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LETTER TO THE EDITOR

In reference to a recent article by Burger and Gochfeld entitled: *Growth and Behavioral Effects of Early Postnatal Chromium and Manganese Exposure in Herring Gull (Larus argentatus) Chicks* (Vol. 50, No. 4, pp. 607–612, 1995), I am disturbed with regard to the study design and the environmental implications presented by the authors. Specifically, there are four broad concerns, including: (i) the relevance of the chromium and manganese compounds injected into herring gull chicks to the forms of chromium and manganese present in the environment in Hudson County, New Jersey; (ii) the doses employed in the study and their relevance to dietary intakes of these elements in nature; (iii) certain citations that do not appear to support statements made; and (iv) less than robust scientific investigative procedures such as the lack of initial body weight measurements of the chicks, unclear dosage used (i.e., was 50 mg/kg Cr(III), 50 mg/kg $Cr(NO_3)_3$ or 50 mg/kg $Cr(NO_3 \cdot 9H_2O$ injected into the chicks), etc.

Burger and Gochfeld (2) injected 2-day old gull chicks intraperitoneally with a single dose of 50 mg/kg chromium nitrate, or 25 mg/kg manganese acetate and applied a battery of behavioral tests beginning 16–18 days post-injection. Deficits in weight gain and some behavioral indicators were interpreted to clearly suggest that chromium and manganese in the environment (e.g., "chromate processing waste [at] 150 sites in northern New Jersey") will exert pronounced neurobehavioral effects ". . . sufficient to suggest that, in nature, a nonimpaired chick would have the competitive advantage." The authors further concluded, "the behavioral deficits we observed in the laboratory relate directly to growth and survival of the chicks in the wild."

In drawing these far-reaching conclusions the authors have failed to account for the rather profound differences in toxicity between dietary exposure to forms of trivalent chromium and manganese typically found in the environment and injection of highly water-soluble organic salts of manganese or nitrate salts of trivalent chromium that are rarely, if ever, found in the environment:

> We used injection rather than providing it in their food to ensure equal doses. We used a single dose because birds in the wild can receive a single dose in food (often from garbage dumps); the levels achieved are similar to levels that can occur in wild birds (10), and use of injection ensures a consistent dose.

The chromite ore processing residue (COPR) present in northern New Jersey, referred to by the authors, contains no water-soluble trivalent chromium (15). The article by C. H. Weng, *et al.* discusses the characteristics of COPR as well as the leaching behavior of chromium in chromium-contaminated soil derived from COPR in Hudson County, New Jersey.

Based on the findings of the work performed by C. H. Weng, *et al.*, soluble Cr(III) is not found in chromium-contaminated soils in Hudson County; the major trivalent chromium species present in COPR are Cr_2O_3 and $Cr(OH)_3$. Therefore, injection of a highly soluble form of trivalent chromium in herring gull chicks is not representative of the forms of chromium in COPR in New Jersey.

Burger and Gochfeld (2) indicated that the 50 mg/kg dose of chromium trinitrate injected into 2-day post-hatchling gulls "did not result in immediate toxicity in that birds were not ill and did not show signs of being sick, they walked and moved well, and they ate when offered food." Very little toxicity information is available concerning chromium trinitrate, and it should have been recognized by the authors that nitrate itself may have been toxic to the chicks. Indeed, the lowest lethal intravenous dose of potassium nitrate is reported to be 100 mg/kg in the cat (11). Use of a nitrate salt of chromium is an unfortunate and compromising choice to test the behavioral effects of the cationic metal. It is, therefore, simply not possible for the authors to attribute their observations entirely to the chromium moiety of the trinitrate salt compound. Moreover, the parenteral administration of the acetic acid salt of manganese cannot possibly provide a good representation of native forms of manganese, which comprises about 0.1% of the earth's crust.

Dose and route of administration/exposure are also major concerns. Studies in most test animals indicate that only about 2% of the dietary chromium is absorbed via the gastrointestinal tract (5).

Chromium absorption by human subjects is inversely related to dietary intake at dietary levels found routinely in normal self-selected diets in the United States. At a daily dietary intake of 10 μg, chromium absorption was about 2%, and with increasing chromium intake to 40 μg, chromium absorption decreased to 0.5%. At dietary intakes >40 μg/day, chromium absorption appears constant at about 0.4% (1).

Eastin et al., (4) demonstrated that the ionic form of chromium in solution appears to be a very important factor in determining the absorption of chromium compounds from the small intestine of young black ducks. Marked differences in bioavailability and toxicity exist between various chromium compounds. Injection of a trivalent chromium compound that does not occur in nature and that is only poorly absorbed via ingestion cannot provide a reasonable model for conditions in nature.

TABLE 1

STATISTICAL DATA ON CONCENTRATIONS OF TOTAL CHROMIUM FOUND IN EDIBLE TISSUES OF BLUE CRAB HARVESTED FROM NORTHERN NEW JERSEY CRAB BREEDING GROUNDS ADJACENT TO COPR SITES

Statistics (n = 38)	Concentrations (mg/kg tissue)
Maximum	1.5
Mean	0.530
Standard error	0.037
95% upper confidence limit of the mean	0.591

Studies of blue crabs harvested from habitats with COPR materials in northern New Jersey revealed total chromium content in edible tissues as summarized in Table 1.

Assuming, only for calculation purposes, an absorption of 100% of the average chromium content in crab muscle tissue (0.530 mg/kg), an equivalent, single dose (i.e., 50 mg/kg as $Cr(NO_3)_3 \cdot 9H_2O$, or 6.5 mg/kg as Cr^{+3}) would be achieved by ingesting 0.80 kg crab meat (14). This is about 12 times the average body weight (viz., 65 g) of hatchling herring gulls. Applying a realistic and conservative 2% gastrointestinal chromium absorption factor, the amount of ingested crab meat needed to produce a systemic absorption of chromium equivalent to the i.p. injection would be about 40 kg, which is more than 600 times the average herring gull hatchling's body weight. This is an exorbitant amount of edible crab tissue to consume in one feeding event, inasmuch as the total daily food intake rate for adult herring gulls ranges from 0.15 to 0.32 kg/day (14). It is, therefore, implausible to assume that injection of 50 mg/kg of chromium trinitrate is even remotely representative of conditions in the wild, as suggested by the authors.

Feeding studies by others do not corroborate the conclusions reached by Burger and Gochfeld (2). Heinz and Haseltine (6) reported that up to 200 mg/kg of chromium added to the diet in the form of chromium potassium sulfate, a water-soluble form of trivalent chromium not commonly encountered in the environment, did not alter avoidance behavior (to fright stimulus) in young black ducks. Accordingly, the effects that may be attributed to parenterally administered chromium appear to be irrelevant with regard to conditions in the wild.

Oral absorption of manganese in the diet is slow and incomplete; about 1 to 4 percent (3). Underwood (12) pointed out that manganese is among the least toxic of the trace elements to mammals and birds. Signs of toxicity are not evident until dietary concentrations exceed 0.1% (8).

A comparison similar to the amount of ingested crab tissue required to obtain a single dose of 50 mg/kg $Cr(NO_3)_3$ was performed for manganese acetate (25 mg/kg). Average concentrations of manganese found in fish and seafood (the typical diet of herring gulls) is 0.2 mg/kg (13) with a range of 0.1 mg/kg to 0.5 mg/kg (7). Studies indicate that, on average, 3.5% of ingested manganese is absorbed via the gastrointestinal tract (13). Therefore, assuming an absorption of 3.5% of the average manganese content in seafood (0.2 mg/kg), approximately 52 kg of seafood would have to be ingested by a hatchling herring gull weighing 65 grams to achieve an equivalent dose (i.e., 25 mg/kg injected as $Mn(C_2H_3O_2)_2 \cdot 4H_2O$, or 5.6 mg/kg as Mn^{+2}).

In the "Exposure in Nature" subsection of the Discussion section of the paper, Burger and Gochfeld (2) mention that "chromium-contaminated waste from the chromium processing industry resulted in dredge materials that provide the single largest input of chromium to the New York bight." It is interesting to note that review of the two references given by the authors identified no apparent reference to the chromium processing industry resulting in dredge materials that contributed an input of chromium into the New York bight. One of the sources cited for this information is a NOAA Technical Memorandum titled *Contaminant Inputs to the New York Bight* (9) published in 1976. The conclusions of this memorandum discuss heavy metal contamination of the New York bight as follows:

> Heavy metals, especially lead and chromium, comprise the most significant manmade inputs into the New York Bight when compared to background loads from the flow entering the bight across its ocean boundaries. Dredge spoils contribute the major portion (24–80%) of the heavy metal input, with the exception of mercury for which wastewater contributes 70%.

On first glance, this memorandum would appear to support Burger and Gochfeld's statement on chromium in dredge materials if one ignores the reference to the chromium processing industry. However, if the time is taken to review the complete report, one can learn that the only metals analyzed for in the dredge spoils from the New York bight were mercury, lead, and zinc. The values for the other metals, cadmium, chromium and copper, were estimated from the literature by multiplying the resultant lead concentration by a lead to constituent ratio. For example, chromium was estimated to be present at concentrations 48% of the lead concentrations. No actual measurements of chromium were obtained. The uncertainty in the chromium concentrations in the dredge spoils is, therefore, extremely high. It is inconceivable that inferences on the amount of chromium in dredge spoils would be established solely on estimated values from the literature (i.e., apparently based on published values from the Great Lakes).

The testing protocol also poses some curiosities. It is unclear how 2-day hatchling gulls "were matched by age and weight," when it was also pointed out that "we initially did not weigh or test the birds because we wanted to avoid added stress." It is difficult to imagine that, having punctured the abdomens of the chicks with a hypodermic needle and injecting solution, any additional stress would occur by merely placing the animals on a scale. Had differences in age or weight existed between the three groups at the outset of the experiment, it would not be unexpected to observe a difference in weight gain throughout the 50-day study period. It may also be noted that no differences were observed between chromium nitrate-injected gulls and controls in about half the behavioral test categories, and only small differences in most of the others. Could subtle differences in body weight or age between the groups contribute to some of the behavioral deficits? The significance of these findings is unclear, and not relevant to vulnerability of herring gulls in the wild.

No measurements of chromium and manganese in commercial dog and cat food or canned fish were reported in order to establish the baseline of the gull chick's diet. In addition, no baseline conditions for blood levels of chromium and manganese were provided.

An unfortunate aspect of scientific literature today, particularly with regard to environmental issues where controversy exists, is that often it is difficult to judge the true level of objectivity that is used in the generation of published work.

The conclusions reached by this very flawed study and, with little regard for reality, extrapolated from the laboratory to the condition in the environment, are not justified by the study design.

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EDITOR'S NOTE: Kenneth G. Symms, Ph.D., DABT, is Technical Director of Risk Assessment for Environmental Standards, Inc. of Valley Forge, PA. This company, Environmental Standards, has served in a consulting capacity to Maxus Energy Corporation in the investigative process associated with the New Jersey chromite ore processing residue (COPR) issue.

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