

A cross-fostering analysis of the effects of PCB 77 on the maternal behavior of rats

J.A. Cummings, A.A. Nunez, L.G. Clemens*

Departments of Zoology and Psychology, and the Neuroscience Program, Michigan State University, East Lansing, MI 48824 USA

Received 1 September 2004

Abstract

Polychlorinated biphenyls (PCBs) are environmental contaminants known to cause multiple behavioral and developmental problems in humans and animals. In rats, gestational exposure to the PCB congener 3, 4, 3', 4'-tetrachlorobiphenyl (PCB 77) affects the brain and behavior of the offspring as well as the maternal behavior of the dams. Whether the behavior of dams is affected by direct effects of the contaminant or indirectly by actions of the PCB on the developing offspring is not known. We investigated this question using a cross-fostering paradigm in which pregnant rats were exposed to either oil vehicle or 2 mg/kg of PCB 77 on gestational days 6 through 18, and then raised pups that had been exposed to either oil or PCB 77 during gestation. Maternal behavior was observed on postnatal days 1, 2, 4 and 6. Some of the effects on maternal behavior, including an increase in the frequency of nursing bouts and in the amount of maternal autogrooming, can be ascribed to prenatal exposure of the litters to the PCB. Other behavioral effects, including an increase in time on the nest and in the amount of pup grooming as well as a reduction in high-crouch nursing, appear to be due to both direct effects of the PCB on the dams and effects mediated by changes in the offspring. Our results show that exposure to PCB 77 can have complex effects on the behavioral interactions between the dams and their litters with a potential impact on the development of the offspring.

© 2005 Elsevier Inc. All rights reserved.

Keywords: PCB 77; Laboratory rats; Maternal behavior; Environmental contaminants; Cross-fostering

1. Introduction

Polychlorinated biphenyls (PCBs) are persistent contaminants that remain in the environment because of their stable chemical structure and long half-life. Although they were banned from use in the 1970s, PCBs can still be found today in sediment, run-off and wildlife, and have also been detected in human umbilical cord plasma and breast milk [1–3]. These findings indicate a risk not only to adult individuals that are exposed to the toxicants, but also to the more vulnerable developing organism exposed in utero and via lactation. Studies examining humans that have come in contact with PCBs [4–6] and laboratory studies with

various animal models [7–10] have demonstrated that PCB exposure is associated with both neurological and behavioral deficits.

In the present experiment we focus on the dioxin-like PCB congener 3, 4, 3', 4'-tetrachlorobiphenyl (PCB 77) because it has high toxic potency and affinity for the Ah receptor, has a low degradation rate in vivo, and it is among the most abundant PCB congeners in human tissues [11,12]. Further, in vivo and in vitro studies have shown that PCB 77 has both estrogenic and anti-estrogenic activity [13,14] (see [15] for review). PCB 77 is detected in the brains of the developing offspring as well as in the brains of the dams when administered to rats subcutaneously during pregnancy [7] thus, it could affect the central nervous system and behavior of both the developing litter and the pregnant adult. Developmental effects of PCB 77 on the behavior of male and female offspring are well-documented [8,16,17], and recently we reported an effect of this contaminant on the

* Corresponding author. 203 Natural, Science Michigan State University, East Lansing, MI 48824, USA. Tel.: +1 517 353 1727; fax: +1 517 432 2789.

maternal behavior of rats [18]. In addition to its possible estrogenic and anti-estrogenic actions [13,14], under some conditions PCB 77 exposure enhances central dopaminergic activity [9], and both estrogen and dopamine play significant roles in several aspects of maternal behavior in rats [19,20].

The few studies that have reported effects of environmental contaminants on maternal behavior of mammals (mice [21,22]; rats [18]) have used experimental protocols in which both the pregnant animal and the developing litter are exposed to the toxic agent. With that approach it is impossible to differentiate between effects on maternal behavior that are the result of direct actions on the dams' endocrine and/or nervous systems from those that stem from indirect effects mediated by changes in the physical and behavioral profiles of the exposed litter. Here we use a cross-fostering design in an attempt to gain insights about the contributions of direct and indirect effects of PCB 77 exposure on maternal behavior in rats. We also investigated if the maternal behavior of dams that were exposed to PCB, or who raised pups exposed to PCB, was different from that of dams that were never exposed to the contaminant and raised unexposed litters.

2. Methods

2.1. Animals and housing

Thirty-six timed-pregnant Long–Evans rats from Charles River Laboratories (Raleigh, North Carolina) arrived at our laboratory on gestation day (GD) 5, and were maintained on a 14:10-h light/dark cycle with lights off at 1100 h at an ambient temperature of 21 °C in a laminar-flow unit (NUAIRE). A dim red light remained on at all times. The rats were housed singly in plastic cages (45 × 22 × 21 cm) with wood shavings as bedding, and were allowed free access to water and Harlan Rodent Chow 8640 food pellets. Animals were maintained in a facility accredited by the Association for Assessment and Accreditation of Laboratory Animal Care, and the Michigan State University Animal Care and Use Committee approved experimental procedures.

2.2. Procedure

The dams were weighed daily and given subcutaneous injections of the oil vehicle or 3, 4, 3', 4'-tetrachlorobiphenyl (PCB 77; Accustandard, New Haven, CT; >99% pure as determined by gas chromatography performed by the vendor) emulsified in corn oil in the dose of 2 mg/kg from GD 6 to GD 18. Selection of this dose and treatment period was based on the findings that a dose of 1.5 mg/kg PCB 77 on GD 7–18 resulted in detectable but relatively low concentration of the contaminant in the maternal nervous system [7], as well as on the observation that the higher dose used here affects the maternal behavior of dams

treated during this gestational period [18]. Nest building materials in the form of 30 brown paper towel strips were placed on the wire top of each cage on GD 20. Parturition took place during the mid- to late-light phase of the animals' light/dark cycle on GD 22–23. On the day of birth [day of birth = postnatal day (PND) 0], the litters were culled to 8 animals (4 females and 4 males) and cross-fostered or left with their own mothers to create the following groups: (1) oil treated dams with their own oil pups, (2) oil treated dams with a new litter of oil pups, (3) PCB treated dams with their own PCB pups, (4) PCB treated dams with a different litter of PCB-exposed pups, (5) PCB treated dams with a litter of oil pups, and (6) oil treated dams with a litter of PCB-exposed pups. Each group contained six dams.

Dams and litters were videotaped on PND 1, 2, 4 and 6 for the animals' last hour of light and first hour of dark (2 h/day/animal). Litters were weighed every day after taping. Videos were analyzed using The Observer 3.0 (Noldus Information Technology), a behavioral data acquisition computer program. During review of the videotapes, the following behaviors were recorded: time on the nest, licking and grooming of the pups, maternal autogrooming, and amount of time spent nursing. Nursing behaviors included resting, or supine nursing, in which the dam was lying on the pups or on her side, and two quiescent nursing postures: low and high crouch. The low-crouch nursing posture is one in which the dam becomes immobile in response to stimulation from the pups as they ventrally root in order to attach to a nipple prior to nursing. High-crouch nursing can be distinguished by a distinct splaying rigidity of the limbs and increased dorsal arching of the dam's back, a position that is exhibited in response to persistent stimulation from the pups, such as continued rooting and nipple attachment. Total time spent nursing is the total of all time spent in one of the three nursing postures while on the nest. The number of nursing bouts, defined as visits to the nest that involved nursing of the litter, was also recorded. Average pup weight gain and pup survival between PND 1 and PND 6 were determined for all litters. All percentages are relative to the 2-h scoring period, save the percentages for the high crouch nursing behavior, which was calculated from the total time spent nursing.

Two investigators scored the maternal behaviors from the video recordings. Because of procedural demands, it was impossible to keep one of these two investigators unaware of the treatment received by each dam. A subset of the recordings was scored independently by both investigators and a correlational analysis was used to evaluate the inter-observer reliability. For all the maternal behaviors analyzed, the positive correlation between the two data sets was greater than .90.

2.3. Analyses

A preliminary analysis revealed that the maternal care exhibited by dams rearing adopted young of the same

Download English Version:

<https://daneshyari.com/en/article/9150155>

Download Persian Version:

<https://daneshyari.com/article/9150155>

[Daneshyari.com](https://daneshyari.com)