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Bioaccumulation of Mercury in Blowflies Collected near the Mercury Mine of Idrija, Yugoslavia

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In studies performed to elucidate the bioaccumulation and fate of mercury in the global environment, the area around the mercury mine of Idrija belongs to one of the most intensively investigated localities. In fact, the traditions of mercury research in this area can be traced back to the pioneer work of Theophrastus Bombastus von Hohenheim (1493-1541 A.D.), more commonly known as Paracelsus, who described mercurialism amongst Idrijan miners and developed the use of mercury as a drug against syphilis, as a diuretic and as an antiseptic in the care of wounds (D'ITRI and D'ITRI 1977). The most important work with regards to the environment has been performed recently by a team of Yugoslavian research workers (BYRNE and KOSTA 1970, BYRNE et al. 1971, FURLAN and KOSTA 1972, ZELENKO and KOSTA 1973, STEGNAR et al. 1973 ab, FURLAN 1974 ab, KOSTA et al. 1974 abc, BYRNE et al. 1975, KOSTA et al. 1975). The Yugoslavian work is of special importance because of the variety of different objects studied in a single locality, where heavy pollution with elementary mercury has continued for more than 400 years.

In the Yugoslavian studies performed in Idrija, although some entomological aspects have been considered, the role of sarcosaprophagus insects has been neglected. These insects, however, have grown to be a speciality in the mercury studies carried out at the Department of Environmental Conservation in Helsinki University (NUORTEVA and HÄSÄNEN 1972, NUORTEVA et al. 1975, NUORTEVA 1977, NUORTEVA et al. 1978 abc) so it was decided to investigate the occurrence and fate of mercury in blowflies from Idrija.

MATERIALS AND METHODS

Fly traps baited with cattle liver and marine fish were used to collect blowflies at three localities on the shores of the Idrijca River during August 1-9, 1978. The first locality lies in scrub by the shoreline about 1 km upstream from the mercury distil-

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lation plant, the second on a hilly slope just above the distillation plant (= area I by BYRNE et al. 1971) and the third in scrub by the shoreline about 0.8 km downstream from the distillation plant. When the material was collected, the mining and distillation of mercury in Idrija had been stopped for about half a year. Obviously this had considerable influence on the amount of mercury present in the air as well as its fallout on the vegetation. The degree of surface contamination was thus less than normal in the area.

Finnish observations on the mercury contents in free living blowflies are used for comparisons with the Idrijan materials. Earlier published evidence from Bromarv and Hämeenkyrö (NUORTEVA et al. 1975) has been completed with material trapped in Äetsä during September 6-8, 1978 on the shores of the Kokemäenjoki River, about 1 km downstream from the caustic soda factory of Finnish Chemicals.

A trout (Salmo trutta fario L.) which was used in the rearing experiments was obtained from the Idrijca River about 3 km downstream from the mercury distillation plant on August 3, 1978. The fish, 23 cm in length, had a mercury content of 0.66 ppm in the flesh, 0.94 ppm in the skin, 1.77 ppm in the intestine, 5.62 ppm in the liver, 17.5 ppm in the spleen and 24.0 ppm in the kidney. The mercury distribution between the different organs is characteristic of contamination by elementary mercury in fish (BYRNE et al. 1971, ZELENKO and KOSTA 1973, KOSTA et al. 1974 b).

Ephemerid larvae had obviously been the main source of mercury for the trout in question, because remains of these larvae were found in its intestine. Three samples of ephemerid larvae collected from the river at a distance of 6 km downstream from the distillation plant on August 3, 1978 were found to contain mercury at 0.27, 0.36 and 0.56 ppm (fresh weight). One sample collected at a distance of 1 km downstream from the plant had 4.28 ppm mercury. These mercury contents as well as the mercury content in the trout were low when compared to earlier observations (BYRNE et al. 1971). The decrease in the mercury levels is obviously due to the half year closure of the mercury mine as well as of the fact that the Idrijca River is extremely rapid and is thus able to eliminate in a short time all mercury pollution from its bottom, consisting of rocks, stones and pebbles, but very little sediments.

The rearing experiments with fly larvae on trout flesh were carried out in polythene containers, 15 cm in height and

16 - 18 cm in diameter. Small-meshed gauze formed the centre of the lid and the centre of the bottom. In the upper part of the container a horizontal funnel was attached from which the emerging adult flies were collected in a transparent plastic jar. These polythene containers contained sand and a layer of moss, under which the larvae could pupate after eating the trout flesh (Fig. 1).

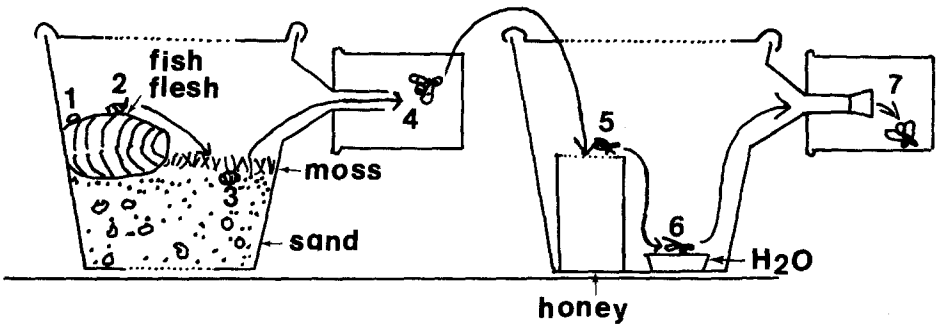

Fig. 1. A scheme for the rearing experiments. 1 = blowfly egg, 2 = blowfly larva, 3 = pupa, 4 = adult fly in the transparent plastic jar, 5 = adult fly devouring honey, 6 = adult fly drinking water, 7 = adult fly trapped for mercury analysis.

The emerging flies gathered in the plastic jar in accordance with their positive phototaxis (the rearing containers were held on a window sill with the outlet funnel towards the window).

Adult flies emerging from the rearing containers were either killed immediately for mercury analysis or transferred to a feeding container which had two feeding dishes, one with honey and the other with water (Fig. 1). During the feeding period for adult flies, the outlet funnel was held closed with a plug. The plug was opened only for a brief period in order to collect some flies from the container for mercury analysis.

For mercury analyses, the samples of adult flies were air dried at room temperature for ten months, then oven dried at 50 °C for 48 h . There existed thus a good possibility for evaporation of surface mercury from flies. The dried flies were then ground in a mortar and digested in 5 ml of a mixture of HNO_3 and H_2SO_4 (1:4 v/v) and were shaken in a waterbath at 60 °C for 3 h . The mercury content was determined by a Perkin-Elmer Coleman MAS-50 flameless atomic absorption spectrophotometer, which was calibrated by neutron activation analysis, The dry weight mercury contents of adult flies thus obtained were con-

vered to fresh weight values by dividing them by 3.8. This coefficient has been obtained by comparative analyses of dried and fresh fly specimens from the same reared fly sample (NUORTEVA et al. 1978 ab).

RESULTS

The mean mercury contents observed in free-living L. illustris and L. caesar trapped in Idrija and in three Finnish areas are shown in Fig. 2

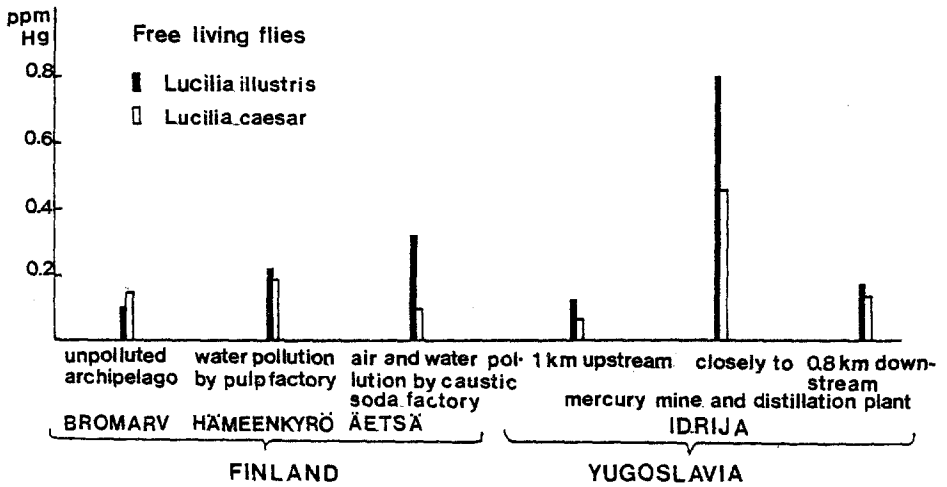

Fig. 2. Mercury contents in Lucilia illustris and L. caesar in some Finnish localities and in the area of the Idrijan mercury mine and distillation plant. The mercury contents are given on fresh weight basis. The dry weight contents are 3.8 times higher.

These results show that the mercury distillation plant of Idrija has caused heavier contamination of blowflies than the pulp factory in Hämeenkyrö or the caustic soda factory in Äetsä. The polluting effect of the distillation plants is, however, restricted to the near vicinity of the plant. The degree of mercury contamination in blowflies at a distance of 1 km from the distillation plant was not essentially higher than the normal background contamination in Finland.

In the rearing experiment with L. illustris on trout flesh the mercury content rose from 0.14 ppm up to 1.18 ppm, during the larval feeding period. Puparia and freshly emerged imagines had about the same amount of mercury (0.99 and 1.01 ppm respectively), but in adults living on honey the mercury levels decreased in two days to a third and remained at this level (Fig. 3).

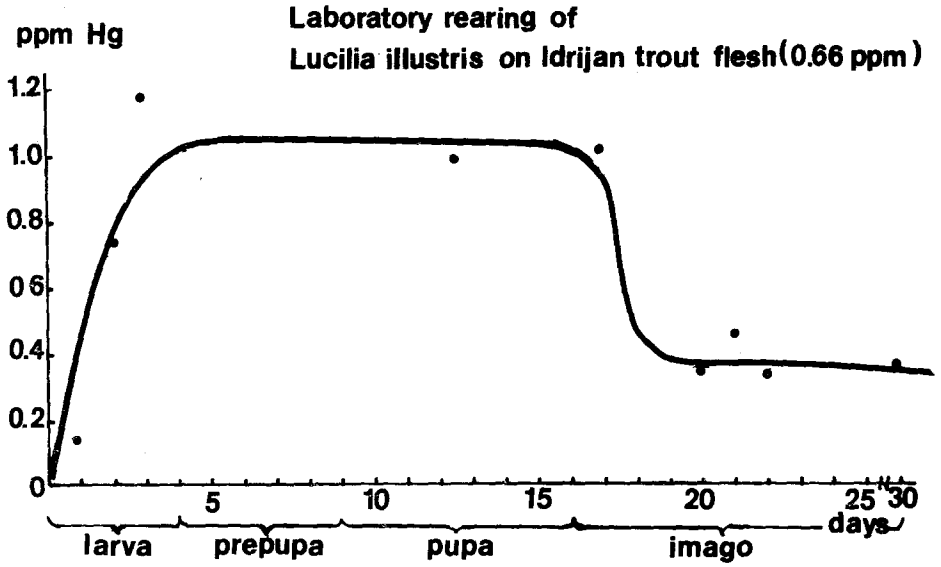

Fig. 3. Mercury contents (from fresh weight in ppm) in the different developmental stages of Lucilia illustris reared on trout flesh with 0.66 ppm of mercury and maintained as an adult on honey.

DISCUSSION

The Yugoslavian investigators have shown that the main part of the total mercury burden in heavily contaminated Idrijan fishes is elementary mercury and only a small fraction of it is methylmercury (ZELENKO and KOSTA 1973, KOSTA et al. 1974 b). They have also noted that elementary mercury is excreted more rapidly than methylmercury. The rapid excretion of elementary mercury can be seen by the fact that the highly elevated mercury contents in fish near the pollution source rapidly decline within a short distance from the distillation plant. This feature appeared to be evident also in the present investigation, where highly elevated mercury contents were observed in blowflies collected near the mercury distillation plant but could not be found at a distance of 0.8 - 1 km (Fig. 2).

In experiments where Lucilia illustris specimens were reared from eggs on Idrijan trout flesh, the bioaccumulation coefficient was 1.53. In 72 comparable rearing experiments performed on Finnish mercury polluted fish and several species of blowflies the mean bioaccumulation coefficient was 4.3 (NUORTEVA 1978

ab). This indicates that it is easier for the blowfly larvae to eliminate such dietary mercury (mainly metallic) which comes from Idrijan trout than such mercury (mainly methyl mercury) which comes from Finnish fish.

Observations on the mercury excretion in freshly emerged adult L. illustris flies showed that they had excreted during the first two days of their adult life about 66 % of their mercury. Blowflies reared on Finnish fish had correspondingly excreted on the average 47 % of their mercury. Here too it thus seems to be easier for the blowflies to excrete dietary mercury from Idrijan fish than mercury from Finnish fish.

The ease of elementary mercury excretion in blowflies is further supported by one reported Finnish experiment (NUORTEVA et al. 1978 ab), where the blowfly Phormia terraenovae R. - D. was reared on liver of a seal (Phoca hispida Schreb. found dead in the Finnish lake, Pihlajavesi on April 20, 1975 and having 36.0 ppm mercury in the liver). In this rearing experiment freshly emerged adult flies had in their bodies 18.2 ppm of mercury and they excreted 69 % of their mercury in two days. Mercury from the seal liver thus appeared to be excreted with the same ease as the mercury from Idrijan fish. This similarity is undoubtedly related to the fact that 86 - 97 % of the total mercury in seal liver is elementary mercury (KOEMAN et al. 1973).

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