A Sensitive Bio-Behavioral Assay for Methyl Mercury

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The growing accumulation of methyl mercury in the environment has aroused widespread interest in its toxic effects(1). Methyl mercury compounds are most readily concentrated by tissues of the central nervous system and since symptoms resulting from their ingestion are seen only after extended periods, the true cause of an illness may often be overlooked(2). It is important, then, to study the effects of "safe" concentrations of methyl mercury to determine whether present standards actually represent acceptable environmental levels.

Most of the damage attributable to methyl mercury exposure is irreversible(3) and, due to the neural disordering and related behavioural disintegration which predominate as consequences of methyl mercury exposure, it seemed appropriate to develop a bio-behavioural assay for the compound. The most desirable approach would be one that studied a relatively constant stereotyped behaviour which was faithfully reproducible yet sensitive to the slightest perturbations in neural physiology and metabolism. Witt and his associates have developed an extremely sensitive bio-assay for various neurotropic drugs(4), using the web of the orb-weaving spider as the visible reproducible record of its internal physiological state. Very slight changes in the physiology or metabolism of the spider result in detectable alterations in web structure. This technique has been extended as a tool for quantifying the cumulative effects of long term ingestion of

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methyl mercury. Spiders (Araneus diadematus) were allowed to construct webs in specially designed cages. Photographs of these webs were obtained daily and provided a means of measuring the various structural components. After a suitable control period spiders were fed small amounts of methyl mercuric chloride in a drop of sugared water along with a fruit fly. Additional control spiders never received methyl mercury. Four groups of experimental spiders were fed doses of 1, 2, 5, 50 μμg/day.

Results and Discussion

Two measures of dose dependent effects were observed. General web structure as well as frequency of web construction are affected after methyl mercury ingestion. There were both immediate and long term effects.

When the number of webs built by all groups (including controls) in the week immediately preceding methyl mercury ingestion was compared

Table 1

GROUP	N	A	B	C
control	12	4.90	3.92	3.92
1 μμg/day	6	4.65	4.72	6.51
2 μμg/day	5	4.50	6.30	6.75
5 μμg/day	5	4.75	3.32	1.42
50μμg/day	4	4.70	1.44	0.15

Mean frequency of web construction for control and experimental groups of N subjects each during (A) the pretreatment control week, (B) the first week of methyl mercury ingestion and (C) the second week of methyl mercury. The control group received no methyl mercury.

with the first and second weeks thereafter, it was found that the frequency of web building by the

control spiders decreased slightly while the experimental groups showed variable effects (see Table 1). Low doses (1 and 2 µµg/day) seemed to facilitate web construction. In each group more webs were built in the week immediately following the beginning of methyl mercury ingestion; in the second week, web building frequency increased further. The higher dose group (2 µµg/day) also built more webs in a given week than the lower dose group.

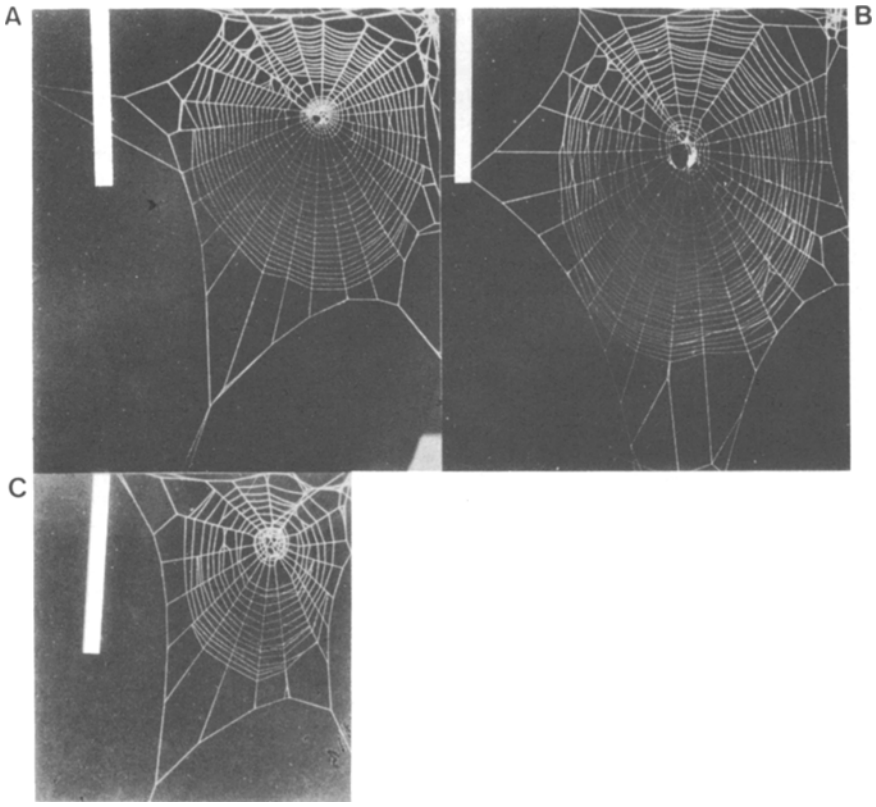

Figure 1. Spider D27. A. Pretreatment control web. Threads at top and upper left became tangled subsequent to the web's completion and are not unusual. Note the size and detail. B. After one week of methyl mercury--2µµg/day. The web is larger and slightly less detailed. C. After the second week of methyl mercury . All webs are to the same scale. Note the 160mm ruler in each picture.

In addition to the facilitation of web building per se, effects on structure were also observed. More than half of the webs built immediately after the first administration of methyl mercury at low levels increased in either size or detail or both. Over time these were interspersed with more normal (similar to control) and some abnormally small webs. These small and sometimes distorted webs predominate after the second week and are typical of the long term ingestion of low levels of methyl mercury (see Fig. 1).

At higher doses (5 and 50 μμg/day) rather different effects are observed. The frequency of web construction decreases to the point of complete elimination of the behaviour. The webs that do occur differ markedly in their structure from the normal. In general they are much smaller and less detailed and resemble the long term webs observed at low dosages.

From this data it is apparent that the bioassay as outlined is extremely sensitive to very low amounts of ingested methyl mercury. As such it could prove a valuable tool for monitoring suspected environmental sources of contamination. This bioassay procedure can now be extended to assess other consequences of low level mercury poisoning such as its effects on reproductive behaviour and genetic mechanisms.

References

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