Algae of Carcoar Dam, New South Wales, Australia

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Abstract

May, V. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1988. Algae of Carcoar Dam, New South Wales, Australia. Cunninghamia 2(1): 1–7. — This paper presents the results of a study of the algae of Carcoar Dam, New South Wales, Australia.

Introduction

An algal study was undertaken of Carcoar Dam (33°37′S, 149°12′E) on the Belubula River near Bathurst in the southern Central Tablelands from September 1977 to February 1981, which included a period of drought (1980–81). Inflow from the River provides high levels of nutrients from an abattoir and a sewage treatment works. Frequently the dam water appears green because of its high algal content and livestock deaths have been recorded, apparently due to toxic algae. Five stations were sampled, four in Carcoar Dam and one immediately upstream (Figure 1), at 2–4 week intervals. Methods are fully described in May & Powell (1986) from work on Chaffey Dam. A full data set, including tabular and graphic analysis, is lodged with the Library, Royal Botanic Gardens, Sydney.

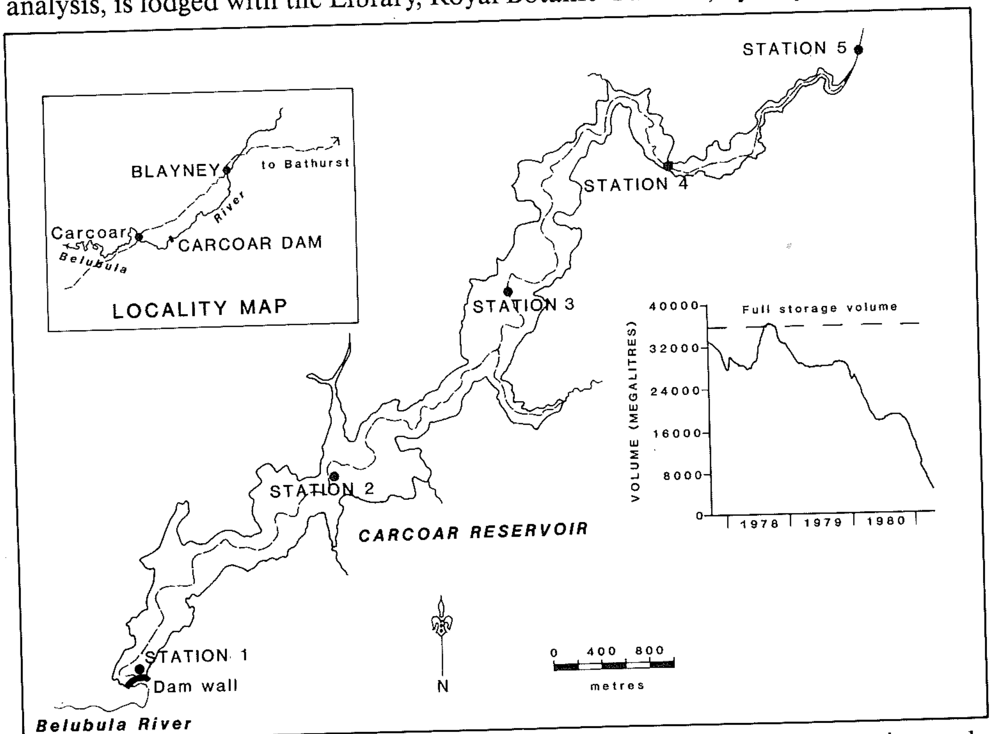

Figure 1. Location of Carcoar Dam and the Belubula River showing collecting stations and the volume stored in the dam over the study period.

Results and discussion

Sixty-one algal taxa[1] were recorded; 33 were common (frequency >5%), 24 were rare (frequency ≤5%) and four were found only as drift material (Table 1, Status). The common taxa are the chief indicators of changing conditions within the Dam; the rare species are of far less importance, but often reinforce the patterns shown by the common taxa.

Belubula River station

The Belubula River station (station 5) differed in many ways from the four dam stations, with many different species showing lower or higher frequency or abundance ratings (Table 1, Distribution Between Stations). The common taxa were present throughout the year but showed increased frequencies from late winter to summer and high abundance usually between October and November.

Seasonal growth

There were relatively fewer differences in persistence or abundance between the four dam stations than between the dam stations and the river station, with 12 of the 33 common taxa being found at all four stations within the dam in each of the first three years and at stations 1 to 3 in the fourth year (during drought) (Table 1, Persistence). Most of these occurred at any time of the year, but often were more common during summer (Table 1, Annual Distribution). Other species were less evenly distributed, appeared later in the year and usually were less common. Only *Anabaina*, *Anacystis* and *Melosira granulata* showed medium or high abundance ratings each year at all dam stations (Table 1, Abundance); *Sphaerocystis* showed a similar pattern except during the drought. Most taxa were more common in summer, but the greatest total biomass occurred later, between February and April, due largely to the very heavy growth of the blue-green algae *Anacystis* and *Anabaina*.

Depth of station

Most taxa flourished at or near the surface (top 0.5 m) rather than at lower depths. More frequent in bottom collections, however, were *Melosira granulata*, *Schizothrix*, *Staurastrum* and usually *Cyclotella* (Table 1, Vertical Distribution).

High and very high abundance ratings were recorded only in surface collections for *Anabaina* and *Anacystis* (and usually also *Sphaerocystis*), while *Melosira granulata* and *Staurastrum* became abundant or very abundant either in surface collections or equally in surface and bottom collections. Very similar results were reported for Chaffey Dam by May and Powell (1986).

Drought

From the onset of drought (February 1980), the common taxa showed differing responses: as increased or reduced frequency, slightly earlier seasonal appearance, wider distribution or greater abundance (Table 1, Drought). In addition, 12 taxa were found only during the drought period, though all were rare.

Nutrients

Stratification of the dam water occurred to a varying degree each summer (data supplied by Water Resources Commission). The associated anoxia and high nutrient levels in the bottom water, combined with adequate light penetration,

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[1] Where only one species of a genus is reported, the generic name alone is used. A full list of species names and authorities is given in Table 1.

Table 1: Species recorded from Carcoar Dam and Belubula River, together with information about their occurrence related to the position of stations, depth of water, and drought.

Taxon	1 Status	2 Dist. b. Stns.	3 Persist-ence	4 Annual Dist.	5 Abund.	6 Vert. Dist.	7 Drought
Actinastrum hantzschii Lag.	C	I	—	Jan–Mar	1	—	—
Agmenellum thermale (Kuetz.) Drouet & Daily	R	—	—	—	—	—	—
Anabaina circinalis Rabenh.	C	I	x	Jan	2	Ss	M
Anacystis cyanea *(Kuetz.) Drouet & Daily	C	I	x	Feb	2	Ss	—
(Microcystis aeruginosa Kuetz.)							
Ankistrodesmus falcatus (Corda) Ralfs	C	I	x	Sept	1	S	L
Aphanizomenon (ecophene of *Calothrix parietina* (Naeg.) Thuret)	R	—	—	—	—	—	—
Botryococcus braunii Kuetz.	C	L	x	Nov	1	S	M
Ceratium hirundinella (O. F. Muell.) Dujardin	R	—	—	—	—	—	x
Chlamydomonas sp.	R	—	—	—	—	—	x
Cladophora sp.	D	—	—	—	—	—	—
Closterium aciculare T. West	C	L	—	Feb–Mar	1	—	M
C. acutum (Lyngb.) de Bréb.	C	I	—	Apr	2	—	M
C. parvulum Naeg.	C	F	—	Jan	—	—	—
C. sp. 1	C	F	—	Jun, Dec	—	—	—
Crucigenia rectangularis (A. Braun) Gay	R	—	—	—	—	—	—
Cyclotella meneghiniana Kuetz.	C	—	x	Jan–Sept	2	B	—
Diatoms (undetermined species)	C	—	x	Dec–Jan	2	—	M
Dictyosphaerium pulchellum Wood	R	—	—	—	—	—	—
Eudorina elegans Ehrenb.	R	—	—	—	—	—	—
Euglena acus Ehrenb.	C	F	—	Jan, Aug	—	—	—
E. polymorpha Dang.	C	I	—	Feb	2	—	—
E. sp. aff. *tripteris* (Dujardin) Klebs	R	—	—	—	—	—	x
E. sp. 1	R	—	—	—	—	—	x
Glenodinium sp.	R	—	—	—	—	—	—
Gonium pectorale Muell.	R	—	—	—	—	—	—
Melosira granulata (Ehrenb.) Ralfs	C	I	x	Sept	2	B	—

Taxon	1 Status	2 Dist. b. Stns.	3 Persist- ence	4 Annual Dist.	5 Abund.	6 Vert. Dist.	7 Drought
M. varians Ag.	C	—	—	Oct–Nov	—	—	L
Micractinium pusillum Fres.	R	—	—	—	—	—	—
Microcoleus lyngbyaceus (Kuetz.) Crouan	C	—	—	Jan–Feb	—	—	M
Oedogonium sp.	D	—	—	—	—	—	—
Oocystis gigas Archer	C	L	—	Feb	1	—	—
O. parva West & West	C	I	x	Dec	1	—	—
Oscillatoria ?lutea Ag.	C	I	—	Dec	—	—	—
Pandorina morum (Muell.) Bory	C	—	—	Jun	—	—	—
Pediastrum boryanum (Turp.) Meneghini	C	F	—	Jan	—	—	—
P. duplex Meyen	C	—	—	Dec	—	—	M
Peridinium granulosum P'fair	R	—	—	—	—	—	x
Phacus caudatus Huebner	C	F	—	Jan	—	—	—
Scenedesmus abundans (Kirchner) Chodat	R	—	—	—	—	—	—
S. bijugus (Turp.) Kuetz.	C	—	—	Jan–Feb	—	—	—
S. obliquus (Turp.) Kuetz.	C	—	—	Dec–Jan	—	—	M
S. quadricaudus (Turp.) de Bréb.	C	F	—	Jan–Feb	—	—	M
Schizothrix calcicola (Ag.) Gomont	C	I	x	Dec	1	B	M
Schroederia judayi G. M. Smith	R	—	—	—	—	—	—
Selenastrum bibranum Reinsch.	R	—	—	—	—	—	x
Sphaerocystis shroeteri Chodat	C	I	x	Oct	2	S	—
Spirogyra sp.	D	—	—	—	—	—	—
Spirulina subsalsa Oersted	R	—	—	—	—	—	x
Staurastrum pingue Teiling	C	I	x	Dec–May	2	B	—
Stigeoclonium sp.	D	—	—	—	—	—	—
Synura adamsii G. M. Smith	C	—	—	Aug	1	—	—
Tetraëdron constrictum G. M. Smith	R	—	—	—	—	—	—
T. limneticum Borge	R	—	—	—	—	—	x
T. regulare Kuetz.	R	—	—	—	—	—	—
T. trigonum (Naeg.) Hansgirg	R	—	—	—	—	—	x

Tetraspora lubrica (Roth) Ag.	R	—	—	—	—	—	x
Trachelomonas armata (Ehrenb.) Stein	C	—	—	Mar–Apr	1	S	M
T. girardiana (P'fair) Deflandre	R	—	—	—	—	—	x
T. hispida (Perty) Stein	C	—	x	Jan	2	S	—
T. sp.	R	—	—	—	—	—	x
Volvox globator L.	C	L	—	Nov	1	—	—

1 Status (all species). C = Common species (>5%). R = Rare species (≤5%). D = Drift species.

2 Distribution between stations (common species). L = Lacustrine species (absent from station 5). I = Intermediate species, not strongly lacustrine or fluvial. F = Fluvial species (abundant only at station 5).

3 Persistence (common species). x = Species that occurred in all four dam stations in each of the first 3 years and in stations 1–3 during drought.

4 Annual Distribution (distribution during the year) (common species). Most common months of occurrence at most stations.

5 Abundance (common species). 1 = Medium abundance rating. 2 = High abundance rating. (Some abundance figures are also mentioned under Distribution Between Stations, Vertical Distribution, and Effect of Drought.)

6 Vertical distribution (common species). S = Frequency usually highest in surface collections. B = Frequency usually highest in bottom collections. s = abundance usually highest in surface collections.

7 Drought (effect of drought). Common species: M = species becoming more common during drought. L = species becoming less common during drought. Rare species: x = species found only during drought (1980–81).

* *Anacystis* Meneghini (1837) is the oldest name (Drouet & Daily, 1956) available for the genus when it is treated in the broad sense including *Microcystis* Lemmermann (1907). The latter name was conserved (Lanjouw, 1961) against the earlier name *Microcystis* Kuetzing (1833), a Euglenoid genus. The type species for the genus *Anacystis* is *A. marginata* Meneghini (1837) (now = *A. montana* (Lightft.) Dr. & Daily), while the type species for the segregate genus *Microcystis* is *M. aeruginosa* (Kuetzing) Kuetzing (1848). The name of the latter species, when treated as *Anacystis*, is *A. cyanea* (Kuetzing) Drouet & Daily (1952), the name *A. aeruginosa* being already in use for a different species, *A. aeruginosa* (Zanardini) Drouet & Daily (1948).

stimulated intensive growth each year of *Anacystis* and *Anabaina*, both potentially toxic Cyanophytes. A larger biomass, indicated by higher chlorophyll *a* readings in surface water, developed when more definite stratification occurred. The very dense surface growth of blue-green algae at Station 4 parallels the results found in Burrinjuck Dam (May 1978), showing that these algae occur most often in regions just below the entry of nutrient-rich rivers into the dam. Thus, the stratification and bottom water nutrient concentration appear to control the total biomass of blue-green algae produced, but it appears to be the condition of the surface water that determines the dominant species.

Relative occurrence of *Anacystis* and *Anabaina*

It seems likely that it is changes in the conditions in the surface water, in particular changes in the concentration of available nitrogen (NO_x), that determine which of the Cyanophyte pair of species becomes dominant, the nitrogen-fixing *Anabaina* flourishing better than the non-nitrogen-fixing *Anacystis* when there is a lower NO_x concentration (see Fitzgerald, 1969). It appears that, with lower concentrations of NO_x, *Anabaina* is stimulated to fix its own atmospheric nitrogen and so can continue dense growth, provided that phosphorus is available; meantime the growth of *Anacystis* is restricted by the nitrogen shortage.

Later in the season, after April, possibly due to a drop in temperature, a reduction of biomass (and hence more available nitrogen) appears to be associated with the disappearance of *Anabaina*; some nitrogen will be recycled from the decomposition of *Anabaina* and this will further aid the growth of *Anacystis*. Ganf (1980) and Ashton (1979) have found temperature changes to be important in controlling shifts in species composition.

Comparison with other dams

The overall composition of the phytoplankton of Carcoar Dam is compared with that of other Australian Dams in Table 2. Since 1909, when the study of Yan Yean was carried out, the general incidence of blooms of Cyanophyte algae has increased (Carmichael 1981), as occurs at Carcoar and in numerous other reports. This demonstrates a drift from predominantly Chlorophycean-dominated clean water to a more enriched (polluted) water dominated by Cyanophytes with or without associated Euglenophytes.

Control measures

Traditionally, control of unwanted algae is by chemical means, by limiting the supply of nitrogen, phosphorus or both in the water (usually this comes from point sources). In Carcoar Dam at least, the practical method of controlling the excessive growth of blue-green algae is to reduce the level of phosphorus in the water, since a reduction in nitrogen is offset by extra nitrogen-fixing by *Anabaina*.

If the effects of stratification are reduced (by aerating the hypolimnion or by using artificial circulation to mix the whole water column), particularly early in the season, this could also limit the growth of blue-green algae (Pastorok *et al.* 1980).

Acknowledgements

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Table 2: Comparison of phytoplankton composition at various Australian dams
(A = number of species; B = number of abundant genera).

	Carcoar (May, 1988)		Chaffey (May & Powell, 1986)		Burrinjuck (May, 1978)		Yan Yean (West, 1909)
Algal class	A	B	A	B	A	B	B
Chlorophyta	36 (59)*	4 (36)	25 (52)	8 (53)	21 (65)	88 (77)	8 (80)
Chrysophyta	5+ (8)	3 (27)	5+(10)	3 (20)	4+(13)	22 (19)	2 (20)
Cyanophyta	8 (13)	2 (18)	6 (13)	2 (13)	4 (13)	4 (3)	0 (0)
Euglenophyta	9 (15)	2†(18)	10 (21)	1 (7)	2 (6)	0 (0)	0 (0)
Pyrrhophyta	3 (5)	0 (0)	2 (4)	1 (7)	1 (3)	1 (1)	0 (0)
TOTAL	61	11	48	15	32	115	10

* Percentages in brackets
\+ Understated as unidentified species grouped as 'Diatoms'
† Only at station 5

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