Disruption of Brain Development and Reproductive Behavior of Birds

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Extrapolation of xenobiotic exposure to the “real world”

- Methoxychlor, dicofol, and alkylphenols in agriculture in Yolo Co.
- Application rates and acreages available.
- Sensitivity of local species unknown
Current research on songbirds

- Altricial chicks require extended parental care
- Complex, but well understood brain neuroanatomy and physiology
- Song system is estrogen sensitive
- Brain is dimorphic
Hormonal Influence in Brain Differentiation

• Testosterone produced by neo-natal male gonads
• Uptake and aromatization by specific areas of brain
• Estrogen modulates differentiation of male specific nuclei. Mechanism uncertain, BDNF clearly involved, apoptosis?
Dosing and testing protocol

- Oral gavage
- 5-11 days post hatch
- 1µl / g body wt. / day in canola oil
- Parental care of chicks for 30-40 days
- Mixed sex juvenile cages
- Behavioral testing at 120+ days
- Behavior assessed with stimulus males and females on alternate days
- Testosterone implants to force/enable altered behavior
- Histology of brain, gonad
Effective doses given to finches
(µg /g/body wt. /day)

• Estradiol benzoate: 2.7
• Methoxychlor: 35
• Octylphenol: 21
• Dicofol: 37
Extrapolated dose to nestling songbirds

- Body wt. During sensitive period: 3-10g
- Food consumption: 1-8 g insects / day

- Dicofol @ 189 ppm,
  Exposure dose is 189-1512µg/day

- Octylphenolpolyehoxylate @ 22ppm:
  Exposure dose is 22-176µg/day
"Broodiness" of Male Zebra Finches

- % males nest perching before TP
- % males nest perching after TP

- Canola Oil
- 10mM EB
- 100mM EB
- 1000mM EB
- 100mM OP
- 1000mM OP
- 100mM MXC
- 1000mM MXC
- 100mM D

Only 1 data point.
Summary of Effects on Males

• Estradiol and Xenoestrogens active orally
• Microgram per day doses cause changes in male default behavior patterns:
  • Latency for courtship song
  • Reduced copulation
  • “Broodiness”
  • Responses in both
    Zebra Finches and Japanese Quail
Differentiation of brain and behavior in birds:

- **Song System:**
  - Passerine birds only
  - Species specific patterns in dimorphism
  - Estrogen sensitive during post-natal development

Female Zebra Finch
Zebra Finch “Song Circuitry”

- Learning and memory pathways in blue
- Motor pathway in red
- Males sing, females do not

David Clayton, Univ Illinois
Threshold for enabling song is about 125µm³.
Vocalizations of captive Zebra finches

- Male Zebra Finch
- Distance Calls
- Chatter ("tet" call)
- Courtship song
Vocalizations of female zebra finches

- Normal Females
  - “tet” call
  - distance call

- “Male type” songs by sensitive exposed females
Female Finches Singing Courtship Song

- "0" - "10"
- Canola Oil
- 10mM EB
- 100mM EB
- 1000mM EB
- 100mM OP
- 1000mM OP
- 100mM MXC
- 100mM MXC
- 100mM D

# female finches

- # Females singing
- # Females tested to date
Estrogen and xenoestrogen induced changes in female finches

- Sexually dimorphic brain nuclei induced (retained? / enhanced?)
- Singing enabled in exposed females
- Aggressive behavior in many females
- Significant phenotypic variability by family
Reproductive Performance Tests

- Neonatal Dosing of zebra Finches, days 5-11
  - Estradiol benzoate 27µg/gBW/day
  - Octylphenol 21µg/gBW/day

- Group caging: 6 pair per cage
- Dosed males and females together
- Dosed birds with control mates
- Reproductive activity from Day 140
Reproductive Activity:

- Estradiol females lay eggs, clutch size similar
- No eggs hatch from treated group
  - dosed males and females together
  - eggshell thinning in most females
- Mixed pair trials in progress:
  - some fertility and hatching success.