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Aquatic angiosperms of some British Columbia saline lakes

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Some limnological parameters and the distribution of aquatic angiosperms were studied in 12 similar and neighbouring lakes in the Chilcotin region of British Columbia. The lakes had similar temperature patterns, but conductivities ranged from 40 to 12,000 μmhos/cm at 25 C. Angiosperms occurred in lakes of less than 4,000 μmhos, and showed zonation with depth. Most species seen were cosmopolitan. The number of species recorded decreased with increasing alkalinity. A discrete assemblage of plants was restricted to the most freshwater lake (40 μmhos). Macrophytes occur in saline lakes elsewhere to a conductivity of 30,000 μmhos. The evidence suggests that when the dominant anion is sulphate, plants can tolerate much higher alkalinity levels than when carbonate or bicarbonate. In tropical areas, temperature may also affect salinity tolerance of cosmopolitan species.

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Introduction

During an investigation of the littoral invertebrates in a series of saline lakes in the Chilcotin region of British Columbia, it was noted that neighbouring lakes often had different vegetation. Although the vegetation of saline lakes has been considered in Saskatchewan (Rawson and Moore, 1944) and elsewhere in northwestern North America, it has not been investigated in British Columbia. Athalassic lakes vary greatly in ionic composition, which could affect vegetation. However, since in the Chilcotin saline lakes the dominant ion is often sodium, whereas many of those in Saskatchewan are magnesium dominated, it seemed worth while to compare lakes in the two regions.

Materials and Methods

Twelve lakes of equivalent size and morphometry, and encompassing a wide salinity range, were selected for study from a larger group on undulating dry parkland on the Becher's Prairie of the Chilcotin Plateau. All lakes are at an altitude of 950 m, and lie on glacial till underlain by Permian, Triassic, and Tertiary Plateau Beds. Mean precipitation is 35 cm/yr, and mean monthly temperatures range from −10 C in January to +25 C in July. The lakes have been studied by Scudder (1969), Topping (1969), and Cannings (1972), and these provide more detail on the localities; suffice is to state here that all lakes lacked permanent inflow and outflow streams.

Water temperatures were measured in five lakes (Barnes, Lye, Round-up, Greer, and East) using Ryan temperature chart recorders placed in 20-cm-deep water from mid-May to mid-October 1972. Water samples were collected monthly, filtered, and conductivity determined using a Copenhagen radiometer; results were corrected to 25 C. Water light transmission was measured every four days with a 20-cm Secchi disc, and oxygen was measured monthly by the Miller method (Walter *et al.*, 1970).

In each lake the presence or absence of cyanophyte blooms was noted, and records kept of aquatic angiosperm distribution, abundance and flowering or fruiting status. Herbarium species were collected monthly and plants were identified using Steward *et al.* (1963) and Hitchcock *et al.* (1959–69). Determinations were verified in the Herbarium of the University of British Columbia.

Results

ENVIRONMENTAL PARAMETERS

The location and limnological data for each lake are given in Table I. Temperature measurements showed that warming was rapid after

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TABLE I

Some physical and chemical features of the lakes studied (in part after Scudder, 1969, and Topping, 1969) [lake names in parentheses are those in Scudder (1969); others are those on 1:50.000 map *MCE 120*, Edition 2]

Lake	Position		Area (ha)	Depth (m)		pH	Major cation	Major anions	Conductivity μmhos/cm. 25 C)	Mean oxygen (surface) mg/1
	Lat. N	Long. W		mean	max.					
Barnes (*Box 4*)	52°00′30″	122°28′	17.2	2.0	4.5	9.3–9.7	Na	CO_3, HCO_3	11820	7.9
Round-up (Phalarope)	52°02′	122°30′30″	30.8	2.6	6.2	9.2–9.3	Na	CO_3, HCO_3	6890	8.1
Lye (*Box 20–21*)	52°01′	122°29′30″	46.5	2.8	5.4	9.1–9.6	Na	CO_3, HCO_3	6550	8.1
Jackson (Near Op. *Box 4*)	52°00′	122°27′30″	5.8	1.4	2.3	8.8	Na, Mg	SO_4	3230	
Greer (*Box 89*)	51°59′30″	122°26′	15.2	1.0	2.3	8.4–9.5	Na	HCO_3	1600	9.8
Rock (Rock)	51°58′	122°25′	34.6	1.1	2.5	8.6–10.5	Na	HCO_3	1500	9.8
(Near Phalarope)	52°02′	122°31′	5.1	1.3	3.0	8.6	Na	HCO_3	1460	
(Near Op. Cresc.)	52°59′30″	122°27′	6.9	1.4	3.3	9.0	Mg	CO_3, HCO_3	830	
(*Box 17*)	51°59′30″	122°26′30″	2.7	1.1	3.3	9.0	Mg	CO_3, HCO_3	780	
Barkley (Op. *Box 4*)	52°00′	122°28′	4.5	0.7	2.2	9.3	Mg	CO_3, HCO_3	720	
East (Racetrack)	51°59′30″	122°26′	27.0	1.9	6.5	7.8–9.7	Na	HCO_3	600	13.0
(*Box 27*)	51°59′	122°25′	4.3	0.5	1.5	6.9	Mg	CO_3, HCO_3	40	

ice-melt at the end of April, and thereafter water temperatures fluctuated above 20 C from mid-May to early September, dropping steadily until ice formed again in October. Air temperatures below freezing and up to 38 C were occasionally recorded during the summer, but the maximum water temperature recorded was 26.7 C. Temperature patterns of all lakes studied were similar, suggesting that temperature was not a factor influencing plant distribution between lakes.

Specific conductivities increased sharply as surface melt-waters became mixed with more saline waters beneath, and there was some later increase, probably owing to evaporation. Mean conductivities have been used in Table I and in discussion. Conductivity thus appears to be a major feature of difference between lakes.

Transparency fluctuated with season, associated with the presence of cyanophyte blooms in the less saline lakes. Oxygen levels were also least steady in these lakes, but neither factor was judged likely to affect the macroflora.

PLANTS

Zonation

Aquatic angiosperms present are listed in Table II. Submergent forms were first seen in lakes of less than 4,000 μmhos/cm (mean conductivity) by the end of May. Growth was rapid, forming dense swards which remained well developed all summer. Plants started to die back in early September, when lakes were heavily used by migrating ducks, and were absent when ice formed again.

Distinct zonation with depth was seen among submerged plants. *Zanichellia palustris* L. was usually found close inshore, then *Myriophyllum spicatum* L. and *Potamogeton* species, and finally *Ruppia maritima* L. to a depth of 1.6 m.

A marginal fringe of *Juncus balticus* Willd. was seen around most lakes, but through the seasonal fall in water level this was usually stranded out of the water by midsummer. *Scirpus validus* Vahl formed isolated clumps in 20–50 cm water in several lakes, and *Poly-*

TABLE II

Distribution of aquatic angiosperms found in saline lakes of the Chilcotin region, British Columbia

Lakes	Barnes	Round-up	Lye	Jackson	Greer	Rock	Nr. Phalarope	Nr. Op. Cresc.	*Box 17*	Barkley	East	*Box 27*	Plant status*
Approximate conductivity (μmhos/cm at 25 C)	12,000	7,000	6,500	3,000	1,500	1,500	1,500	800	800	700	600	40	
†*Scirpus validus* Vahl	×	×	×		×	×					×		C, B
†*Juncus balticus* Willd.	×	×	×		×	×					×		C, B
†*Polygonum amphibium* L.				×	×		×	×	×	×	×		C
Myriophyllum spicatum L.				×	×	×		×	×	×	×		C, B
Potamogeton pectinatus L.				×	×	?	?	×	×	×	×		C, B
Ruppia maritima L.				×	×	×	×						C, B
Zannichellia palustris L.					×	×		×	×	×			C, B
Potamogeton pusillus L. (or *P. foliosus* Raf.)								×		×	×	×	C (A)
Ceratophyllum demersum L.								×		×	×		C
Potamogeton richardsonii (Bennett) Rydb.									×	×			A
†*Sagittaria cuneata* Sheld.									×			×	A
†*Hippurus vulgaris* L.										×			C
Potamogeton natans L.												×	C, B
†*Sparganium emersum* Rehmann												×	C
Utricularia vulgaris L.												×	C
†*Callitriche ?verna* L.												×	C

*C, circumboreal or cosmopolitan species; *A*, widespread in North America; *B*, reported from brackish water habitats in Hitchcock *et al.* (1959–69); † Emergent form (all others submergent).

gonum amphibium L. grew both on the damp margins and the water surface of lakes below 4,000 μmhos/cm.

Correlation With Salinity

Almost all species recorded were cosmopolitan or circumboreal in distribution, and many were noted in Hitchcock *et al.* (1959–69) to occur in brackish waters. In the freshwater environment of *Box 27* a new assemblage of typically freshwater plants was encountered. As these did not enter the alkaline lake series, only a few of the commonest are reported in Table II.

Not all of the brackish-water species had equivalent tolerance levels, as indicated in Table II, and numbers of species decreased with increasing salinity. Species tolerating highest salinities were often found across the entire range studied, but an exception is seen in the restriction of *Ruppia maritima* L. to higher levels only. *Sagittaria cuneata* Sheld. and *Hippurus vulgaris* L. were found erratically; they seem to belong to the freshwater habitat, and their presence in more alkaline lakes may be connected with ground-water seepage.

Discussion

Results indicate a sharp division between the more saline lakes (over 4,000 μmhos/cm) with moderate oxygen levels, little conspicuous phytoplankton, and no submerged plants, and those less saline with often high oxygen, algal blooms, and dense beds of submerged vegetation. Since most plants encountered were cosmopolitan, comparison between saline water bodies in different regions has relevance and interest.

All but one of the Chilcotin lakes studied are dominated by carbonate or bicarbonate (Table I). Highly saline lakes had sodium as the dominant cation, but some with conductivities under 4,000 μmhos were dominated by magnesium (Scudder, 1969). Lakes in Saskatchewan are predominantly magnesium sulphate (Rawson and Moore, 1944). Those in the Pacific Northwest of the United States are often predominantly sodium sulphate (Brannon, 1911; Castenholz, 1960); the alkaline crater lakes in the Rift Valley of Kenya are mainly sodium bicarbonate (Jenkins, 1936), and most Australian saline lakes are dominated by sodium chloride (Williams, 1966, Bayly and Williams, 1966).

Since conductivity values depend on the specific conductance of each ion present, attempts to convert total dissolved solids data may vary in precision. For general comparisons of data expressed in different ways, we have used the median value of the usual range of the constant in Williams (1966), such that $T = 0.65\ K$, where K is the conductivity in μmhos/cm at 25 C, and T is total dissolved solids in parts per million. All literature results have thus been expressed as appropriate conductivities.

No clear correlation emerges of plant distribution with any particular conductivity. Thus *Potamogeton pectinatus* L. occurs at 30,500 μmhos in Saskatchewan (Rawson and Moore, 1944), but not above 4,000 μmhos in British Columbia. *Ruppia maritima* also reaches these limits in the two localities, and is found at about 15,000 μmhos in the sodium sulphate Devil's Lake, North Dakota (Brannon, 1911). *Potamogeton richardsonii* (Bennett) Rydb. and *Ceratophyllum demersum* L. are found up to 3,500 μmhos in Saskatchewan, but not over 800 μmhos in British Columbia.

Thus, where the dominant anion is sulphate, euryhaline plant species are found to tolerate much higher salinities than when the water chemistry is dominated by carbonate or bicarbonate. The dominant cation does not show the same correlation. In corroboration, a fine-leaved najadaceous species was seen in a Cariboo region lake similar in morphometry, altitude, and latitude to those in the Chilcotin, but dominated by sodium sulphate, and with a mean conductivity of 16,500 μmhos (Scudder, 1969).

In East Africa, *P. pectinatus* and *C. demersum* did not occur at over about 320 μmhos. These lakes are, like those in the Chilcotin, largely sodium carbonate (Jenkin, 1936). Since conductivity values need upward correction by 2.5 per cent per degree Celsius (Williams, 1966), the lower alkalinity limits of these plants may be influenced by higher mean lake temperatures. However, some other effect, perhaps of temperature and alkalinity acting synergistically, must be postulated to account for the great difference between regions.

Thus, in some temperate regions at least there is a marked correlation of plant distribution with the dominant anion. In Saskatchewan, lakes with more sodium than magnesium tended to be more productive of invertebrates (Rawson and Moore, 1944), but the importance of the cation may not be general. Since submerged vegetation provides another dimension of structural diversity for invertebrates (Shelford, 1918), the fauna of lakes may be both directly (through their euryhaline tolerance levels) and indirectly (through the effect on plants) limited by the water chemistry.

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References

BAYLY, I. A. E., and WILLIAMS, W. D. (1966). Chemical and biological studies on some saline lakes of south-east Australia. *Aust. J. Mar. Freshwat. Res.*, 17:177–228.

BRANNON, M. A. (1911). Factors influencing the flora of Devil's Lake, North Dakota. *Int. Rev. Ges. Hydrobiol.*, 4:291–299.

CANNINGS, R. A. (1972). *An Ecological Study of Some of the Chironomidæ Inhabiting a Series of Saline Lakes in Central British Columbia.* M.Sc. thesis, Univ. of British Columbia.

CASTENHOLZ, R. W. (1960). The algæ of saline and freshwater lakes in the Lower Grand Coulee, Washington. *Research Studies* (Washington State University, Pullman), 28:125–155.

HITCHCOCK, C. L., CRONQUIST, A., OWNBEY, M., and THOMPSON, J. W. (1959–1969). *Vascular Plants of the Pacific Northwest, Vol. 1 to 4.* Univ. Wash. Press, Seattle, Wash.

JENKIN, P. M. (1936). Reports on the Percy Sladen expedition to some Rift Valley lakes in Kenya in 1929—VII. Survey of the ecological results with special reference to the alkaline lakes. *Ann. Mag. Nat. Hist., Ser. 10,* 18:133–181.

RAWSON, D. S., and MOORE, S. E. (1944). The saline lakes of Saskatchewan. *Can. J. Res.*, 22:141–201.

SCUDDER, G. G. E. (1969). The fauna of saline lakes in the Fraser Plateau in British Columbia. *Verh. Int. Ver. Limnol.*, 17:430–439.

STEWARD, A. N., DENNIS, L. R. J., and GILBEY, H. M. (1963). *Aquatic Plants of the Pacific Northwest,* 2nd ed., Oregon State Univ. Press, Corvallis, Ore., 261 p.

SHELFORD, V. E. (1918). Conditions of existence. *In* Ward, H. B., and Whipple, G. C., *Freshwater Biology.* p. 21–60.

TOPPING, M. S. (1969). *Giant chromosomes, Ecology and Adaptation in Chironomus Tentans.* Ph.D. thesis, Univ. of British Columbia.

WALKER, K. F., WILLIAMS, W. D., and HAMMER, U. T. (1970). The Miller method for oxygen determination applied to saline lakes. *Limnol. Oceanogr.*, 15:814–815.

WILLIAM, W. D. (1966). Conductivity and the concentration of total dissolved solids in Australian lakes. *Aust. J. Mar. Freshwat. Res.*, 17:169–176.