeropterans, chironomids and mites. It did not support an abundant pyralid moth fauna as seen in some well vegetated lakes in the Paroo, but mainly hyposaline/mesosaline ones (Timms 1998a, unpublished data). During the saline phases, there were few typically euryhaline species, only *Branchionus plicatilis*, *Microcyclops* sp. b, *Daphniopsis queenslandensis*, *Mytilocypris splendida* and *Trigonocypris globulosa* and some salt-tolerant freshwater taxa like *Boeckella triarticulata*, *Micronecta* sp. and *Anisops gratus* (Table 2 & 3). This is in accord with other freshwater lakes in the area with saline end phases (B. Timms, unpublished data).

The Paroo is an important area for inland waterbirds (Kingsford et al. 1994; Kingsford & Porter 1999; Roshier et al., 2002) and Lake Yumberarra with its 59 species supports the most species. These figures are biased in favour of Yumberarra as land-based surveys record more species than aerial counts (most other Paroo data are based on aerial surveys) (Kingsford 1999b) and the longer period of observations on Lake Yumberarra. Certainly it has more species than other Currawinya Lakes (Numalla 50, Wyara 48, Mid Kaponyee 43, Karatta 33, South Kaponyee 14, North Kaponyee 12 — A. McDougall unpublished data), though this may be because of more intense observations. The common species are similar to those of other lakes in the area (see Kingsford & Porter 1999). The White-bellied Sea Eagle is rare in the area (marked as a small outlier from the main area of distribution (Barrett et al. 2003); the bird seen on Yumberarra may have been based at Lake Wombah, 50 km to the east, where a pair of this species nested during 1998-2000 (B. Timms, unpublished data). Three of other rarer species, Plumed Whistling Duck, Musk Duck and Chestnut Teal are near the edge of their recorded range on
Lake Yumberarra (Barrett et al. 2003), though all three have been occasionally recorded in Paroo lakes previously (Kingsford et al. 1994). Lake Yumberarra is not used intensively by migratory waders, unlike many other Paroo lakes, including Lake Wyara (Kingsford et al. 1994).

Numbers of individual birds are much lower in Yumberarra than most other Paroo lakes because of its small size, but the maximum density recorded in L. Yumberarra (115 birds ha⁻¹) is much greater than that of other lakes even allowing for aerial counts usually being up to 50% too low (Kingsford et al. 1994) (e.g. highest is Lake Altiboukla at 35 birds ha⁻¹by aerial and 69 from ground counts). Even the average density of birds on Lake Yumberarra during 1999 (36.9 ±7.4 SE birds ha⁻¹ excluding the December peak of 115) is similar to or higher than peak densities (adjusted from aerial to ground count figures) at many Paroo lakes (up to ca 35 birds ha⁻¹, excluding Lake Altiboukla and Mullawoolka Basin). Mean density of waterbirds in Yumberarra for the five years 1998-2002 at 27.2 ±5.5 SE birds per ha is greater than those for lakes in eastern Australia studied by Kingsford et al. (2004), except two unnamed small rainfilled lakes near Menindee). Lake Yumberarra productiveness probably stems from its unusually clear waters which promote abundant macrophyte growth, as in the difference between clear Lake Wyara and turbid Lake Numalla nearby (Kingsford & Porter 1994).

Furthermore the attractiveness of Yumberarra to waterbirds is enhanced by its medium disturbance in the flood-drought cycle and complete lack of river regulation (Kingsford et al. 2004).

Marked fluctuations in the number of waterbirds on inland lakes are common (Reid 1988, Kingsford & Porter 1994, Kingsford et al. 1994, Timms 1997a, Halse et al. 1998) and among other factors, are associated with intermittently abundant food, breeding and congregation as other waters dry. All three major factors explain much of the variation in Lake Yumberarra, especially food availability. Waders found food initially as shore was flooded and ex-terrestrial sources were common, and herbivores utilized the abundant macrophyte growth in the second year. In 2000 and 2001 piscivores were more abundant as depth decreased and later as salinity increased, conditions conducive for fishing. After mid-2001 piscivore numbers fell, as fish presumably became scarce (none were caught in the nets). The low total numbers during much of 2000 are enigmatic. Other lakes at Currawinya and in nearby areas also had few birds at this time (authors, unpublished data), and it is possible many had left for lakes freshly filled in the Lake Eyre basin (Roshier et al. 2002). Fluctuations in less common species were sometimes biased by the fleeting appearance of small flocks, e.g. a flock of Freckled Duck (470) was present only once during the drying phase in 2002.

High salinity in the terminal stage of drying no doubt adversely affected waterbirds (Kingsford & Porter 1993), so that the full potential of the lake as a refuge in dry times was not realised. This combined with the lake’s abundant early macrophyte growth means that maximum numbers of waterbirds occurred early in the life of the lake and not as it dried, as normally is the case in inland lakes (Kingsford et al. 1998, Kingsford & Porter 1999).
Thirty-eight water birds were recorded breeding in wetlands of the Paroo and Warrego systems (Kingsford et al. 1994, Kingsford & Porter 1999). Many of these bred in Lake Yumberarra, but only in small numbers, so that this lake is not a major breeding site. Its importance lies in serving as an important waterbird habitat in a mosaic of potential habitats across the continent (Roshier et al. 2001).

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