The CEH Predatory Bird Monitoring Scheme: implication for exposure of wildlife to POPs

Richard F. Shore
Structure

• What and why monitor?
• Why use predatory birds?
• The Predatory Bird Monitoring Scheme
• Monitoring changes over time
• Monitoring spatial variation
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Polychlorinated Biphenyls (PCBs)

- No longer manufactured
- Many “open” systems still providing diffuse sources
  High point sources
- High environmental persistence
- Lipophilic (fat soluble)
- Can be used as analogues to inform us about the fate and behaviour of other POPs
Polychlorinated Biphenyls (PCBs)

- Congeners vary in toxicity and persistence
- Some (co-planar) congeners have a similar structure to and work in the same toxic manner as dioxins
- Reproductive toxicity, hepatotoxicity, mutagenicity, carcinogenicity, immunotoxicity
- Recent work suggests main chemicals in UK raptors that cause Ah-receptor mediated toxicity
### Why monitor?

<table>
<thead>
<tr>
<th>Characterise risk</th>
<th>Characterise variation in risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Understand fate and behaviour</td>
<td>• Change over time?</td>
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<tr>
<td>• Which species are exposed</td>
<td>• Spatial variation?</td>
</tr>
<tr>
<td>• What is level of exposure [and potential effects]</td>
<td>• Habitat and food-chain variation in transfer</td>
</tr>
<tr>
<td>• How widescale is exposure?</td>
<td>• What are the sources?</td>
</tr>
<tr>
<td>• Does exposure/sensitivity vary within and between species?</td>
<td>• Is mitigation working?</td>
</tr>
</tbody>
</table>
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Why use predators for monitoring?

• Organic pollutants are bioconcentrated by top predators

• Top predators likely to accumulate high concentrations and may be at most risk from toxic effects

• Why choose predatory birds rather than other predators?
Why use predatory birds for monitoring?

Most predators
- Multiple food chains
- Bioavailable fraction
- Bioconcentrate
- Sentinels
- Populations sensitive
- “Rare” species
- Charismatic

Predatory Birds
- Spatial integrators
- Eggs and tissues
- May use other receptors for inorganic compounds
- Relatively easy to sample (incl. non-destructively)
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Predatory Bird Monitoring Scheme

- Co-funded by JNCC and EA and CRRU
- Monitors [expanding] range of contaminants of concern
- Long-term (>40 years)
- Large scale (UK)
- Started due to concern over OC insecticides and mercurial seed dressings
Which species are monitored?

- Marine, freshwater and terrestrial food chains
- Conservation priority
- Birds died from variety of causes
- Quantifies variation in accumulation (surrogate for exposure)
How does it work?

Volunteer submission → PM examination → Sample archive ~ £4KK

Data analysis and publication → Chemical analysis

Graph: liver concentration (µg/g) over time (1960-2000)

Data: DDE concentration
Predatory Bird Monitoring Scheme

- PCBs
- Second generation rodenticides
- Mercury
- Organochlorine insecticides
- Effects (eggshell thickness)
- Polybrominated flame retardants
- Other contaminants (PAHs, arsenic etc)
Typical results: peregrines and contaminants
Typical results: rodenticides

**Difenacoum**
- $r = 0.849$, $P<0.001$

**Bromadiolone**
- $r = 0.791$, $P<0.001$

**Brodifacoum**
- $r = 0.401$, ns

**Flocoumafen**
- $r = 0.281$, ns
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Declines in PCBs in eggs but not livers

- Merlin egg
- Golden eagle egg
- Sparrowhawk
- Kestrel
Other organic pesticides have declined

- DDE
- PCBs
- HEOD
- PCBs
Why have liver PCB levels not declined in terrestrial species?

• Non-spatial trends “mask” any decline?
• Has there really been a decline in liver PCB concentrations in terrestrial species?
PCB variation in sparrowhawks

Liver PCB concentration

Variation in liver residue magnitude

- Up to 50% variation in liver PCB residues explained by body condition, age and sex
- Body condition is major physiological factor (remobilisation of residues from fat to the liver)
- Starved birds have higher liver PCB concentrations than non-starved birds
- Influence of nutritional state on residue magnitude not taken into account in long-term monitoring
Determining the effect of nutritional state on time trends for residues

- Re-analysed long-term liver residue data to take into account nutritional state
- Does variation in nutritional state masked environmental patterns, and if so why?
- If nutritional state is taken into account, is there any evidence that liver PCB residues are declining?
Sparrowhawk PCBs

- All birds
- Starved birds
- Non-starved birds
Sparrowhawk PCBs

mean log liver [PCB] µg/g ww

starved (o)  non-starved (●)

year
Sparrowhawk PCBs

geometric mean [PCB] µg/g ww

non-starved birds

year

75 80 85 90 95 2000 2005
Mechanisms

Non-starving birds

Intake → Liver → Fat [& other tissues]
Mechanisms

Starving birds

Intake \xrightarrow{\text{X}} \text{Liver} \xrightarrow{\text{Fat [\& other tissues]}}

Concentration ↑

Weight ↓
Evidence of remobilisation of residues from fat

**Liver Weight (g)**

- **sparrowhawk**

![](Liver_weight.png)

- **Hg**
  - starved/non starved gm [Hg] µg/g
  - 90 95 2000 2005
  - dw

![](Hg_graph.png)

- **PCBs**
  - starved/non starved gm [PCB] µg/g
  - 90 95 2000 2005
  - ww

![](PCBs_graph.png)

**Predatory Bird Monitoring Scheme**

**Centre for Ecology & Hydrology**

**Natural Environment Research Council**
Implications for monitoring non-lipophilics

Sparrowhawk Hg

all birds

starved birds

non-starved birds
Conclusions about the effects of nutrition

- Variation in nutritional state can obscure environmental trends and may extend detection time
- Decline in liver total PCB concentrations in sparrowhawks but little change post 1990
- Data consistent with storage in and remobilisation from fat
- “Constant” PCB concentrations in starved birds - are liver concentrations at “saturation”?
- Effects of starvation on liver weight means nutritional state may affect monitoring for non-lipophilic compounds
- Starved birds vs non-starved birds for monitoring...trends vs risk?
### How long to detect trends?

<table>
<thead>
<tr>
<th></th>
<th>Sparrowhawk</th>
<th></th>
<th>Merlin</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>start of</td>
<td>yr trend</td>
<td>time</td>
<td>start of</td>
</tr>
<tr>
<td></td>
<td>data run</td>
<td>detected</td>
<td>(years)</td>
<td>data run</td>
</tr>
<tr>
<td>PCB</td>
<td>1970</td>
<td>no trend</td>
<td>no trend</td>
<td>1970</td>
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*It can take a long time and lots of money!*
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Spatial analysis

- If sufficient data, can examine variation in risk and large-scale effects. Examples include:
  - clusters (identify point sources)
  - degree of urbanisation
  - latitude, rainfall (relate to large scale processes)
  - may not be proximate causes
  - how important (how much variation do they explain)
Clusters

- Similar methods to detecting leukaemia clusters but not just presence/absence
- Difficult to detect without targeted study
- Highly influenced by a few individuals
- May only identify very big sources

Broughton et al. (2003)
Association with urban areas

• Positive association between urbanisation and PCB residues in kestrels but not sparrowhawks

• Effect relatively small

• Plausible species differences?

• Plausible contamination source?

• Food availability?

Shore et al. (2006a)
Climatic effects

- Higher PCB concentrations in birds from areas with higher rainfall
- Effects relatively small
- Reflects atmospheric deposition of PCBs?
- Reflects variation in food availability and nutritional state?

Shore et al. (2006a)
Summary: Spatial variation in PBMS

• Requires large amount of data when looking at national picture

• More complex than examining temporal trends unless monitoring is targeted

• Better suited to stratified targeted monitoring (eg, Shore et al 2006b)

• Identification of proximate causes is problematic

• Can be useful for identifying high risk areas/regions

• Useful for hypothesis generation
What next?

- PBMS “evolved away” from original driver of OC insecticides
- Move to congener-specific PCB analysis allows better characterisation of fate and behaviour but shorter data runs
- Starting to move towards “new” POPs and development of “health indices” that can be related to chemical assimilation
- MS methods allows scanning for “unknowns” to identify new risks