Long-term exposure to polybrominated diphenyl ethers (PBDEs) or polychlorinated biphenyls (PCBs) through diet affects embryonic development of Common Sole (Solea solea)

Ommès M.H.*, Lemarre C.*, Le Bayon N., Le Delliou H., Zambonino J.L., Murray C.T, Loeza V.*
1IFREMER, Laboratoire Biogeochimie des Contaminants Organiques, Nantes, France.
2IFREMER, Laboratoire Adaptation Reproduction & Nutrition, Brest, France.
3IFREMER, Laboratoire Biogeochimie des Contaminants Organiques, Nantes, France.

Background

How environmental conditions may influence fish survival and eventually affect the recruitment dynamics of fish populations?

- Previous studies
  - in situ: levels and patterns of contamination of three French coastal fish nurseries
  - experimental controlled studies of dietary POPs exposure in common sole juveniles under long-term exposure: toxicokinetics

Common Sole: Solea solea

selected as a model that incorporates the physiological potential impact of organic contaminants

- fatigue of economical relevance in France and Europe; benthic habitat; spawning grounds not far from the nursery areas located in coastal environments or estuaries, that make this fish particularly vulnerable to environmental toxicants
- spawners: batches of eggs, with translucent pelagic eggs; reared fish

Introduction

In the natural environment, persistent organic pollutants (POPs) do not reach high concentrations in surface waters due to their lipophilicity so the main route of exposition to non-molecular effects for this species to confirm the impact of toxicants.

The induction of non-developed embryos, as well as in different tissues (muscle, liver and female gonads). Morphological deregulation observed.

Females produced non developed eggs. The cause of decreasing capacity leading to the absence of the fertilization process, should be elucidated. Sole eggs appeared to be sensitive to pollutants and can be used to evaluate the possible toxicity of parental contaminanted feeding. This is a preliminary study. Further studies will later describe the mechanisms involved in the hatching success.

Materials & Methods

- Fish and experimental conditions
  - 3 Sole broodstocks (replicate x2; 267g: 207g)
  - seawater open system, wastes treated with active carbon column
  - diet
    - 3 diets of commercial pellets (CP 40%; CF 23%)
    - POPs congeners diluted in an evaporated isooctane solvent
  - 3 Sole broodstocks (replicate x2; POps congeners diluted in an evaporated isooctane solvent)

- Embryonic exposure to contaminants such as polybrominated diphenyl ethers (PBDEs) and polychlorinated diphenyl ethers (PCBs).

- Egg viability assessment
  - Sole egg characteristics:
    - moisture 92.7% fresh weight (FW) dry weight (DM) 7.3% FW lipid content 11.7% DM size 0.137 mm, oil globules
  - Viability: egg buoyancy (%)
    - Dead eggs discarded

- Egg quality & development
  - chemical analysis, stored
  - diffusibility plate (using methylene blue as dye exclusion test)
  - viable eggs counted

- Spawns
  - spawning naturally overnight, eggs collected in a mesh collector fitted to the tank, transformed containers and sieves for 4000

- Egg incubation
  - using an open seawater (desatured, filtered & UV sterilised)
  - PCBs CB (149, 118, 153, 105) diet or
  - PBDEs CB (118, 153, 105) diet or
  - with solvent alone, Control diet
  - thirty-six month period of experimental dietary exposure
  - ad libitum feeding, at 0.1 to 0.6% daily biomass

Temporal chronology of daily spawns collected from one tank: March to May 2011

- Survival
  - (floating eggs around 7-10h post-spawn incubated)
  - % Survival

- Results
  - Embryonic development
    - (at 12-15.5°C checked under light microscope, magnification x40)
      - Early stages: normal phenotypes in the control group
      - Mid-stages: interference with organogenesis
      - Late stages: undevoloped embryos
  - Common sole embryo mortality following parental exposure to non (Control) or contaminated diets of different organic contaminants (PBDEs = PCBs).

- egg viability: egg buoyancy (%)
  - mean egg buoyancy of (n = 13)
  - 1L: 48.0% (n = 26), C: 65.3% (n = 13)
  - Mortality: death rate (%)
  - PBDE: 55.3% (n = 14), PCB: 48.0% (n = 26), C: 65.3% (n = 13)

- Hatching success
  - (hatching rate % per egg batch incubated, batch characterised by mean egg buoyancy of
    - PBDE: 55.3% (n = 14), PCB: 48.0% (n = 26), C: 65.3% (n = 13)
  - Incubation conditions
    - water flow rate per incubator: 67.5 mL/min, Cv: 2.5%

- Features
  - incubation at 13°-15°C temperature
  - 1L vol. cylinder-conical incubator
  - 500 floating eggs (using plankton plate)

- Incubators set in a fibreglass table (designed for embryonic development in fishery biology studies for farmed fish species)

Conclusion

Incubation is a valid tool for ecotoxicological studies on marine fish. Contaminants may accumulate in the gonads of broodstocks and affect the gametes and their quality. Reproductive traits were modified or reduced: exposure to PBDEs in females produced non-developed eggs. The cause of decreasing capacity leading to the absence of the fertilization process, should be elucidated. Sole eggs appeared to be sensitive to pollutants and can be used to evaluate the possible toxicity of parental contaminanted feeding. This is a preliminary study. Further studies will later describe the mechanisms involved in the hatching process and PCBs and PBDEs concentrations in surface waters due to their lipophilicity so the main route of exposition to non-molecular effects for this species to confirm the impact of toxicants.

Perspectives

Future work will include chemical as well as biochemical analysis to assess any possible hormonal disruptor in broodstocks. Measures of concentrations of PCBs or PBDEs (congeners or hydroxylated forms), in the whole eggs are required to explain the induction of non-developed embryos, as well as in different tissues (muscle, liver and female gonads). Morphological alterations or mortality rates are often described as non-specific criteria for eggs. Future studies should be conducted on the molecular effects for this species to confirm the impact of toxicants.

References

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