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Accessory Publication

Relative salinity tolerance of macroinvertebrates from the Barwon River, Victoria, Australia

Ben J. Kefford[A,C], *Phil J. Papas*[B] *and Dayanthi Nugegoda*[A]

[A]Department of Biotechnology and Environmental Biology, RMIT University, PO Box 71, Bundoora, Vic. 3083, Australia.

[B]Arthur Rylah Institute for Environmental Research, Department of Natural Resources and Environment, 123 Brown Street, Heidelberg, Vic. 3084, Australia.

[C]Corresponding author. Email: ben.kefford@rmit.edu.au

Abstract. Salinity levels are rising in many freshwater environments, yet there are few direct measurements of salinity tolerance of organisms likely to be salt sensitive. The relative salinity tolerance to artificial seawater of macroinvertebrates from the Barwon River in Victoria, Australia, was assessed by measuring the 72-h lethal concentrations required to kill 50% of individuals (LC_{50}). LC_{50} values ranged from an electrical conductivity of 5.5 to 76 mS cm^{-1} (mean 31 mS cm^{-1}, $n = 57$) and followed a log-normal distribution. The most salt-sensitive groups tested were Baetidae (LC_{50} value range: 5.5–6.2 mS cm^{-1}), Chironomidae (10 mS cm^{-1}) and several soft-bodied non-arthropods (Oligochaeta, Gastropoda, Nematomorpha, Tricladida and Hirudinea; 9–14 mS cm^{-1}). Other groups, from least to most tolerant, were non-baetid Ephemeroptera (>12.6–15 mS cm^{-1}), Plecoptera (>12.6–>20 mS cm^{-1}), Trichoptera (9–>26 mS cm^{-1}), Corixidae (18–26 mS cm^{-1}), non-corixid Hemiptera (33–44 mS cm^{-1}), Coleoptera (19–54 mS cm^{-1}), Hydracarina (39 mS cm^{-1}) and Odonata (30–55 mS cm^{-1}), and macrocrustaceans (Decapoda, Isopoda and Amphipoda; 38–76 mS cm^{-1}).

Lethal salinity tolerance and selected field distributions of freshwater macroinvertebrate taxa tested in the present study

Where results were available for a number of methods, water temperatures, etc., the information given is for the method most comparable with the present study. The tolerances were established in artificial seawater (ASW), seawater (SW), saline lake water (SLW), oil brine (OB), estuary water (EW), evaporated river water (ERW), food salt (FS), sodium chloride (NaCl), sodium sulfate (Na_2SO_4) or, where not given, it is unspecified in the original publication. ASW, SW, SLW, EW and OB were diluted were appropriate. The time of the test is given in hours or days.

Taxa	Location	Measure and salt source	Time	Tolerance (mS cm^{-1})	References
Gastropoda					
Physa	USA	LC_{50} in OB	96 h	8.5	1
Physa	USA	LC_{50} in NaCl	96 h	7.1	1
Burnupia sternchorias (Ancylidae)	South Africa	LC_{50} in Na_2SO_4	96 h	7.5–10	2
Potamopyrgus antipodarum (Hydrobiidae)	New Zealand	Remains out of its shell up to 28			3
Posticobia sp. (Hydrobiidae)	Australia	LC_{50} in SW	96 h	31	4
Coxiella (Pomatiopsidae)	Australia	Remains out of its shell up to 160 in SLW			5
Oligochaeta					
Eight Tubificidae, one Lumbriculidae	North America	Range in LC_{50} values	96 h	9.9–14	6, 7
Hirudinea					
All Hirudinea	Canada	Maximum field distribution of 3.3 but most species not found above 1.7			8
Neophelopsis obscura (Erpodellidae)	Canada	Die within 2 h at 1.2 but survive >30 days at 1.1 in SLW			8
Actinobdella inequiannulata (Glossiphoniidae)	Not given	Only surviving to 13			9
Baetidae (Ephemeroptera)					
Cloen crassi	South Africa	Tolerance in SW		9.5–14	10
Cloen africanum	South Africa	Tolerance in SW		4.6–9.3	10
Unidentified Baetidae	USA	LC_{50} in OB	96 h	11	1
Mix of Baetidae	South Africa	LC_{50} in NaCl	96 h	5.0–10	2
Mix of Baetidae	South Africa	LC_{50} in Na_2SO_4	96 h	10	2
Tricotythus sp.	South Africa	LC_{50} in NaCl	96 h	1. 0	11
Tricotythus sp.	South Africa	LC_{50} in Na_2SO_4	96 h	4.0–8.0	11
Tricotythus tinctus	South Africa	Mean LC_{50} in NaCl	96 h	2.9	12
Tricotythus tinctus	South Africa	Mean LC_{50} in Na_2SO_4	96 h	2.8	12
Afroptilum sudafricanum	South Africa	LC_{50} in Na_2SO_4	96 h	2.2	12
Adenophlebia auriculata	South Africa	LC_{50} in Na_2SO_4	96 h	5.3	12
Choroterpes sp.	South Africa	LC_{50} in NaCl	96 h	2.9	12
Baetis rhodani	UK	Survived 4 h in SW at 12 but not at 23			13
Rhithrogena semicolorata	UK	Survived 4 h in SW at 12 but not at 23			13
Other Ephemeroptera					
Mix of Leptophlebiidae and Caenidae	Australia	LC_{50} in FS	96 h	20	14
Hexagenia (Ephemeridae)	USA	LC_{50} in OB	96 h	14	1
All Ephemeroptera	Australia	Maximum field distribution 5.7			15
Plecoptera					
Dinocras cephalotes and *Perla bipunctata* (Perlidae)	UK	Both survived 6 h in SW at 46 but not 24 h			13
Small unidentified Nemouridae	UK	Could not survive 4 h in SW at 46			13
All Plecoptera	Australia	Maximum field distribution 4.2			15
All Plecoptera	Spain	Maximum field distribution 8.4			16
Paragnetina media (Perlidae)	Canada	LC_{50} in NaCl	72 h	16–21	17
Trichoptera					
Cheumatopsyche modica, *C*. sp. 1 and *Asmicridea edwardsii* (Hydropsychidae)	Australia	Increased mortality in laboratory tests	96 h	1.6–3.2	18
Phryganea grandis and *P. pagetana* (Phryganeidae)	Norway	LC_{50}	96 h	>27	19
Limnephilus marmoratus (Limnephilidae)	Norway	LC_{50}	96 h	Less tolerant than above	19
Limnephilus affinis	UK	Survived several months in 34			20
L. stigma and *Anabolia nervosa* (Limnephilidae)	UK	Died with 3 days in 9.3 NaCl			21
Corixidae (Hemiptera)					
All Corixidae	Australia	Maximum field distribution 18			22
Sigara australis and *Agraptocorixa hitifrons*	Australia	Did not survive in laboratory much beyond 18			20
Micronecta gracilis	Australia	Unaffected up to 7.9			18
Other Hemiptera					
Anisops barbata (Notonectidae)	India	Survived 76 h in SW at 19			23
Sphaerodema rusticum (Belostomatidae)	India	Survived 72 h in SW at 23			23
Ranatra elogata (Nepidae)	India	Survived 48 h in SW at 23			23
Laccotrephes ruber (Nepidae)	India	Survived 66 h in SW at 37			23

Coleoptera					
Cybister tripunctalus, C. cognatus, C. sugillatus (Dytisicidae)	India	Survived between 66 and 96 h in SW at 46			23
C. tripunctatus	India	Survived 65 h in SW at 33			23
Diaptomus clavipes (Diaptomidae)	USA	LC_{50} in OB	96 h	8.7	1
Diaptomus clavipes	USA	LC_{50} in NaCl	96 h	5.6	1
Adult Elmidae	Australia	Mortal above	96 h	4.8	18
Odonata					
Bradynopyga geminata (Libellulidae)	India	Survived 96 h in SW at 19			23
Tramea virgina (Libellulidae)	India	Survived 96 h in SW at 19			23
Idictinogomphus rapax (Gomphidae)	India	Survived 86 h in SW at 23			23
Hemianax ephippiger (Aeshnidae)	India	Survived 90 h in SW at 19			23
Unidentified Libellulidae	USA	LC_{50} in oil brine	96 h	20	1
Unidentified Libellulidae	USA	LC_{50} in NaCl	96 h	21	1
Unidentified Coenagrionidae	USA	LC_{50} in oil brine	96 h	20	1
Decapoda					
Paratya australiensis	Australia	LC_{50} in EW	72 h	29	24
P. australiensis	Australia	LC_{50} in SW	96 h	34	25
P. australiensis	Australia	LC_{50} in SW	96 h	35	4
P. australiensis	Australia	LC_{50} in ASW	96 h	6.0	26
P. australiensis	Australia	LC_{50} in SW	96 h	30	27
Caridina nilotica (Atyidae)	South Africa	LC_{50} to mix of NaCl and Na_2SO_4	96 h	4.4	12
Amarinus lacustris	Australia	$LC_{3.5}$ in SW	96 h	61	4
A. lacustris	Australia	LC_{50} slow acclimatization in ERW	Weeks	48	28
Cherax quadricarinatus (Parastacidae)	Australia	LC_{30} in SW	21 days	32	29
C. destructor	Australia	LC_{50} juvenile and adult in SW	96 h	34, 40	30
Macrobrachium australiense (Palaemonidae)	Australia	LC_{50} in SW	96 h	48	4
M. potiuna	Brazil	LC_{50} in SW	48 h	19	31
Cambarus sp. (Cambaridae)	USA	LC_{50} in OB	96 h	24	1
Cambarus sp.	USA	LC_{50} in NaCl	96 h	23	1
Amphipoda					
Austrochiltonia australis	Australia	LC_{50} in SW	96 h	39	4
A. subtenuis	Australia	LC_{50} in SW	96 h	42	4
Hyalella azteca (Talitridae)	USA	LC_{50} in OB	96 h	14	1
H. azteca	USA	LC_{50} in SLW	96 h	25	32
Gammarus fossarum (Gammaridae)	Netherlands	Survived half as long as specimens in controls in SW at 4.0			33

1, Clemens and Jones (1954); 2, Palmer *et al*. (1996); 3, Winterbourn (1970); 4, Williams (1984); LC_{50} values calculated from raw data; 5, Williams and Mellor (1991); 6, Chapman and Brinkhurst (1980); 7, Chapman *et al*. (1982); 8, Scudder and Mann (1968); 9, Sawyer (1986); 10, Forbes and Allanson 1970, 11, Goestsch and Palmer (1997); 12, Palmer and Scherman (2000); 13, Williams and Williams (1998); 14, Kefford and Robley (1996); 15, Kefford (1998); 16, Prenda and Gallardo-Mayneco (1999); 17, Kapoor (1979); 18, Metzeling *et al*. (1995); 19, Haage (1969); 20, Sutcliffe (1960); 21, Sutcliffe (1961); 22, Knowles and Williams (1973); 23, Shirgur and Kewalramani (1973); 24, Walker (1972); 25, Hargraves (1975); 26, Bacher and Garnham (1992); 27, Walsh (1994); 28, Walker (1969); 29, Jones (1990); 30, Mills and Geddes (1980); 31, de Souza and Moreira (1994); 32, Galat *et al*. (1988); 33, Doregelo (1974).

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