NOTES

THE HAZARD PRESENTED TO FRESHWATER LIFE BY AERIAL COPPER SPRAYING

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INTRODUCTION

The recent large increase in radiata pine forest areas treated with copper spray mixtures to combat *Dothistroma pini* infection has caused concern among amateur and professional conservationists lest the numerous and important streams and lakes in these areas become polluted. Many New Zealand fresh waters are extremely soft, and overseas work has shown that under these conditions as little as 15 μg Cu/l may be toxic to some aquatic plants and animals (Anon., 1963). In addition, Sprague *et al.* (1965) recently discovered that although the incipient lethal amount to young salmon in a Canadian river was 48 μg Cu/l, the parr avoided water containing much lower concentrations. The routine application of spray in this country supplies only 4 lb Cu/acre to the catchment, but should other pollutants be present in slightly sub-lethal concentrations in the waters of a stream, the addition of only a trace of copper may cause mortality, for many common toxic agents, such as Zn, NH_3, and phenol, exert an effect equal to their sum (Herbert *et al.*, 1965).

On the other hand, the World Health Organisation considers 1000 μg Cu/l is an acceptable limit of copper in drinking water (Anon., 1958) and reservoirs in Europe are routinely treated with 100 μg Cu/l to control algal growth, with no marked effects on the animal life present. Care must, of course, be exercised in applying results collected elsewhere to local conditions, especially as the copper oxide, which forms the active ingredient in the sprays used here, is almost insoluble; so it is likely to be released only slowly into the catchment. However, as most North Island soils already contain 7 to 10 ppm Cu (Wells, 1962), the relative increase in total copper from spraying will usually be minimal.

Since few pertinent data are available for fresh waters and their fauna and flora, the Rotorua Forest Conservancy made facilities available to the Marine Department for a short survey of the Ngatamawahine Stream, in the north Kaingaroa Forest, before and after the beginning of standard spraying treatment over this catchment.

METHODS

The stream was first inspected on 28 September, 1966. The turbulent flow (about 8 cusecs) and rocky bed were typical of many streams in forest areas and provided a good habitat for

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TABLE 1: THE WEIGHT AND RELATIVE COPPER CONTENT OF THE FRESHWATER ANIMALS AND SUSPENDED SOLIDS IN THE WATER OF THE NGATAMAWAHINE STREAM FROM SAMPLES COLLLECTED ON THREE OCCASIONS DURING 1966–67

The analyses include the shell of the snail *Potamopyrgus* and the cases of the caddis flies *Olinga and Helicopsyche*

Animals Sampled	Potamo-prygus	Olinga	Archichau-liodes	Hydro-psyche	Colo-buriscus	Helico-psyche	Zeph-lebia	Seston
3/10/66								
Number collected	50	25						1 litre
Average fresh wt (mg)	17.72	16.32						
Average dry wt (mg)	7.24	6.24						45.0
µg Cu/g fresh wt	48.3	7.3		21.8	9.5			333.0 (dry)
% water	53.7	61.7		80.0	79.0			
15/11/66								
Number collected	46	20	4	13	21	42	37	1 litre
Average fresh wt (mg)	19.3	11.55	129.5	26.2	20.2	12.5	19.7	
Average dry wt (mg)	9.0	5.55	24.5	5.15	4.29	8.89	4.38	1.0
µg Cu/g fresh wt	11.23	6.5	2.9	7.35	22.4	3.8	6.17	9,500 (dry)
% water	53.4	48.0	81.0	80.1	79.0	29.0	77.7	
6/12/67								
Number collected	6	17	2	50	33	25	20	950 ml
Average fresh wt (mg)	19.5	16.0	140.45	38.94	30.8	7.0	16.93	
Average dry wt (mg)	9.8	6.82	30.6	7.85	5.0	4.7	2.74	1.0
µg Cu/g fresh wt	36.29	11.93	11.57	6.03	5.92	5.78	5.17	1,750 (dry)
% water	49.79	57.43	78.21	79.84	81.38	32.08	83.82	
Average µg Cu/g fresh wt	31.94	8.58	7.23	11.73	12.61	4.79	5.67	

several of the bottom fauna that are food for trout. Collections were made on 3 October, 1966, of the animals present, and samples of the water were taken for subsequent filtration and analysis. The forest areas were treated with copper sprays on 2 November, 1966, and 30 November, 1967, and stream collections were made about a week afterwards. Where possible, the whole organism such as would be ingested by trout was collected (for example, *Potamopyrgus, Olinga,* and *Helicopsyche*) and analysed complete with shell or case. The animals were brought alive to the laboratory, identified, and placed in a centrifuge tube over a wad of dry filter paper. Gentle centrifuging removed the surface water before the fresh weight was determined. The animals were then dried to constant weight at 100°C. The water samples were filtered through tared Millipore filters, which were then similarly dried and weighed. The dry residues, after ashing and extraction with mineral acid, and the filtered water were then analysed for copper content with an atomic absorption spectrophotometer with a lower sensitivity of 50 μg Cu/l. The numbers of animals collected were not especially noted at first, but subsequently the average weights were calculated, as the information was likely to be of general interest.

RESULTS AND DISCUSSION

The analytical results are presented in Table 1. The dissolved copper content of the water was very small in all samples and below the limits of the method used, but the fine particulate debris filtered from the water carried detectable quantities. Although the amount of this seston decreased sharply after the first spraying in 1966, its copper content increased by several times after spraying operations began.

No such effect was found among the animals investigated, but their copper contents were rather variable over the period. The snail *Potamopyrgus* averaged the largest content of copper, three to six times the amount found in the insect larvae. This accumulation may have been high owing to deposition into the shell material throughout the life of the organism, but it has been shown that at least some constituents of the shell of another *Potamopyrgus* species can vary within a few weeks according to the dissolved content of the water environment (Edwards and Heywood, 1960). However, the present evidence does indicate that copper is secreted by the animal, for the caddis *Helicopsyche,* which has the heaviest shell, as shown by its relatively low water percentage, also has the lowest average copper content. The inorganic case of this animal is largely composed of sand grains taken from the substratum, whereas that of the snail is secreted during growth. Similarly, the other cased caddis, *Olinga,* which has a case largely of secreted material, contains nearly twice as much copper as that in *Helicopsyche.* Apart from this, the results provide little information on the effect of diet on the animals' copper content. Although the seston contains comparatively large amounts of copper, the insects such as *Zephlebia* which feed by rasping organic material from the surface of the substrate did not contain significantly less copper than those such as *Hydropsyche* and *Coloburiscus* which filtered the water (Marples, 1962). The copper content of the highly predatory neuropteran larva *Archichauliodes* varied greatly and this cannot be understood at present.

The results in Table 1 show that, after spraying, increased amounts of copper were carried in an insoluble form in the stream, but that there was no general increase in the copper content of the animals investigated. These results suggest that some of the copper applied as spray to the catchment makes its way into the drainage waters and that the aquatic fauna either does not consume this material, or if it does, the additional copper is not accumulated in the animals' bodies.

Attempts to estimate large population changes by drift-net sampling had to be terminated shortly after the survey began owing to unexpected staff shortages and so no evidence was gathered of possible insect mortality after the copper spraying. However, since the animal life in the stream remained abundant and no increased copper content was found in the species analysed, it was concluded that such mortalities, if they occurred, were probably small and could be left for detailed evaluation on a subsequent survey.

Clearly, several important aspects of the consequences of widespread copper spraying remain to be investigated. The effect of increased rainfall on copper leaching, the toxic levels of the leached copper to all the species of aquatic animals in local waters, and the population changes in streams draining sprayed areas must all be examined before any firm conclusions can be reached. The present brief survey has merely provided some evidence that aerial spraying with the material used had no immediately serious polluting effect. If toxicity levels are to be established and the further effects of copper spraying studied in detail, more detailed observations will be required. In the meantime, the data collected here indicate the order of the copper contents that might be expected in some animals and their environment before and after a spraying programme had been started.

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