APPENDIX D: RESPIRATION OF ZOOPLANKTON AND BENTHOS

PART I: RESPIRATION RATES OF AQUATIC INVERTEBRATES FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

PART II: RESPIRATION RATES OF AQUATIC INVERTEBRATES AS A FUNCTION OF BODY WEIGHT AND TEMPERATURE FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

1. The definitions of abbreviations and symbols used in Appendix D, Parts I and II, are listed below:

L	laboratory study
F	field study
T	temperature
W	weight
R	respiration
BOD	biological oxygen demand
AFDW	ash-free dry weight
h	hour
mg	milligram
µg	microgram
ℓ	litre
µℓ	microlitre
wt	weight
g	gram
m	metre
mm	millimetre
ca.	approximately
fc	foot-candle
ind	individual
cal	calorie
cm/sec	centimetre per second
O_2	dissolved oxygen concentration
?	unknown or could not be determined from data
$\bar{X}$	mean value
%	percent
>	greater than

PART I: RESPIRATION RATES OF AQUATIC INVERTEBRATES FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

APPENDIX D: PART I - RESPIRATION RATES OF AQUATIC INVERTEBRATES FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
PHYLUM: MOLLUSCA						
Class: Gastropods						
Holisoma trivolvis	L	Manometric (Gilson respirometer)	5	1.00	Control data; acclimated to 15°C and starved 24h; 86.3 mg dry tissue weight	Shannon and Trama (1972)
			15	3.30		
			20	4.60		
Planorbis contortus	L	Polarographic (flow through chamber)	10	2.60	Acclimated to 10°C (4 days); fed native food; free movement; dry wt.= 1 mg	Calow (1975)
Planorbis albus	L	Manometric (Warburg respirometer)	8	0.84	Calculated from Tables 3 and 4; Dry weight = 1.0 mg (without shell)	Mason (1977)
Bithynia tentaculata	L		8	0.59		
			20	0.58		
Valvata piscinalis	L		8	0.14		
			20	0.67		
Ancylus fluviatilus	L	Polarographic (flow through chamber)	18	4.00	Acclimated to 18°C (4 days); fed native food; free movement; dry wt. = 1 mg	Calow (1975)
Ferrissia rivularis	L	Polarographic (?)			Calculated from Figure 4; Specimens were collected at night and immediately tested	Burky (1971)
			10	0.26-0.25	January - February	
				0.26-0.48	March - April	
				0.53-0.51	May - June	
				0.48-0.40	July - August	
				0.40-0.32	September - October	
				0.26-0.24	November - December	
				0.37	$\bar{X}$ monthly rate	
			20	0.56-0.48	January - February	
				0.56-0.96	March - April	
				1.17-1.28	May - June	
				1.28-1.28	July - August	
				1.12-0.88	September - October	
				0.77-0.64	November - December	
				0.91	$\bar{X}$ monthly rate	

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Ferrissia rivularis(cont.)	L	Polarographic (?)	0	0.13	Calculated from Figure 2; acclimated to test temperature dry wt. = 1.38-1.62 mg	Burky (1971)
			4.5	0.16		
			6	0.22		
			11	0.33		
			15	0.96		
			18	0.99		
Class: Pelecypoda						
Pisidium casertanum	L	Polarographic (flow through chamber)	11	0.13 0.43	O_2 = 1%; specimens active = 19%; dry wt = ?	Jonasson (1964)
Pisidium casertanum	L	Polarographic (flow through chamber)	8 16	0.78 0.38	Dry wt. = 0.20 mg = O_2 = 1.8% = 0.27 mg = = 2.2%	Berg and Jonasson (1965)
Pisidium casertanum	L	Manometric (Warburg respirometer)	8 20	0.58 0.42	Calculated from Tables 3 and 4, dry wt. = 1 mg (without shell)	Mason (1977)
Scrobicularia plana	L	Polarographic (flow through chamber)	0.5 4.0 9.5 13.5 17.5 22.5	0.20 0.30 0.40 0.64 1.02 1.42	Calculated for a standard snail (dry wt. = 0.5 g, without shell); acclimated to ambient field temperature in lab	Hughes (1970)
PHYLUM: ANNELIDA						
Class: Hirudinea						
Helobdella stagnalis	L	Manometric (Warburg respirometer)	8 20	0.67 1.78	Calculated from Tables 3 and 4; dry weight = 1 mg at each temperature	Mason (1977)
Class: Oligochaeta						
Potamothrix hammoniensis	L	Manometric (Warburg respirometer)	8 20	1.29 1.55	Calculated from Tables 3 and 4; dry weight = 1 mg	Mason (1977)
Enchytraeidae	L	Manometric (Warburg respirometer)	8 20	0.60 2.19		Mason (1977)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Tubifex tubifex	L	Polarographic (closed bottle)	5	0.53	$\bar{X}$ Dry weight = 72.2 mg; O_2 > 85%; Fed Sediment	Brinkhurst et al. (1972)
			10	0.46	= 55.8	
			15	0.87	= 56.6	
			20	1.15	= 58.7	
Tubifex tubifex	L	Manometric (Warburg respirometer)	20	2.19	O_2 = 0.5%; acclimated at test temperature	Palmer (1968)
				5.66	= 1.0% for 3 days; Dry Wt. = 2.5 mg	
				12.89	= 3.0%	
				11.15	= 10.0%	
				12.88	= 21.0%	
Tubifex baratus	L	Polarographic (flow through chamber)	8	0.42	Dry weight = 1.09 mg; O_2 = very low (1.7-2.4%)	Berg and Jonasson (1965)
				0.15	= 4.30 mg;	
				0.55	= 1.78 mg;	
					specimens were active	
Tubifex baratus	L	Polarographic (flow through chamber)	11	0.05	O_2 = 1%; specimens were active	Jonasson (1964)
				0.51	= 19%; Dry weight = ?	
Ilyodrilus hammoniensis	L			0.10		
				0.31		
Ilyodrilus hammoniensis	L	Polarographic (flow through chamber)	8	0.20	Dry weight = 0.35 mg; O_2 = very low (1.8-2.2%)	Berg and Jonasson (1965)
			16	0.53	Dry weight = 0.23 mg	
					Specimens were active	
Limnodrilus hoffmeisteri	L	Polarographic (closed bottle + BOD probe)	5	0.39	$\bar{X}$ Dry weight = 72.2 mg; O_2 > 85%; Fed sediment	Brinkhurst et al. (1972)
			10	0.46	= 66.8	
			15	0.68	= 59.9	
			20	1.05	= 55.2	
Peloscolex multisetosus	L	Polarographic (closed bottle + BOD probe)	5	0.85	$\bar{X}$ Dry weight = 17.4 mg;	Brinkhurst et al. (1972)
			10	0.77	= 18.8	
			15	0.92	= 15.8	
			20	1.22	= 15.6	

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
PHYLUM: ARTHROPODA						
Class: Insecta Order: Plecoptera						
Taeniopteryx nebulosa	L	Polarographic (flow through chamber)	8	0.25	O_2 = 1 mg/l	Calculated from Figure 2	Nagell (1973)
				0.90	= 3	(Curve B); acclimated 6 days	
				1.26	= 5	and starved 96 h; Dry weight = ?	
				1.32	= 7		
				1.26	= 9		
Nemoura cinerea	L	Polarographic (flow through chamber)	8	0.63	= 1 mg/l	Calculated from Figure 3	Nagell (1973)
				1.26	= 3	(Curve B); acclimated for 1 day	
				1.61	= 5	and starved 96 h; Dry Weight = ?	
				1.68	= 7		
				1.61	= 9		
Nemoura californica	L	Manometric	10	2.39	Dry weight = 1-2 mg; Acclimated 48 h		Knight and Gaufin (1966)
Diura nanseni	L			0.42	= 2 mg/l	Calculated from Figure 4	Nagell (1973)
				0.84	= 3	(Curve B); acclimated 6 days	
				1.38	= 5	and starved 96 h; Dry weight = ?	
				1.34	= 7		
				1.32	= 9		
Acroneuria californica	L	Manometric (Gilson respirometer)	15	1.01	July - August; Dry weight = 5.4-11.3 mg		Heiman and Knight (1975)
			24	4.20			
			30	1.20			
			16	0.88	September; Dry weight = 11.3 mg		
			25	2.10			
			30	2.51			
			12	0.84	November; Dry weight = 18.28 mg		
			20	1.26			
			23	1.68			
					All specimens were acclimated 5-15 days and starved 48 h.		

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Acroneuria pacifica	L	Manometric (Gilson-Warburg apparatus)	10	2.72	Dry weight = 10-40 mg; Acclimated for 48 h	Knight and Gaufin (1966)
				1.56	= 50-80	
				0.99	= 100-200	
				3.92	= 10-40	
				1.81	= 40-80	
				1.32	= 100-200	
Pteronarcys californica	L	Manometric (Gilson-Warburg apparatus)	10	1.99	= 10-30 ; Acclimated for 48 h	Knight and Gaufin (1966)
				0.93	= 100-200	
				0.58	= 150-250	
				0.43	= 300-450	
				2.96	= 10-30	
				1.09	= 100-200	
				0.96	= 150-250	
				0.99	= 300-450	
Classenia sabulosa	L	Manometric (Gilson-Warburg apparatus)	10	2.54	= 10-40 ; Acclimated for 48 h	Knight and Gaufin (1966)
				1.53	= 50-80	
				0.98	= 100-200	
			20	3.55	= 10-40	
				2.14	= 50-80	
				1.46	= 100-200	
Pteronarcella badia			10	1.25	= 50	
Arcynopteryx signata	L	Manometric (Gilson-Warburg apparatus)	10	2.43	Dry weight = 10-30 mg; Acclimated for 48 h	Knight and Gaufin (1966)
			20	4.15	= 10-30	
Arcynopteryx parallela	L	Manometric (Gilson-Warburg apparatus)	10	1.39	= 10-50	Knight and Gaufin (1966)
Isoperla fulva	L	Manometric (Gilson-Warburg apparatus)	10	3.29	= 10-40	Knight and Gaufin (1966)
Brachyptera spp.	L	Manometric (Gilson-Warburg apparatus)	10	4.62	= 2	Knight and Gaufin (1966)
Order: Ephemeroptera						
Isonychia sp.	L	Winkler titration (closed bottle)	6.5	1.69	$\bar{X}$ Dry weight = 6.2 mg; Acclimated for 72 h; artificial substrate provided; O_2 = 95% of initial	Ulanoski and McDiffett (1972)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Isonychia bicolor	L	Manometric (Gilson respirometer)	2- 7	1.44	$\bar{X}$ Dry weight = 4.0 mg; Values are means of 8-hour	Sweeney (1978)
			3- 8	1.78	= 2.7 rates during pulses;	
			5-10	1.91	= 4.6 Specimens collected and	
			5-11	2.14	= 3.0 immediately tested;	
			6-11	2.88	= 2.8 substrate provided	
			10-15	2.27	= 2.3	
Stenonema fuscum	L	Winkler titration (closed bottle)	6.5	1.40	$\bar{X}$ Dry weight = 5.2 mg; Acclimated for 72 h; artificial substrate provided, O_2 = 95% of initial	Ulanoski and McDiffett (1972)
Stenonema pulchellum	L	Modified Winkler titration (closed bottle)	15	2.64	$\bar{X}$ Dry weight = 1.19 mg; Fed diatoms (Range = 1-2.01 mg)	Trama (1972)
			20	3.64		
			25	5.51		
Stenonema bicpunctatum	L	Polarographic (flow through chamber)	20	2.20	From Table 2. Dry weight range = 1.2-12 mg	Rueger et al. (1969)
		Manometric (Gilson-Warburg apparatus)		2.21		
Stenonema canadensis	L	Polarographic		0.79		Rueger et al. (1969)
		Manometric		0.85		
Stenonema nepotellum	L	Polarographic		2.66		Rueger et al. (1969)
		Manometric		1.91		
Potamanthus rufous	L	Manometric (Warburg respirometer)	20	0.61	From Figure 12. Dry weight range = 1.2-10.8 mg	Rueger et al. (1969)
Baetisca laurentina	L	?		0.66	From Figure 12. Dry weight range = ?	Rueger et al. (1969)
Leptophlebia sp.	L	?		0.84	From Figure 12. Dry weight range = ?	Rueger et al. (1969)
Ephemera simulans	L	?		0.50	From Figure 12. Dry weight range = ?	Rueger et al. (1969)
Ephemera simulans	L	Winkler tritration (closed bottle)	13	1.88	Substrate size = none; Dry weight = ?	Eriksen (1964)
				0.86	= -4 (length = 20-22 mm)	
				0.55	= -2	
				0.87	= 0	
				1.79	= 2	
				1.76	= 4	

APPENDIX D, PART 1 (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Ephemera simulans	L	Winkler titration (closed bottle)	13	0.29 0.57 0.57 0.87	O_2 = 0.6 mg/l; Substrate size = 2; = 1.0 Dry weight = ? (Length = = 3.0 20-22 mm) = 5.0	Eriksen (1964)
Hexagenia limbata	L	Winkler titration (closed bottle)		2.30 1.67 1.42 1.71 1.99 1.99 1.60 0.78 0.79 0.84	Substrate size: none; Dry weight = ? -4 (length = 20-22 mm) -2 0 2 4 O_2 = 0.45 mg/l; Glass burrows provided = 1.00 = 3.00 = 5.00	Eriksen (1964)
Cloeon dipterum	L	Polarographic (flow through chamber)	8	0.63 0.84 1.05 1.11 1.17 1.19 1.21 1.23	O_2 = 1.0 mg/l; Calculated from Table 5 = 1.5 (curve B); starved for 3 days = 2.0 Dry weight = ? = 3.0 = 5.0 = 7.0 = 9.0 = 11.0	Nagell (1973)
Cloeon dipterum	L	Manometric (Warburg respirometer)	8 20	1.91 1.59	Calculated from Tables 3 and 4, Dry weight = 1 mg	Mason (1977)
Caenis boraria	L	Manometric (Warburg respirometer)	8 20	2.98 1.49		Mason (1977)
Order: Megaloptera						
Corydalus cornutus	L	Winkler titration (Closed bottle)	20	4.6 1.1 1.6	Dry weight = 16.4 mg = 121.0 mg = 129.0 mg	Brown (1978)
Order: Odonata						
Anax junius	L	Manometric (Gilson respirometer)	13 20	2.03-1.30 1.02-0.85 0.75-0.69 2.66-0.95 3.61-2.41 1.94-1.64 1.46-1.38 2.34-1.81	Dry weight = 10.0-40.0 mg; Acclimated to test = 85.0-150.0 temperature; substrate = 225.0-275.0 provided; activity range moderate = 10.0-40.0 = 85.0-150.0 = 225.0-275.0 range	Petitpren and Knight (1970)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Anax junius (Cont.)	L	Manometric (Gilson respirometer)	27	3.49-3.34 3.27-3.24 3.17-3.16 3.31-3.24	Dry weight = 10.0-40.0 mg; Acclimated to test = 85.0-150.0 temperature; substrate = 225.0-275.0 provided; activity range moderate	Petitpren and Knight (1970)
			20	1.36-1.77 0.90-1.89	Summer males Summer females	
Pyrrhosoma nymphula	L	?	Measured at 10 corrected to 8.5		"Best Estimate"; Table 1; $\bar{X}$ Dry weight = 20.74 mg	Phillipson (1970)
Erythromma najas	L	Manometric (Warburg respirometer)	8	0.95	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
Order: Diptera						
Arthocladinae	L	Manometric (Warburg respirometer)	8 20	0.7 1.7	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
Chaoborus flavicans	L	Polarographic (flow through chamber)	8 16	0.29 1.00	Dry weight = 0.95 mg; O_2 = 1.8-2.2% = 1.00 mg; = 2.0-2.2% Specimens active	Berg and Jonasson (1965)
Chaoborus flavicans	L	Polarographic (flow through chamber)	11	0.31	O_2 = 19%; specimens active (profundal) Dry = ca. 1 mg	Jonasson (1964)
Chaoborus punctipennis	L	Manometric (Gilson respirometer)	20	2.95 13.30	Winter; Dry weight = ? (4th instar) Summer and Fall	Sigmon et al. (1978)
Chironomus anthracinus	L	Polarographic (flow through chamber)	8 16	0.12 0.80	Dry weight = 2.7 mg; O_2 = 1.8-2.1% = 2.6 mg = 1.9-2.8%	Berg and Jonasson (1965)
Chironomus anthracinus	L	Polarographic (flow through chamber)	11	0.20 0.34 0.58	O_2 = 1% - profundal Dry weight = ? = 19% - sublittoral = 19% - sublittoral	Jonasson (1964)
Chironomus punctipennis	L	Manometric (Warburg respirometer)	30	17.40	Note high test temperature; Dry weight = 0.15 mg	Ransom et al. (1971)
Chironomus plumosus	L	Manometric (Warburg respirometer)	8	1.4	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
Chironomus plumosus	L	Manometric (Warburg respirometer)	30	9.62	Note high test temperature; Dry weight = 1.05 mg	Ransom et al. (1971)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 10C	Comments	Reference
Chironomus eiparius	L	Manometric (Warburg respirometer)	20	4.81 4.96	Normal shaking; $\bar{X}$ Dry weight = ca. 1 mg Normal shaking x 2; (Acclimated 24 h)	Edwards (1957)
Chironomus tentans	L	Manometric (Warburg respirometer)	8 20	1.1 3.5	Calculated from Tables 3 and 4; Dry weight=1 mg	Mason (1977)
Glyptotendipes polytomus	L	Volume respirometer (pressure constant)	8	2.54 3.96 3.63 0.01 0.002	March Dry weight = ca. 2.02 mg April (early) (late) O_2 = 1.6% - 3.1% O_2 O_2 = 1.3% - 0.6% O_2	Kamler and Srokosz (1973)
Tanytarsus holochoris	L	Manometric (Warburg respirometer)	8 20	0.9 2.4	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
Procladius pectinatus	L	Polarographic (flow through chamber)	8	0.27 0.19	Spring dry wt. = 0.66 mg; O_2 = 1.8-2.2% Winter dry wt. = 0.48 mg	Berg and Jonasson (1965)
Pseudodiamesa arctica	L	Polarographic (closed bottle)	0	0.69 0.48	Calculated from Table 10 ($\bar{X}$ per day for 305 days); $\bar{X}$ Dry weight = 0.338 mg	Welch (1976)
Lauterborniella sp.	L	Polarographic (closed bottle)		1.10 1.18	$\bar{X}$ Dry weight = 0.069 mg	Welch (1976)
Heterotrissocladius oliveri	L	Polarographic (closed bottle)		0.49	$\bar{X}$ Dry weight = 0.104 mg	Welch (1976)
Trissocladius sp.	L	Polarographic (closed bottle)		1.0-1.2	$\bar{X}$ Dry weight = 0.048 mg	Welch (1976)
Orthocladius sp.	L	Polarographic (closed bottle)		0.8-1.5	$\bar{X}$ Dry weight = 0.051 mg	Welch (1976)
Class: Crustacea Subclass: Malacostraca Order: Isopoda						
Asellus aquaticus	L	(Volumetric respirometer)	23	6.3 5.7 5.0 4.9 4.5 4.5 5.2	Dry weight = 0.43 mg = 0.85 = 2.55 = 2.98 = 5.10 = 5.53 $\bar{X}$ Dry weight = 2.81	Prus (1972)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Asellus aquaticus	L	Manometric (Warburg respirometer)	8	1.13	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
			20	4.91		
Asellus racovitzai	L	Polarographic (closed BOD bottle)	18	1.76	Unfed; no substrate provided;	Swiss and Johnston (1976)
				1.99	Dry weight = ?	
				2.05	Fed *Scenedesmus*	
				2.43	*Anabaena*	
				2.72	*Oscillatoria*	
Order: Amphipoda						
Gammaracanthus lacustris	L	Winkler titration (closed bottle)	4-5	0.48	Dry weight = 149.31 mg	Ivanova (1972)
				0.52	= 106.70	
				0.58	= 63.99	
				0.75	= 21.33	
				0.89	= 10.66	
				1.02	= 5.33	
				1.77	= 2.13	
				1.94	= 0.85	
Gammarus pulex	L	Manometric (Warburg respirometer)	8	1.14	Calculated from Tables 3 and 4; Dry weight = 1 mg	Mason (1977)
			20	2.09		
Order: Mysidacea						
Mysis relicta	L	Modified Winkler titration (closed bottle)	0.9	2.4	$\bar{X}$ annual temperature in Char Lake	Lasenby and Langford (1972)
			5.3	3.3	in Stony Lake	
					Dry weight = 1 mg (Acclimated 24 h at each temperature)	
Mysis relicta	L	Polarographic (closed bottle)	4	1.8	Dry weight = 5 mg	Foulds and Roff (1976)
Order: Decapoda						
Caridina fernandoi	L	Winkler titration (flow through chamber)	28	2.7	Dry weight = 3.5 mg; Standard metabolism	Wycliffe and Job (1977)
				2.6	= 52.5	
				4.6	= 3.5; Routine metabolism	
				3.7	= 52.5	
				11.2	= 3.5; Active metabolism	
				7.6	= 52.5	

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Repiration rate mg C/mg C/day x 100	Comments	Reference
Austropotarnobius pallipes	L	Polarographic (closed, mixing respirometer)	10	0.3	Dry weight = 1.2-2.2 mg; standard metabolism	Sutcliffe et al. (1975)
				0.7	= 0.11 active metabolism	
				0.6	= 0.11	
				0.7	= 0.18	
				1.0	= 0.30	
				0.3	= 0.41	
				1.0	= 0.41	
Pacifastacus leniusculus	L	Winkler titration (closed bottle)	20	0.7	O_2 = 1.67 mg/l; Dry weight = 2.4 g	Moshiri et al. (1970)
				0.8	= 2.29	
				1.4	= 5.02	
				2.2	= 7.00	
Pacifastacus leniusculus	L	Modified Winkler titration (closed bottle)	15	light dark	Experimental conditions; males only; acclimated 1 - 2 h, starved 48 h	Moshiri et al. (1971)
				5.1 6.5	Dry weight = ca. 0.371 g (assuming ash - 10% of	
				5.3 6.9	= ca. 0.733 dry weight)	
				1.1 1.3	= ca. 6.071	
				0.6 0.7	= ca. 12.987	
				3.0 3.9	= ca. 5.041	
			2.5	0.9 1.0	$\bar{X}$ Dry weight = ca. 1.832	
			5.0	1.2 1.7		
			10.0	1.3 1.8		
			15.0	2.6 3.3		
			20.0	2.0 2.3		
				1.7 2.0	$\bar{X}$ for all temperatures	
Subclass: Branchiopoda Order: Cladocera						
Daphnia galeata	L	Winkler titration (closed bottle)	10	13.0	Algae concentration = $5x10^5$ cell/l; Dry weight = ?	Larow et al. (1975)
				44.1	= $5x10^6$ (probably	
				46.2	= $10x10^6$ 0.001-0.03 mg)	
				27.7	= $5x10^5$	
				62.1	= $5x10^6$	
				77.2	= $10x10^6$	
Daphnia pulex	L	?	?	15.5	Light intensity: 0 f.c.; Dry weight=0.003-0.056	Buikema (1972)
				23.7	14 mg	
				58.2	110	

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Daphnia pulex	L	Winkler titration (closed bottle)	20	18.2-19.2	Range in light; Dry weight = 0.0036 mg	Tezuka (1971)
Daphnia pulex	L	Manometric and Winkler Warburg and closed bottle	20	21.6 15.6 13.8 18.8 19.8 15.5	Dry weight = 0.003 mg; starved 24 h = 0.009 = 0.016 = 0.020 = 0.026 = 0.046	Richman (1958)
Daphnia magna	L	Polarographic BOD probe (closed, circulating chamber)	18	14.6 17.5 11.8 8.5	Food concentration = 5.3×10^5 μ^3/ml, Dry weight = 0.138 mg = 4.2×10^6 = 8.4×10^6 = 17.7×10^6	Karsting and Leeuw-Leegwater (1976)
Daphnia magna	?	?	?	14.8		Sushchenya (1958b) as cited by Ivanova (1970)
Daphnia longispina	L	Winkler titration (closed bottle)	16-18	12.1-13.5	Range (in dark); Dry weight = 0.0011 mg	Tezuka (1971
Daphnia longispina	?	?	?	16.02		Manuilova (1958) as cited by Ivanova (1970)
Daphnia longispina	?	?	?	14.6		Shushkina and Pecen' (1964) as cited by Ivanova (1970)
Daphnia cuculata	?	?	?	16.1		Manuilova (1958) as cited by Ivanova (1970)
Daphnia hyalina	F	?	3	0.9 1.4 2.5	Seston concentration: 0.8 cal/l; Dry weight = ? 1.4 2.5	Blazka (1966)
	L	?	5 10 20	5.0 8.4 17.9		
	F	?	5 10 20	4.2 4.6 9.0		
Diaphanosoma brachyurum	?	?	?	27.2		Sushchenya (1958b) as cited by Ivanova (1970)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Bosmina longirostris	?	?	?	18.5		Sushchenya (1958b) as cited by Ivanova (1970)
Bosmina coregoni	?	?	?	17.0		Manuilova (1958) as cited by Ivanova (1970)
Simocephalus vetulus	?	?	?	13.1		Sushchenya (1958b) as cited by Ivanova (1970)
Simocephalus vetulus	?	?	?	15.4		Manuilova (1958) as cited by Ivanova (1970)
Simocephalus vetulus	L	Manometric (Cartesian diver)	?	5.7	pH= 4; Dry weight = 0.0629 mg; Resting rate	Ivanova and Klekowski (1972)
				9.6	4.8	
				9.6	5.8	
				9.6	6.9	
				9.8	8.7 = 0.053	
		Winkler titration (closed bottle)		23.6	4.0 = 0.063; ordinary rate	
				19.5	4.8	
				16.1	5.8	
				13.5	6.9	
				20.1	8.7 = 0.053	
Ceriodaphnia reticulata	L	?	15	18.0	Food consumption = 1.12 cal/cal/day, Dry	Gophen (1976)
		(closed bottle)	22	20.0	= 2.72 weight = 0.0021-0.004mg	
			27	50.0	= 2.91	
Leptodora kindtii	L	Manometric (Scholander respirometer)		light dark	Illumination condition; Dry weight = ? (length =	Moshiri et al. (1969)
			5	10.6 3.8	female 6.7 mm); (Acclimated 1 h	
				7.8 4.0	(ovigerous) at each temperature)	
				9.4 4.0	male	
			15	90.3 43.6	female	
				51.9 30.4	(ovigerous)	
				261.9 162.2	female	
				160.0 81.6	(ovigerous)	
				84.5 47.1	$\bar{x}$	
Leptodora kindtii	L	?	Measured at 16 and corrected to 20	12.5	Dry weight = 0.051 mg	Hillbricht-Ilkowska and Karabin (1970)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Subclass: Copepoda						
Copepoda	F	Modified Winkler titration (closed bottle)	18-20	17.8 20.4 14.5 15.1 10.8 9.1 7.5	Light; dry weight = 0.003 mg; Depth 6 m; ambient pressure Dark Light Dark	Bishop (1968)
Diaptomus kenai	L	Modified Winkler titration (closed bottle)	22	27.2 44.8	$\bar{X}$ for 1900-1500 h; Dry weight = ? (Probably ca. 0.005 mg) $\bar{X}$ for 1500-1900 h	Duval and Green (1976)
Diaptomus ashlandii	L	Modified Winkler titration (closed bottle)		44.7 73.8	$\bar{X}$ for 1900-1500 h; $\bar{X}$ Dry weight = 0.0056 mg $\bar{X}$ for 1500-1900 h	Duval and Green (1976)
Diaptomus oregonensis	L	Modified Winkler titration	22-23	19.4	Adult female; Dry weight = 0.011 mg	Richman (1964)
Diaptomus oregonensis	L	Micro-Winkler titration (closed bottle)		Fed / Starved	Food condition; Dry weight = 0.0048 mg	Comita (1968)
			10	14.5 / 10.8		
			15	19.3 / 13.2		
			20	30.1 / 19.8		
Diaptomus siciloides	L	Micro-Winkler titration (closed bottle)	10	11.9 / 5.6	Food condition; Dry weight = 0.0032 mg	Comita (1968)
			15	34.3 / 30.0		
			20	52.4 / 44.8		
Diaptomus septopus	L	Micro-Winkler titration (closed bottle)	15	11.2 / 8.0	Food condition; Dry weight = 0.022 mg	Comita (1968)
			20	17.9 / 14.9		
Diaptomus clavipes	L	Micro-Winkler titration (closed bottle)	15	11.7 / 11.6	Food condition; Dry weight = 0.028 mg	Comita (1968)
			20	16.5 / 15.7		
Diaptomus arcticus	L	Micro-Winkler titration (closed bottle)	10	3.6	Food condition; Dry weight = 0.300 mg	Comita (1968)
			15	4.4		
			20	6.4		
Diaptomus gracloides	L	Winkler titration (closed bottle)	0.5	0.9	$\bar{X}$ Dry weight = 0.006 mg; Note low temperatures	Ostapenya et al. (1969)
			2.5	1.2		
			3.9	1.3		

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Cyclops vericans	L	Polarographic electrode (closed respirometer)	16	25.7 52.6	$\bar{X}$ normal rate; Dry weight = 0.020-0.031 mg $\bar{X}$ after 9 h of anaerobiosis	Chaston (1969)
Macrocyclops albidus	L	Manometric (Cartesian diver)	21	25.0-46.0 10.0-20.0 10.0	Nauplii; Dry weight = $6x10^{-5}$-$4x10^{-4}$ mg Copepodids; = $4x10^{-4}$-0.010 Adults and Stage V Copepodids; = ca. 0.032	Klekowski and Shushkina (1966b)
Limnocalanus macrurus	F, L	Polarographic electrode (closed bottle)	0.2	10.7 6.7 6.4 4.3 3.4 2.7 3.0	Dry weight = 0.0003 mg; Calculated from Figure 1 = 0.0006 = 0.0016 = 0.0060 = 0.0100 = 0.0300; Calculated from Figure 2	Roff (1973)
			2	3.2		
			4	4.1		
			10	8.3		
			15	9.6		
Calamoecia lucasi	L	Micro-Winkler titration (closed bottle)	25	13.3 28.5 33.3 52.3	Food concentration = $1x10^4$ yeast cells/ml; Dry weight = 0.0023 mg = $2x10^4$ = $4x10^4$ = $6x10^4$ Acclimated to experimental temperature 36-48 h	Green (1975)
PHYLUM: ROTATORIA						
Brachionus calyciflorus	L	Micro-Winkler titration (closed bottle)	20	Fed / Starved 181.5 / 30.3 141.8 / 22.7 113.4 / 18.2 94.4 / 15.1 81.0 / 12.9 66.7 / 10.7 113.2 / 18.3 65.7	Food condition; Estimated Dry weight = from (Pilarska 1977c) = $6x10^{-5}$ mg = $8x10^{-5}$ = $1x10^{-4}$ = $1.2x10^{-4}$ = $1.4x10^{-4}$ = $1.7x10^{-4}$ $\bar{X}$ Grand $\bar{X}$	Galkovskaya (1963)
Brachionus calyciflorus	L	Micro-Winkler titration (closed bottle)	10 15 20 23	20.6 31.4 50.5 64.6	Dry weight = $1.69x10^{-4}$ mg	Pourriot (1973)

APPENDIX D, PART I (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Brachionus rubens	L	Manometric (Cartesian diver)	20	41.4	Food concentration: $1x10^7$ algal cells/l; Dry weight	Pilarska (1977c)
				24.1	$1x10^6$ = $7.6x10^{-5}$ mg; Age 12 h	
				29.0	$1.2x10^3$	
				49.1	$1x10^7$ = $9.3x10^{-5}$ mg; 13-24 h	
				24.5	$1x10^6$	
				32.4	$1.2x10^3$	
				40.8	$1x10^7$ = $1.1x10^{-4}$ mg; 24 h	
				28.0	$1x10^6$	
				37.6	$1x10^3$	
				41.8	$1x10^7$ = $1.4x10^{-4}$ mg; 24 h	
				29.0	$1x10^6$ (ovigerous female)	
				37.6	$1x10^3$	
Brachionus plicatilis	L	Manometric (Cartesian diver)	20	16.3	Senile adult; Dry weight = $1.58x10^{-4}$ mg	Doohan (1973)
				67.7	Postovigerous adult	
				35.0	Ovigerous female (2 eggs); = $3.42x10^{-4}$	
				38.1	(1 egg); = $2.52x10^{-4}$	
				26.0	Adult = $1.58x10^{-4}$	
				37.1		
				40.1		
				30.0		
				26.1		
				27.6		
				30.3		
				31.4		
				35		
				32		
				30		
				33.9	$\bar{X}$ adult rate	
Rhinoglena frontalis	L	Micro-Winkler titration (closed bottle)	5	19.1	$\bar{X}$ Dry weight = $1.27x10^{-4}$ mg; Acclimated 15 min	Pourriot (1973)
			10	24.0		
			15	26.6		
			20	31.6		
			23	42.4		
Zooplankton (Diaptomus kenai, Diaptomus tyrelli, Holopedium gibberrum, Daphnia rosea)	L	Modified Winkler titration (closed bottle)	10	91.8	Dry weight (Biomass) = 0.050 mg/ml; Acclimated 24 h	Duval and Green (1976)
			16	23.0	to each temperature, $\bar{X}$ Daily rates (Figure 1)	
			20	21.0		

APPENDIX D, PART I, (Continued)

Taxon	Lab or field	Method	Temperature (°C)	Respiration rate mg C/mg C/day x 100	Comments	Reference
Zooplankton (primarily copepods)	F	Modified Winkler titration (closed bottle)	18-20	32.1	Dry weight/individual = 0.00096 mg; Captured at 5M-Tested at 5M	Bishop (1968)
			4	6.2	= 0.00101 5M- 45M	
				28.0	= 0.00302 45M- 5M	
				8.7	= 0.00336 45M- 45M	
			4	7.5	= 0.0030-0.0034 mg	
			8	9.2		
			12	10.7		
			16	15.0		
			20	20.4		

PART II: RESPIRATION RATES OF AQUATIC INVERTEBRATES AS A FUNCTION OF BODY WEIGHT AND TEMPERATURE FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

APPENDIX D: PART II - RESPIRATION RATES OF AQUATIC INVERTEBRATES AS A FUNCTION OF BODY WEIGHT AND TEMPERATURE FOR VARIOUS TAXONOMIC AND FUNCTIONAL GROUPS

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
PHYLUM: MOLLUSCA					
Class: Gastropoda					
Planorbis contortus	4	Polarographic (flow through chamber)	$R = 0.04W^{-0.325}$	log R=0.20+0.68 log W (R in µl O_2/ind/h) W in mg AFDW (ca. 0.3-1 mg)	Calow (1975)
	10		$R=0.07W^{-0.342}$	log R=0.45+0.66 log W	
	15		$R=0.12W^{-0.340}$	log R=0.67+0.664 log W	
Potamopygus jenkinsi	10	Manometric (Cartesian diver)	$R=0.009W^{-0.176}$	log 1000 R=0.194+0.824 log 100 W (R in µl/ind/h) W in mg wet wt. (0.02-10 mg Dry weight)	Lawton and Richards (1970)
		(Gilson respirometer)	$R=0.010W^{-0.21}$	log 1000 R=0.234+0.795 log 100 W	
Ancylus fluviatilis	4	Polarographic (flow through chamber)	$R=0.036W^{-0.34}$	log R=0.147+0.659 log W (R in µl O_2/ind/h) W in mg AFDW (ca. 1-9 mg)	Lawton and Richards (1970)
	10		$R=0.066W^{-0.31}$	log R=0.415+0.693 log W	
	18		$R=0.177W^{-0.323}$	log R=0.841+0.677 log W	
Class: Placypoda					
Pelecypoda	20	†	$R=0.012W^{-0.28}$	$R=0.094W^{0.721}$ (R in mg O_2/ind/h) W in mg AFDW; calculated from data on freshwater species	Winberg et al. (1973)
Scrobicularia plana	0.5	Polarographic electrode (flow through chamber)	$R=0.0018W^{-0.224}$	$R=71.78W^{0.7757}$ (R in µl O_2/ind/h) W in g dry wt. (20-1000 mg dry weight - tissue)	Hughes (1970)
	4.0		$R=0.0026W^{-0.242}$	$R=102.22W^{-0.7580}$	
	9.5		$R=0.0035W^{-0.233}$	$R=138.84W^{0.7580}$	
	13.5		$R=0.0054W^{-0.249}$	$R=212.18W^{0.7673}$	
	17.5		$R=0.0071W^{-0.440}$	$R=279.76W^{0.7507}$	
	22.5		$R=0.0120W^{-0.236}$	$R=479.82W^{0.5596}$	
	30.75		$R=0.0042W^{-1.034}$	$R=164.25W^{0.7636}$ a=0.0362T+1.851 (a value in $R=aW^b$)	

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
PHYLUM: ARTHROPODA					
Class: Insecta Order: Plecoptera					
Acroneuria californica	12-30	Manometric (Gilson respirometer)	$R=2.1x10^{-5}$ 6278.3+680.6(T)-144.8(T^2)	$R=-6278.3-680.6(T)-14.88(T^2)$ (R in µl/g dry wt/h) T in °C (July-August); acclimated 5-15 days at 24°C	Heiman and Knight (1975)
	16-30		$R=2.1x10^{-5}$ -613.3+88.5(T)-0.916(T^2)	$R=-613.3+88.5(T)-0.916(T^2)$; (September)	
	6-24		$R=2.1x10^{-5}$ 772.1-83.4(T)-3.74(T^2)	$R=772-83.4(T)-3.74(T^2)$; (November); all specimens were acclimated to 24°C	
Order: Ephemeroptera					
Isonychia bicolor	12.5-28.5	Manometric (Gilson respirometer)	$R=0.0134W^{-0.225}(T^{0.031})$	log R=-0.225 log W + 0.31 log T-0.193 (R in µl O_2/mg dry wt/h); W in mg dry wt (T in °C); 0.01-2 mg dry wt	Sweeney (1978)
Order: Odonata					
Anax junius	13	Manometric (Gilson respirometer)	$R=0.0422W^{-0.3153}$	log R=3.268-0.3153 log W (R in µl O_2/g dry wt/day) W in g dry wt; (0.02-400 dry wt)	Petitpren and Knight (1970)
	20		$R=0.058W^{-0.2410}$	log R=3.402-0.2410 log W (0.004-30 g dry wt)	
	27		$R=0.038W^{-0.0300}$	log R=3.227-0.0300 log W (0.002-30g dry wt)	
Pyrrhosoma nymphula	16	Manometric (Cartesian diver)	$R=0.057W^{-0.316}$	log 100 R=0.684 log 100 W-0.320 (R in µl O_2/ind/h); W in mg wet wt. (0.05-60 mg dry wt)	Lawton and Richards (1970)
		Winkler titration (closed bottle)	$R=0.048W^{-0.12}$	log 100 R=0.822 log 100 W-0.397 (acclimated to 10°C for 4 months)	
Order: Hemipters					
Sigara alternata	12.5	Manometric (Gilson respirometer)	$R=0.017W^{-0.101}$	$R=0.825W^{-0.101}$ (R in µl O_2 mg dry wt/h); W in mg dry wt.; calculated from Table 4 (Dry weight = ?)	Sweeney and Schnack (1977)
	16.5		$R=0.031W^{-0.194}$	$R=1.49W^{-0.194}$	

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
Sigara alternata (Cont.)	20.5	Manometric (Gilson respirometer)	$R=0.041W^{-0.30}$	$R=2.00\ W^{-0.30}$	Sweeney and Schnack (1977)
	25.0		$R=0.069W^{-0.399}$	$R=3.326W^{-0.399}$	
Order: Diptera					
Culex pipiens	25	Manometric (Gilson respirometer)	$R=0.017W^{-0.814}$	None (estimated from Figures 1-3); 0.018=0.32 mg dry wt	Buffington (1969)
			$R=0.121W^{-0.293}$		
			$R=0.151W^{-0.254}$		
Pseudodiamesa arctica	0	Polarographic (closed bottle)	$R=0.0048W^{-0.38}$	ln R=-1.227+0.620 ln XV (R in µg O_2/ind/h); W in mg dry wt (calculated from Table 7); dry wt = ?	Welch (1976)
Lauterbornia sp.	0	Polarographic (closed bottle)	$R=0.0071W^{0.028}$	ln R=-0.8431+1.028 ln XV	Welch (1976)
Heterotrissocladius oliveri	0	Polarographic (closed bottle)	$R=0.0025W^{-0.264}$	ln R=-1.902+0.7360 ln XV	Welch (1976)
Trissocladius sp.	0	Polarographic (closed bottle)	$R=0.0047W^{-0.235}$	ln R=-1.242+0.7652 ln XV	Welch (1976)
Orthocladius sp.	0	Polarographic (closed bottle)	$R=0.042W^{-0.207}$	ln R=0.932+0.794 ln W	Welch (1976)
Tanypus punctipennis	5-30	Winkler titration (closed bottle)	$R=0.0042T^{0.825}$	None; 0.392 mg dry wt	Olah (1976)
			$R=0.0062T^{0.825}$	0.064 mg dry wt	
			$R=0.0026T^{0.413}$	0.020 mg dry wt calculated from Figure 5	
Glyptotendipes polytomus	8	Manometric (volumetric respirometer)	$R=0.034W^{-0.33}$	$R=0.3W^{0.67}$ (R in µl O_2/ind/h); W= mg wet wt (0.202-4.04 mg dry wt)	Kamler and Srokosz (1973)
Chironomus riparius	10	Manometric (volumetric respirometer)	$R=0.023W^{-0.29}$	$R=1W^{-0.29}$ (R in µl/mg dry wt/h); W in mg dry wt (0.1-2.0 mg dry wt); calculated from Figure 4	Edwards (1957)
	20		$R=0.061W^{-0.30}$	$R=2.61W^{-0.30}$	

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
Class: Crustacea					
Freshwater Crustacea	20	?	$R=0.0028W^{-0.213}$	$R=0.14W^{0.787}$ (R in ul O_2/ind/h); W in g wet wt (0.0086-0.173 mg dry wt)	Suschenya (1969)
			$R=0.0056W^{-0.213}$		
			$R=0.056W^{-0.213}$		
Subclass: Malacostraca Order: Isopoda					
Asellus aquaticus	23	Manometric (volumetric respirometer)	$R=0.069W^{-0.133}$	$R=0.45W^{0.8675}$ (R in ul O_2/ind/h); W in mg dry wt (1.06-6.4 mg dry wt)	Prus (1972)
Order: Amphipoda					
Gammaracanthus lacustris	4-5	Winkler titration (closed bottle)	$R=0.0064\ W^{-0.201}$	$R=0.0778W^{0.799}$ (R in mg O_2/ind/h); W in g dry wt (2.3-213.3 dry wt)	Ivanova (1972)
	11		$R=0.0124W^{-0.228}$	$R=0.147W^{0.772}$	
	15-18		$R=0.008W^{-0.23}$	$R=0.093W^{0.77}$	
Order: Mysidacea					
Mysis relicta	6	Modified Winkler titration (closed bottle)	$R=0.041W^{0.221}$	$R=0.0024W^{0.779}$ (R in mg O_2/ind/h); W in mg dry wt (0.098-1 mg dry wt); acclimated 24 h	Lasenby and Langford (1972)
Mysis relicta	4	Polarographic electrode (closed bottle)	$R=0.0255W^{-0.222}$	log R=0.1789+0.778 log W (R in ug O_2/ind/h); W in mg dry wt (0.5-20 mg dry wt); resting	Foulds and Roff (1976)
			$R=1.390W^{-0.297}$	log R=1.917+0.703 log W (1.6 cm/sec - swimming speed)	
			$R=2.790W^{-0.285}$	log R=2.218+0.714 log W (2.1 cm/sec)	

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
Order: Decapoda					
Caridina fernadoi	28	Winkler titration (flow through chamber)	$R=0.032W^{-0.045}$	$R=0.283W^{1.050}$ (R in mg O_2/ind/h); W in mg wet wt (0.35-52.5 mg dry wt); standard metabolism	Wycliffe and Job (1977)
			$R=0.043W^{-0.004}$	$R=0.384W^{1.004}$ (Routine metabolism)	
			$R=0.081W^{-0.075}$	$R=0.713W^{0.925}$ (Active metabolism)	
Austropotamobius pallipes	10	Mackereth O_2 electrode (mixing respirometer)	$R=0.003W^{-0.002}$	$R=27.21W^{1.002}$ (R in µg O_2/ind/h); W in g wet wt standard metabolism (1.25-2.1 g dry wt)	Sutcliffe et al. (1975)
			$R=0.009W^{-0.139}$	$R=84.88\ W^{0.861}$; active metabolism	
Subclass: Branchiopoda Order: Cladocera					
Daphnia pulex	?	?	$R=aW^{-0.23}$	light spectrum: violet (0.003-0.056 mg dry wt)	Buikema (1972)
			$R=aW^{-0.367}$	blue	
			$R=aW^{-0.620}$	green	
			$R=aW^{-0.172}$	red	
			$R=aW^{-0.161}$	light intensity: 110 fc	
			$R=aW^{-0.358}$	55	
			$R=aW^{-0.56}$	28	
			$R=aW^{-0.012}$	7	
			$R=aW^{-0.201}$	35	
			$R=aW^{-0.63}$	1.7	
			$R=aW^{-0.070}$	0	
			$R=aW^{-0.274}$	$\bar{X}$	

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
Daphnia pulex	20	Manometric and Winkler (Warburg and closed bottle, respectively)	$R=0.00003W^{-0.119}$	$R=0.0014W^{0.881}$ (R in µl O_2/ind/h); W in mg dry wt (0.0031-0.046 mg dry wt)	Richman (1958)
Daphnia magna	18	Polarographic probe (closed circulating respirometer)	$R=0.098W^{-0.184}$	$R=4.15W^{0.816}$ (R in µl O_2/ind/h); W in mg dry wt (0.001-0.18 mg dry wt)	Kersting and Leeuw-Leegwater (1976)
Daphnia magna	20	Winkler titration (closed bottle)	R=0.023(0.293T-4.28W+0.882)	R=0.293T-4.375W+0.882 (R in µl O_2/mg/h); W in mg dry wt (ca. 0.005-0.165 mg dry wt)	Schindler (1968)
Subclass: Copepoda					
Diaptomus spp.	?	Modified Winkler titration (closed bottle)	$R=0.595W^{-0.483}$	long R=1.425-0.483 long W (R in µl O_2/mg/h); W in mg dry wt (0.0013-0.13 mg dry wt)	Siefken and Armitage (1968)
Diaptomus spp.	5	Micro-Winkler titration	$R=0.145W^{-0.391}$	$R=6.50W^{0.669}$ (R in µl O_2/ind/h); W in mg dry wt ($\bar{X}$ of 5 species = 0.003-0.3 mg dry wt)	Comita (1968)
	10		$R=0.163W^{-0.279}$	$R=7.27W^{0.721}$	
	15		$R=0.332W^{-0.346}$	$R=14.87W^{0.654}$	
	20		$R=0.554W^{-0.374}$	$R=24.76W^{0.626}$	
	25		$R=0.846W^{-0.378}$	$R=37.80W^{0.622}$	
Diaptomus sicilioides	5-25	Micro-Winkler titration	log R=6.99 0.057(T)-2.389	log R=0.0574(T)-2.389 (R in µl O_2/ind/h); T in °C (0.0032 mg dry wt)	Comita (1968)
Diaptomus oregonensis	5-25	Micro-Winkler titration	log R=4.71 0.034(T)-1.1914	log R=0.0342(T)-1.1914 (R in µl O_2/ind/h); T in °C (0.0048 mg dry wt)	Comita (1968)
Diaptomus leptopus	5-25	Micro-Winkler titration	log R=1.01 0.0398(T)-1.573	log R=0.0398 (T)-1.578 (R in µl O_2/ind/h); T in °C (0.022 mg dry wt)	Comita (1968)
Diaptomus clavipes	5-25	Micro-Winkler titration	log R=0.779 0.0431(T)-1.545	log R=0.0431(T)-1.545 (R in µl O_2/ind/h); T in °C (0.028 mg dry wt)	Comita (1968)

APPENDIX D, PART II (Continued)

Taxon	Temperature (°C)	Method	Respiration (mg C/mg C/day)	Original equation and comments	Reference
Diaptomus arcticus	5-25	Micro-Winkler titration	log R=0.075 0.029 (T)-0.647	log R=0.0288 (T)-0.647 (R in µl O_2/ind/h); T in °C (0.300 mg dry weight)	Comita (1968)
Limnocalanus macrurus	0.2	Polarographic electrode (closed bottle)	$R=0.0743W^{-0.287}$	$R/W=4.615W^{-0.287}$ (R/W in µg O_2/µg dry wt/h) W= g dry wt (0.003-0.030 mg dry wt)	Roff (1973)
	0-15		log R=0.016 0.0317(T)-1.271	log R=0.0317(T)-1.2711 (R in µg O_2/ind/h); T in °C	
Calamoecia lucasi	10	Micro-Winkler titration (closed bottle)	$R=0.021W^{-0.404}$	log R=0.8933-0.404 log W (R in µl O_2/mg dry wt/h); W in mg dry wt. (0.00015-0.0012 mg dry wt)	Green (1975)
	15		$R=0.021W^{-0.3439}$	log R=0.9510-0.3439 log W	
	20		$R=0.028W^{-0.4000}$	log R=1.2063-0.40000 log W	
	25	$R=0.032W^{-0.3806}$	$R=0.032W^{-0.3806}$	log R-1.398-0.3806 log W	
	variable		log R=0.023 0.035(T)-0.38(log W)+ 0.49	log R=0.0356(T)-0.3823(log W)+0.4892	
Macrocyclops albidus (Nauplii)	21	Manometric (Cartesian diver)	$R=0.327W^{-0.55}$	$R=2.27W^{0.45}$ (R in µl O_2/µg/h); W in µg wet wt (0.001-0.003 mg dry wt.)	Klekowski and Shushkina (1966b)
Zooplankton	18-20	Modified Winkler titration	$R=0.355W^{-0.44}$	$R=12.0W^{-0.44}$ (R in µl O_2/mg dry wt/h); W in mg dry	Klekowski and Shushkina (1966a)
	4		$R=0.308W^{-0.99}$	$R=10.4W^{-0.99}$	

APPENDIX E: NONPREDATORY MORTALITY OF ZOOPLANKTON AND BENTHOS

PART I: NONPREDATORY MORTALITY RATES OF ZOOPLANKTON AND BENTHOS

PART II: UPPER AND LOWER LETHAL TEMPERATURES OF ZOOPLANKTON AND BENTHOS

1. The definitions of abbreviations and symbols used in Appendix E, Parts I and II, are given below:

@	at
ca.	approximately
CI-CV	copepodids I - V of Copepoda
C	carbon
°C	degrees Centigrade
F	field study
K	constant
L	laboratory study
µg	microgram
NI-NVI	nauplii I - VI of Copepoda
NPM	nonpredatory mortality
?	unknown or could not be determined from data
ULT	upper lethal temperature
VS	varied seasonally
$\bar{X}$	mean

PART I: NONPREDATORY MORTALITY RATES OF ZOOPLANKTON AND BENTHOS

APPENDIX E: PART I (Continued)

Taxon	Field or lab	Temperature (°C)	Food	Comments	Nonpredatory mortality (mg C/mg C/day) x 100	Reference
PHYLUM: MOLLUSCA						
Class: Pelecypoda						
Anodonta anatina	F	VS	natural assemblage	$\bar{X}$ daily NPM = annual NPM/365; predatory mortality assumed to = 0		Negus (1966)
				5-6 years old	0.05	
				6-7 years old	0.07	
				7-8 years old	0.10	
				8-9 years old	0.23	
Class: Gastropoda						
Lymnae obruusa	L	10	Elodea sp. and Ludwigia sp.	NPM was significantly correlated with temperature	0.59	Mattice (1976)
		15			0.29	
		17			0.36	
		20			0.50	
		25			1.80	
		26			1.71	
PHYLUM: ARTHROPODA						
Class: Insecta Order: Trichoptera						
Potamophylax cingulatus	F	VS	detritus	Cages in the stream excluded predators;		Otto (1975)
				November	0.22	
				December	0.38	
				January	0.38	
				February	0.11	
				March	0.07	
				April	0.17	
				May	0.10	
				June	0.85	
				July	1.95	
				August	8.98	
				Annual $\bar{X}$	1.32	

APPENDIX E: PART I (Continued)

Taxon	Field or lab	Temperature (°C)	Food	Comments	Nonpredatory mortality (mg C/mg C/day) x 100	Reference
Class: Crustacea Subclass: Malacostraca Order: Amphipoda						
Hyalella asteca	L	10	?	No 1st instar survival	——	Cooper (1965)
		15	?		0.20	
		20	?		0.55	
		25	?		0.61	
Gammarus spp.	L	7.1-11.2	*Cabomba* sp., *Myriophyllum* sp., and green algae	NPM estimates are based on control data	0.78-1.23	Ginn et al. (1976)
		11.7			0.49-0.63	
		25.5			0.60-1.00	
		26.5			0.40-1.10	
		27.7			4.00-5.80	
Gammarus pulex	L	15		$\bar{X}$ % NPM is given at 21, 42, and 70 days for each food type	21 42 70	Willoughby and Sutcliffe (1976)
			decayed elm and oak leaves		0 0 0	
			undecayed elm and oak leaves		0 0 0	
			green grass		0.68 0.48 0.36	
			Clavariopsis sp.		0 0.60 0.48	
			Zygogonium sp.		0.81 1.43 1.43	
			brown grass		0 0 1.14	
			no food		1.78 3.03*	
			Tricladium sp.		1.19 1.52	
					1.09 2.16	
					0.30 0.30	
Subclass: Brachiopoda Order: Cladocera						
Daphnia pulex	L	15	*Chlamydomonas* sp.	IF = immature females; MF = mature females	IF MF	Craddock (1976)
		18	*Chlorella* sp.		1.19 0.98	
		21			1.35 0.98	
		24			5.55 1.04	
		27			6.25 1.85	
		30			4.55 2.38	
		33			63.28 57.14	
					400.00 400.00	

* Percent NPM for 33 days.

APPENDIX E: PART I (Continued)

Taxon	Field or lab	Temperature (°C)	Food	Comments	Nonpredatory mortality (mg C/mg C/day) x 100	Reference
Daphnia pulex	L	R	Chlamydomonas mocurusi	Density in 25 ml of media: 1	2.32	Frank et al. (1957)
				2	2.70	
				4	1.88	
				8	1.82	
				16	1.82	
				24	1.96	
				32	1.96	
Daphnia galeata	L	5	Chlorella sp.	Median % mortality/day	0	Hall (1964)
		11	Ankistrodesmus sp.		0.33	
		20	and other green algae		0.71	
		25			1.66	
Daphnia rosea	F	VS	VS	6-14 July	0.35	Dodson (1972)
				14-20 July	0.70	
				20-25 July	0.71	
				25 July - 1 August	0.36	
				1-8 August	0.40	
				8-15 August	0.59	
				15-22 August	0.37	
				22-29 August	0.18	
				8 August - 4 September	0.63	
				$\bar{X}$	0.57	
Daphnia rosea	F	VS	VS	Predation was considered negligible;		Clark and Carter (1974)
				May	0.05	
				June	0.15	
				July	0.12	
				August	0	
				September	0.04	
				October	0.05	
Daphnia spp.	F	VS	VS	% NPM/day was estimated assuming that Leptodora kindtii was the only predator;		Wright (1965)
				April-June	0.12	
				July-August	0.17	

APPENDIX E: PART I (Continued)

Taxon	Field or lab	Temperature (°C)	Food	Comments	Nonpredatory mortality (mg C/mg C/day) x 100			Reference
Daphnia retrocurva	F	VS	VS	Predation was considered negligible;				Clark and Carter (1974)
				May	0.14			
				June	0.10			
				July	0.15			
				August	0			
				September	0.02			
				October	0.03			
Diaphanosoma leuchtenbergiana	F	?	?	May	0			Clark and Carter (1974)
				June	0			
				July	0			
				August	0.02			
				September	0.09			
				October	0.1			
Ceriodaphnia reticulata	L, F	23 in lab 20-26 in field	?	Lab and field experiments yield the same results	1.62			Hall et al. (1970)
Simocephalus serrulatus	L, F	23 in lab 20-26 in field	?	Lab and field experiments yield the same results	2.5-2.7			Hall et al. (1970)
Subclass: Copepoda								
Calanus helgolandicus	L	14.7-15.3	*Prococentrum micans* @	Data are presented for 3 life periods	Egg-CI	CI-CIII	CIII-Adult	Paffenhofer (1976)
			70.9 µg C/l		0.54	0	0	
			41.8 µg C/l		0.40	0.25	0	
			Gymnodinium polyedra @					
			41.0 µg C/l		0	0	0	
			Gymnodinium splendens @					
			95 µg C/l		3.35	0.49	0	
			Lauderina borealis @					
			48.3 µg C/l		4.80	0.33	0	
			49.9 µg C/l		3.97	0.30	0.38	
			102.3 µg C/l		1.01	0		
			100.6 µg C/l		0.89	0.26		
Calanus helgolandicus	?	15	*Thalassiosira* sp. @					Mullin and Brooks (1970)
			177 µg C/l		2.35			
			266 µg C/l		1.50			

APPENDIX E: PART I (Continued)

Taxon	Field or lab	Temperature (°C)	Food	Comments	Nonpredatory mortality (mg C/mg C/day) x 100	Reference
Calanus helgolandicus	L	15	*Gymnodinium splendens* @ 95 µg C/l	Data was calculated assuming a mean life of 36 days	0.33	Paffenhofer (1971)
			Lauderica borealis @ 49 µg C/l		0.72-0.81	
			101 µg C/l		0.05-0.15	
			36 µg C/l		1.38-1.53	
Rhincalanus nasutus	L	15	*Ditylum* sp. @ 145 µg C/l		0.64	Mullin and Brooks (1970)
		15	*Thalassiosira* sp. @ 196 µg C/l		1.47	
		10	*Thalassiosira* sp. @ 352 µg C/l		1.50	
		10	*Ditylum* sp. @ 200 µg C/l		1.15	
Copepod nauplii	F	17-18	natural assemblage		0.60-1.74	Petipa et al. (1970)
Paracalanus sp.	F	17-18	natural assemblage	Copepodite I - III	0.27-0.62	Petipa et al. (1970)
				Copepodite IV - VI	0.41-0.44	
Diaptomus clavipes	L	20-25	?	Egg-NII	15.55	Gehrs and Robertson (1975)
				NIV-NVI	4.26	
				CI	0.70	
				CII	1.09	
				CIII	0.67	
				CIV	0.38	
				CV	0.91	
				X	1.47-2.5	
Omnivorous zooplankton	F	17-18	natural assemblage		0.98-1.31	Petipa et al. (1970)
Carnivorous zooplankton	F	17-18	natural assemblage	Primary carnivores	0.74-1.33	Petipa et al. (1970)
				Secondary carnivores	0.94-0.96	
				Tertiary carnivores	0 -.24	

PART II: UPPER AND LOWER LETHAL TEMPERATURES OF ZOOPLANKTON AND BENTHOS

APPENDIX E: PART II (Continued)

Taxon	Comments	Acclimation temperature (°C)	Exposure time	Lower lethal temperature (°C)	Upper lethal temperature (°C)	Reference
PHYLUM: MOLLUSCA						
Class: Pelecypoda						
Corbicula manilensis		5	long term		24	Mattice and Dye (1976)
		30		12	34	
		15		2		
Corbicula manilensis		10	several minutes		43	Ieom (1971)
Corbicula manilensis		23	4 days		34	Nabel (1970)
Class: Gastropoda						
Theodoxus fluviatilis	Acclimatization increased tolerance		variable		36-38	Skoog (1976)
Lymnea peregra			variable		36-38	Skoog (1976)
PHYLUM: ARTHROPODA						
Class: Crustacea						
Subclass: Branchiopoda						
Order: Anostraca						
Triops longicaudatus		?	20 minutes		40	Hillyard and Vinigar (1972)
Thamnocephalus platyurus		?	1 hour		42	Hillyard and Vinigar (1972)
Branchipus serratus	Adults	?	?		28	Altman and Dittmer (1966) as cited by Goss and Bunting (1976)
Streptocephalus seali	Temperature was increased 1°C /6-10 minutes in the 1st hour and then 1°C /12-20 minutes thereafter	28-31	?		44.5	Altman and Dittmer (1966) as cited by Goss and Bunting (1976)
Order: Conchostraca						
Caenestheriella synecia	Adults	?	?		38	Jensen et al. (1969) as cited Goss and Bunting (1976)

APPENDIX E: PART II (Continued)

Taxon	Comments	Acclimation temperature (°C)	Exposure time	Lower lethal temperature (°C)	Upper lethal temperature (°C)	Reference
Order: Cladocera						
Daphnia pulex	Reproduction ceased after 27°C	15 or 20	192 hours 0.5 hours		27 30	Craddock (1976)
Daphnia pulex		15,10,15,20,25,30	48 hours		32-35	Goss and Bunting (1976)
Daphnia pulex	Adults	ambient	variable		32	Brown and Crozier (1927) as cited by Goss and Bunting (1976)
Daphnia pulex	Adults	?	?		30	Altman and Dittmer (1966) as cited by Goss and Bunting (1976)
Daphnia pulex		?	?		35-41	Brown (1928) as cited by Bovee (1949)
Daphnia magna		5,10,15,20,25,30	48 hours		30	Goss and Bunting (1976)
Daphnia schodleri	Lethal at high food concentrations Lethal at low food concentrations	? ?	? ?		30 35	Hayward and Gallup (1976)
Daphnia atkinsoni		?	?		26.8-30+	Jensen et al. (1969) as cited by Goss and Bunting (1976)
Daphnia sp.	Highest temperature for successful culture	?	One life cycle		27	Geller (1975)
Alona affinis	Adults	?	?		40.5	Jensen et al. (1969) as cited by Goss and Bunting (1976)
Chydorus globosus		?	?		35.0-35.5	Jensen et al. (1969) as cited by Goss and Bunting (1976)
Eurycercus lamellatus	Adults	?	?		35.0-35.5	Jensen et al. (1969) as cited by Goss and Bunting (1976)
Subclass: Copepoda						
Limnocalanus macrurus	Arctic species; temperature was increased 10°C /hour	3	ca. 2 hours		18-21	Roff (1973)

APPENDIX E: PART II (Continued)

Taxon	Comments	Acclimation temperature (°C)	Exposure time	Lower lethal temperature (°C)	Upper lethal temperature (°C)	References
Cyclops serrulatus	Adults; stepped from 26° C to death point	ambient	——		34-35	Coker (1934) as cited by Goss and Bunting (1976)
Cyclops vernalis		9	?		32.6-33.0	Coker (1934) as cited by Goss and Bunting (1976)
		15			32+	
		29			37.0-39.6	
Cyclops viridus		9	?		31.0	Coker (1934) as cited by Goss and Bunting (1976)
		12			32.5	
		15			32.5-34.0	
		29			35-37	
Eucyclops agilis	Stepped from 26°C to death point	ambient	——		34-35	Coker (1934) as cited by Goss and Bunting (1976)
Thermocyclops neglectus		35	One life cycle		35	Goss and Bunting (1976)
Eurytemora affinis	Adults	5,10,15,20,25	48 hours		25-30	Heinle (1969) as cited by Goss and Bunting (1976)
Subclass: Malacostraca Order: Mysidacea						
Mysis relicta		7.5	5 hours		16.0-16.5	Smith (1970) as cited by Goss and Bunting (1976)
		4.5	16 days; 1.0°C /day		16	
			6 days; 2.5° C /day		18	
			4 days; 5.0°C /day		16	
Order: Isopoda						
Asellus intermedius		10	100 minutes		33.4	Sprague (1963)
		20			35.3	
		25			35.9	
		30			36.7	
Order: Amphipoda						
Pontoporeia affinis		6	24 hours		12.0	Smith (1972) as cited by Goss and Bunting (1976)
			96 hours		10.8	
			30 days		10.4	

APPENDIX E: PART II (Continued)

Taxon	Comments	Acclimation temperature (°C)	Exposure time	Lower lethal temperature (°C)	Upper lethal temperature (°C)	Reference
Hyalella azteca		10	?		34.4	Sprague (1963)
Hyalella azteca	Temperature raised 10° C /5 days	?	?		35-37	Pennak and Rosine (1976)
Hyalella azteca	Temperature raised 0.2° C /day	22-23	?		33-35	Bovee (1949)
Gammarus fasciatus		10 20	100 minutes		32 34	Sprague (1963)
Gammarus pseudolimnaeus		10 20	100 minutes		32 34	Sprague (1963)
Gammarus pseudolimnaeus	The acclimation temperature is the optimum for growth	18	96 hours 30 days		26 22-24	Smith (1973)
Gammarus lacustris		18	96 hours 30 days		26 25	Smith (1973)
Gammarus lacustris	Temperature raised 10° C /5days	?	?		26-28	Pennak and Rosine (1976)
Gammarus spp.	97% mortality in 5 days 87% mortality in 5 days	26.5 27.7	1 hour 2 hours		38.2 36.0	Ginn et al. (1976)
Order: Decapoda						
Pacifastacus leniusculus	The lower median tolerance limits depended on the acclimation temperature	25 20 15	96 hours	2.5 0.4 0.0		Becker et al. (1977)
Class: Insecta Order: Ephemeroptera						
Isonychia sp.	Neither acclimation temperature nor the magnitude of thermal shock were consequential until a combination of the two approached the ULT	4-24	1-40 minutes		33.5-35.0	Sherberger et al. (1977)

APPENDIX E: PART II (Continued)

Taxon	Comments	Acclimation temperature (°C)	Exposure time	Lower lethal temperature (°C)	Upper lethal temperature (°C)	Reference
Order: Trichoptera						
Hydropsyche sp.	Neither acclimation temperature nor the magnitude of thermal shock were consequential until a combination of the two approached the ULT	4-24	1-40 minutes		36-38	Sherberger et al. (1977)

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Leidy, George R
Simulation modeling of zooplankton and benthos in reservoirs: documentation and development of model constructs / by G. R. Leidy, G. R. Ploskey, USDI Fish and Wildlife Service, National Reservoir Research Program, Fayetteville, Arkansas. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.
221, [86] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; E-80-4)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under EWQOS Task IB.1.
References: p. 183-221.

1. Benthos. 2. Environmental effects. 3. Mathematical models. 4. Reservoirs. 5. Simulation. 6. Stochastic models. 7. Zooplankton. I. Ploskey, G. R., joint author. II. United States. Fish and Wildlife Service. National Reservoir Research Program. III. United States. Army. Corps of Engineers. IV. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report : E-80-4.
TA7.W34 no.E-80-4