Int. Revue ges. Hydrobiol. | 58 | 6 | 1973 | 885–892

VERONICA J. THORP and PHILIP S. LAKE

Department of Zoology, University of Tasmania, Hobart, Tasmania

Pollution of a Tasmanian River by Mine Effluents. II. Distribution of Macroinvertebrates

Abstract

The distribution and abundance of macroinvertebrates were studied in the South Esk River, Tasmania; a river subject to cadmium and zinc pollution as a result of mining. The groups most intolerant of cadmium-zinc pollution were the Crustacea, Mollusca and Annelida. Highly tolerant groups included aquatic Hemiptera and Arachnida, and larvae of leptocerid trichopterans. A drop in both species diversity and abundance occurred after floods in winter and was probably due to pulses of cadmium and zinc down the river and also to increased molar action of the unstable substrate.

1. Introduction

Since the late nineteenth century, the South Esk River in Northeast Tasmania has been polluted by effluents from tin and wolfram mines. The chief pollutants are sulphuric acid, cadmium, zinc, copper, lead, iron, and manganese (TYLER and BUCKNEY, 1973).

In previous studies, the effects on the benthic macroinvertebrate fauna of lead-zinc pollution (CARPENTER 1924; JONES, 1940, 1958; NEWTON, 1944) and copper-zinc pollution (SPRAGUE, ELSON and SAUNDERS, 1965) have been reported. The only biological study of heavy metal pollution in Australia is that of WEATHERLEY, BEEVERS and LAKE (1967) on the zinc-polluted Molonglo River.

The aim of this study was to investigate the effects of heavy metal pollution on the distribution and abundance of the macroinvertebrate fauna in the South Esk River.

2. Description of the Stations (Fig. 1)

Four stations along the South Esk River were sampled, one upstream and three downstream of the source of pollution. The combined Aberfoyle and Storys Creeks were sampled before their entry into the South Esk. A control station was selected on the St. Paul's River. All the sampling sites were near flood level in August.

Station 1 is just upstream from Fingal. The South Esk River here consists of a series of long pools in summer, but floods in winter. From upstream, this station may receive effluents from a nearby coal-washing plant, but it appears that the washings have little effect on the river. The banks are lined with a dense growth of willows, wattles, eucalypts, hawthorns, blackberries, grasses and sedges. The river bed is a fine mud and emergent aquatic macrophytes are abundant.

Station 2 is a few metres below the junction of Aberfoyle and Storys Creeks. The creek is quite narrow and swift-flowing. It runs over a bed of unstable stones covered with a deposit of fine grey silt. Aquatic macrophytes and algae are absent. The banks are badly eroded and, apart from a few wattles and gorse bushes on the more stable parts, consist largely of unstable rocks

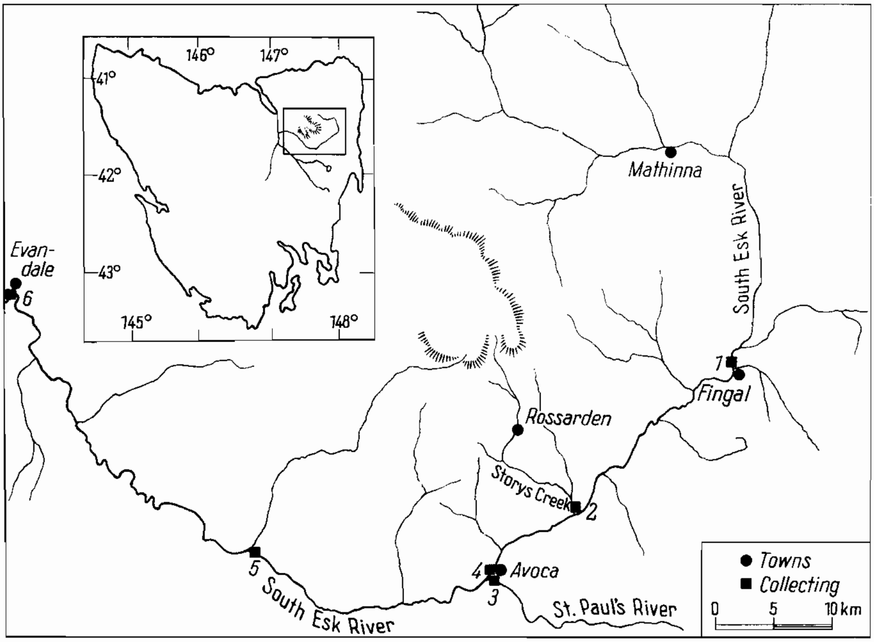

Fig. 1. Survey area showing collection sites.

devoid of terrestrial plants. The banks are littered with dead trees but it is not known whether this is caused by the toxic effects of metal pollution, by flooding, or by the dumping of toxic materials on the banks during flooding.

Station 3 is at St. Paul's River just before it joins the South Esk at Avoca. The river is fairly slow moving and has an abundance of aquatic macrophytes. The banks are lined with willows, tea-trees and grasses.

Station 4 is just outside Avoca about 30 metres upstream of the entry of St. Paul's River into the South Esk. The bank at the collecting site is high and consists of unstable sandy soil thickly covered with gorse bushes. The South Esk here is quite wide and slow-flowing and has a rather sandy bed with a few clumps of reeds.

Station 5 is situated near the property of "Glen Esk". The South Esk at this site is wide and slow-flowing with abundant aquatic macrophytes. The river bed consists of a clayey-mud and the stable banks are lined with willows and sedges.

Station 6 is just downstream of Evandale. The river is wide and flows slowly over a muddy stream bed. The stable banks are lined with willows and sedges.

3. Materials and Methods

Samples were collected in February and in August, 1972, from the stations indicated in Fig. 1. Water samples were collected and filtered, and ions, pH and alkalinity (HCO_3^-) determined as described by TYLER and BUCKNEY (1973).

The invertebrates were sampled in the slower-flowing regions (lentic regions) at each station using a standard F. B. A. long-handled net with a mesh of 8 strands/cm. attached to a 25 cm. square frame. The length of time taken in sampling depended on the ease of access but was generally about 5 minutes and up to 100 yards of the stream was covered. Sweeps were particularly concentrated amongst aquatic macrophytes, with surface sweeps also being made. The animals were stored in 70% ethanol and counted and identified at a later date. Identifications were made, using the keys in the publications of PETERSON (1951), WILLIAMS (1968) and C. S. I. R. O. (1970).

4. Results

The analyses of the water samples are shown in Table 1. The number of animals and the number of species collected at each station are given in Table 2. Figures 2 and 3 give the proportional representation of those groups which comprise 0.5% or more of the macroinvertebrate assemblage at each station in summer and winter respectively.

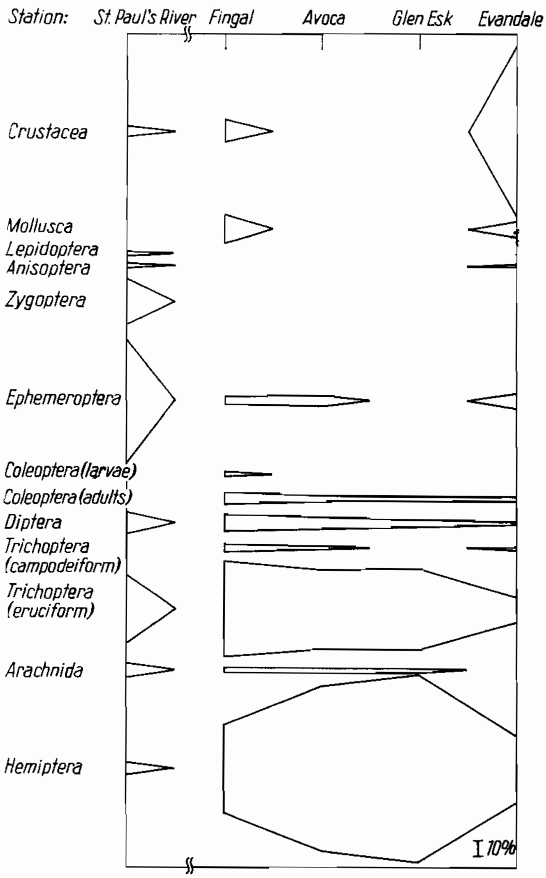

Fig. 2. Proportional representation of groups comprising 0.5% or more of the macroinvertebrate community at each station in summer. The polluted Storys and Aberfoyle creeks enter the South Esk between Fingal and Avoca.

5. Discussion

The chemical data (Table 1) agree with those of TYLER and BUCKNEY (1973), indicating pollution of the South Esk River, particularly by cadmium and zinc, as

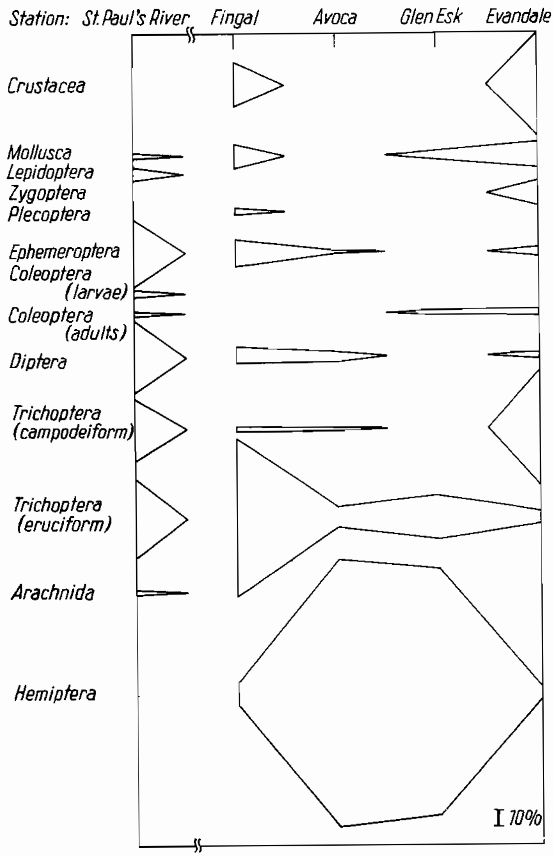

Fig. 3. Proportional representation of groups comprising 0.5% or more of the macroinvertebrate community at each station in winter.

far downstream as Evandale. The increased cadmium concentrations on 23/8/72 were probably due to flooding and failed to meet international drinking water standards (given in Table 7 of Tyler and Buckney, 1973).

It is evident from this survey that heavy metal pollution from Storys and Aberfoyle Creeks markedly affects the abundance and the distribution of macroinvertebrates in the South Esk River. There is a tendency for a reduction in both numbers and in species at polluted stations except for increase in both at Avoca in summer. This increase could be due to reduced predation by, or competition from, species sensitive to heavy metal pollution. Trout are absent from the South Esk River between Storys Creek and Evandale (Tyler and Buckney, 1973). The absence of such a significant predator from the more polluted reaches of the river may well affect the abundance and distribution of the macroinvertebrates, especially the Trichoptera.

The groups which appear to be most intolerant of mild cadmium-zinc pollution are the Crustacea, Mollusca and Annelida. These groups are also intolerant of zinc or lead-zinc pollution (Carpenter, 1925; Jones, 1940, 1958; Wurtz, 1962; Weatherley *et al.*, 1967). The absence of annelids and of the crustacean *Paratya* as far downstream as Evandale is thought to be due to the direct effects of heavy metal pollution, as both are found at or near Fingal. The presence of the amphipod *Austro-*

Table 1. Water properties of the collection sites

p. p. m.	Fingal Bridge		Junction Story's and Aberfoyles		Avoca		Glen Esk		Evandale		St. Paul's River	
	29. II. 72	28. VIII. 72	29. II. 72	23. VIII. 72	29. II. 72	23. VIII. 72	29. II. 72	23. VIII. 72	29. II. 72	23. VIII. 72	29. II. 72	23. VIII. 72
Zn	0.2	0.05	8.0	3.52	0.27	0.3	0.2	0.17	0.22	0.06	0.1	Trace
Cd	0	0.06	0.24	0.33	0	0.05	0	0.002	0	0.01	0	0
Cu	0.06	0.06	0.12	0.04	0.03	0.02	0.05	0.04	0.06	0.04	0.04	0.03
Fe	Trace	0.07	Trace	Trace	Trace	0	Trace	Trace	Trace	0.02	Trace	0.01
Mn	0.01	0.1	0.97	4.7	0.04	0.8	0.02	0.48	0.01	0.2	0.01	0.2
Na	6.85	9.2	6.0	3.75	7.40	7.5	8.6	8.45	9.6	9.35	9.3	8.2
K	1.05	0.85	1.85	1.5	1.0	0.8	1.15	0.72	0.85	0.74	0.7	0.45
Ca	1.75	0.9	17.6	6.0	2.75	1.95	3.45	2.13	3.9	2.65	3.95	2.70
Mg	1.05	1.69	13.8	5.14	2.80	3.17	3.45	3.58	3.85	4.17	4.1	3.76
Total Alkalinity HCO_3^-	19.8	17.69	15	12.26	22.6	21.84	27.0	26.90	28.20	33.67	34.60	36.84
Cl	—	17.27	—	4.43	—	13.61	—	17.66	—	20.10	—	17.97
pH	7.3	6.8	7.2	6.3	7.3	7.0	7.3	7.2	7.4	6.8	7.4	7.3
Total hardness	8.7	9.2	101	36.1	18.4	17.9	22.8	20.0	25.6	23.8	26.7	22.2
Kilometres	0		27.7		38.5		66.8		118.6		27.7	

Table 2. Number of (1) animals and (2) species collected at each station

Station	Summer (29. II. 72)		Winter (23. VIII. 72)	
	(1)	(2)	(1)	(2)
1. Fingal	118	25	376	38
2. Below junction of Storys and Aberfoyle Creeks	0	0	0	0
3. St. Paul's River	399	35	153	27
4. Avoca	542	31	95	7
5. Glen Esk	534	20	293	11
6. Evandale	362	24	48	11

chiltonia australis at Evandale is thought to be due either to a resistance to mild intermittent pollution or to replacement of the species by downstream drift (McLAY, 1970) from unpolluted tributaries.

The groups which do not appear to be greatly affected by heavy metal pollution in this survey include the Hemiptera, Arachnida and some leptocerid Trichoptera. In fact, both the numbers of the corixid, *Micronecta* and of two species of leptocerid trichopterans appear to increase in the region of rather strong pollution at Avoca, even after winter floods. The abundance of leptocerid Trichoptera could be partly due to the absence of trout in the South Esk River from the point of entry of Storys and Aberfoyle Creeks to the vicinity of Evandale.

WEATHERLEY *et al.* (1967) and SPRAGUE *et al.* (1965) also found increased numbers of certain species of trichopteran larvae at polluted zones. Laboratory bioassays suggest that some insect larvae are not directly affected by cadmium. The 96 hour median lethal concentration (LC 50) for the zygopteran larva *Ischnura heterosticta* (Coenagrionidae) was about 250 mg/l and for a trichopteran larva of the family Leptoceridae was over 2,000 mg/l. The 96 hour LC 50 for the ephemeropteran nymph *Atalophlebia australis* (Leptophlebiidae) was 1 mg/l as compared with 0.04 mg/l for the amphipod *Austrochiltonia subtenuis* (Ceinidae) and 0.06 mg/l for the shrimp *Paratya tasmaniensis* (Atyidae) (THORP 1973). These results bear out the opinion of JONES (1940, 1958) that the insect larvae of a stream are largely affected by the indirect effects of heavy metal pollution.

The principal indirect effect of heavy metal pollution is the formation of unstable physical conditions in the stream bed due mainly to the elimination of algal and aquatic macrophytic growth (JONES 1940, 1941, 1958). The increased grinding and scouring or molar action (WELCH 1948) of the stream bed may cause much injury and mortality to the fauna especially the lotic component. Another indirect effect of heavy metal pollution is a reduction in the variety of live plant food, although detritus may be plentiful. This may lead to an alteration in the animal communities (JONES 1958).

One of the major trends apparent from this survey was the drop both in species diversity and abundance in winter, particularly at polluted stations (Table 2). The drop in numbers was probably caused by flooding. JONES (1951) found that flooding in the River Towy reduced the invertebrate population from 300–1,000 to 40–48 per quarter square metre. Flooding would enhance the already greater molar action at polluted stations as compared with unpolluted stations. Moreover, "pulses" of cadmium and zinc from mine tailings would further decrease the abundance and diversity of the stream fauna during periods of flooding. The drop in the number of animals and of species in winter was most marked at Avoca. The very low numbers of animals at Evandale was probably because flooding was most severe at this station. It is also possible that the fauna at Evandale is less well-adapted to heavy metal pollution than the fauna in continuously polluted regions, so that a sudden pollution load could have deleterious effects. Only a few amphipods, 16 out of 48 animals, were found at Evandale in winter as compared with 211 out of a total of 362 in summer (Table 2).

Heavy metal pollution differs from organic pollution in that it tends to reduce both the number of species present and the number of individuals (HAWKES, 1964). No special fauna indicative of heavy metal pollution is developed, although the surviving species may be more abundant (HYNES, 1960). Both these characteristics of heavy metal pollution were demonstrated in this study. The presence of heavy metal pollution is not shown by indicator species but by the dominance of tolerant species with the simultaneous absence or scarcity of sensitive species.

The South Esk River water meets international drinking water standards with the possible exception of cadmium concentrations (TYLER and BUCKNEY, 1973). Unfortunately cadmium is not only highly toxic, but its toxicity is cumulative in mammals (FLICK, KRAYBILL and DIMITROFF, 1971) and in fish (MOUNT and STEPHAN, 1967; PICKERING and GAST, 1972). Cadmium may function in or may be an etiological factor for various pathological processes, including testicular tumours, renal dysfunction, and arteriosclerosis (FLICK *et al.*, 1971). The Report by the Senate Select Committee on Water Pollution (PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA, 1970) considers that since the nervous and bone disease "Itai Itai" (or "Ouch Ouch") experienced in parts of Japan has been positively attributed to excessive quantities of cadmium in rivers polluted by upstream mining operations, there is reason for concern to be felt by communities drawing their water supplies from the South Esk River.

6. Summary

Effects of heavy metal mining pollution on the distribution and abundance of the macroinvertebrate fauna were studied in the South Esk River, Tasmania. The groups most intolerant of cadmium-zinc pollution were the Crustacea, Mollusca and Annelida. Highly tolerant groups included the aquatic Hemiptera and Arachnida, and larvae of leptocerid trichopterans. The drop in both species diversity and abundance after winter floods was probably caused by pulses of cadmium and zinc down the river, and by increased molar action of the unstable substrate.

7. Acknowledgements

We would like to thank Mr. R. BUCKNEY, Department of Botany, University of Tasmania, who provided most of the water analyses, and Mr. J. MURPHY of Aberfoyle Limited, Rossarden, for information. Also we would like to thank Dr. J. A. L. WATSON and Dr. E. F. RIEK of the Division of Entomology, Canberra, for identifying some of the insect species used in the bioassays.

8. References

CARPENTER, K. E., 1924: A study of the fauna of rivers polluted by lead mining in the Aberystwyth district of Cardiganshire. – Ann. Appl. Biol. **9**: 1–23.

– 1925: On the biological factors involved in the destruction of river-fisheries by pollution due to lead-mining. – Ibid. **12**, 1–13.

C. S. I. R. O., 1970: The Insects of Australia – Melbourne University Press 1970: 1029 pp.

FLICK, D. F., H. F. KRAYBILL and J. M. DIMITROFF, 1971: Toxic effects of cadmium: a review. – Environm. Res. **4**: 71–85.

HAWKES, H. A., 1964: An ecological basis for the biological assessment of river pollution. – Chem. Ind. **11**: 437–442.
HYNES, H. B. N., 1960: The biology of polluted waters. – Liverpool University Press 1960: 202 pp.
JONES, J. R. E., 1940: A study of the zinc-polluted river Ystwyth in north Cardiganshire, Wales. – Ann. Appl. Biol. **27**: 368–378.
– 1941: The fauna of the river Dovey, West Wales. – J. Anim. Ecol. **10**: 12–24.
– 1951: An ecological study of the river Towy. – Ibid. **20**: 68–86.
– 1958: A further study of the zinc-polluted river Ystwyth. – Ibid. **27**: 1–14.
MCLAY, C., 1970: A theory concerning the distance travelled by animals entering the drift of a stream. – J. Fish. Res. Bd. Can. **27**: 359–370.
MOUNT, D., and C. E. STEPHAN, 1967: A method for detecting cadmium poisoning in fish. – J. Wildl. Mgmt. **31**: 168–172.
NEWTON, L., 1944: Pollution of the rivers of West Wales by lead and zinc mine effluent. – Ann. Appl. Biol. **31**: 1–11.
PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA, 1970: Water Pollution in Australia. Report from the Senate Select Committee on Water Pollution. – Commonwealth Government Printing Office, Canberra. 214 pp.
PETERSON, A., 1951: Larvae of Insects. An Introduction to Nearctic Species. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera, Trichoptera. – Columbus, Ohio. 416 pp.
PICKERING, Q. H., and M. H. GAST, 1972: Acute and chronic toxicity of cadmium to the fathead minnow (*Pimephales promelas*). – J. Fish. Res. Bd. Can. **29**: 1099–1106.
SPRAGUE, J. B., P. F. ELSON and R. L. SAUNDERS, 1965: Sublethal copper-zinc pollution in a salmon river: a field and laboratory study. – Int. J. Air. Water Poll. **9**: 531–543.
THORP, V. J., 1973: Ecological studies of a zinc and cadmium polluted river and an investigation of the physiological and histological effects of cadmium on selected invertebrates. – Honours Thesis, University of Tasmania. 132 pp.
TYLER, P. A., and R. BUCKNEY, 1973: Pollution of a Tasmanian river by mine effluents. I. Chemical Evidence. – Int. Rev. ges. Hydrobiol. **58**: 873–883.
WEATHERLEY, A. H., J. R. BEEVERS and P. S. LAKE, 1967: The ecology of a zinc-polluted river. – In: A. H. WEATHERLEY (ed.): Australian Inland Waters and their Fauna. Eleven Studies. – Canberra, Australian National University Press: 252–278.
WELCH, P. S., 1948: Limnological Methods. – McGraw-Hill Book Co., Inc. 381 pp.
WILLIAMS, W. D., 1968: Australian Freshwater Life. The Invertebrates of Australian Inland Waters. – Melbourne, Sun Books. 262 pp.
WURTZ, C. B., 1962: Zinc effects on freshwater molluscs. – Nautilus **76**: 53–61.

Miss VERONICA J. THORP
Dr. PHILIP S. LAKE
Department of Zoology
University of Tasmania
Hobart, Tasmania, Australia