Fish ON Pills

How do Oral Contraceptives pose a threat to aquatic vertebrates?

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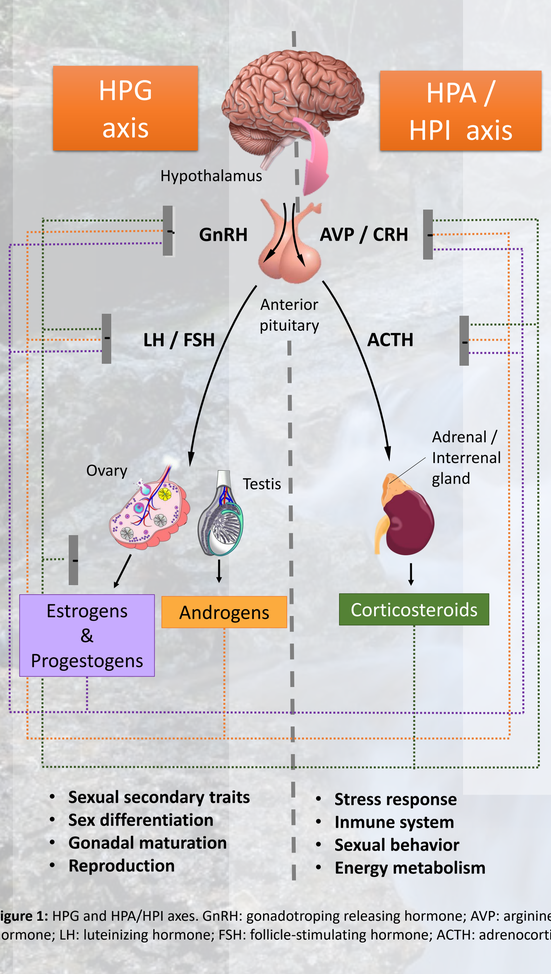
Introduction

Oral Contraceptives (OCs) are used by over 150 million women around the world. OCs consist of synthetic analogues of the steroidal sex hormones estrogens and/or progesterone (called progestins). Natural sex hormones and their synthetic analogues can show effects in the animal endocrine system and are their presence in the environment is therefore concerning. Although not the only one, a major source of these substances are the residues of OCs that are excreted and, since they are not fully removed in wastewater treatment plants (WWTPs), they end up in surface waters. The present work aims to review the present state of the research on this topic. Thus, it intends to (I) trace an outline on the occurrence of OCs in inland surface waters; (II) describe their physiological mechanisms of action; (III) portray their effects on aquatic vertebrates, and (IV) briefly mention the currently existent removal techniques of OC traces in WWTPs.

Occurrence & Mechanism of action

Table 1: *Occurrence in surface waters and biological activity of the main active principles of Oral Contraceptives. ER: estrogen receptors; PR: progestogen receptors; GnR: gonadotropin (follicle stimulating hormone [FSH] and luteinizing hormone [LH]) receptors; AR: androgen receptors; GR: glucocorticoid receptor; MR: mineralocorticoid receptor. Agonists bind to a receptor and produce a biological response. Antagonists bind to a receptor and block the action of its agonist, thus inhibiting the response[1]*

Type	Name (Abbreviation)	Occurrence in surface waters	Biological activity
Synthetic estrogen	**17α – ethynilestradiol (EE2)**	0.1 – 48.2 ng/L (usually 0.1 – 10 ng/L)	ER agonist
Synthetic progestogen (progestin)	**Chlormadinone acetate (CMA)**	< 0.32 - < 0.68 ng/L (two reports)	PR agonist; GnR, ER, AR, GR & MR antagonist
	Drospirenone (DRO)	< 0.85 ng/L (one report)	PR agonist; GnR, ER, AR & MR antagonist
	Dydrogesterone (DYD)	< 0.63 – 9.6 ng/L (two reports)	PR agonist; ER antagonist; Partial AR & MR antagonist
	Levonorgestrel (LNG)	< 0.08 – 38 ng/L	PR & AR agonist; GnR & ER antagonist
	Medroxyprogesterone acetate (MPA)	< 0.1 – 34 ng/L	PR & GR agonist; GnR & ER antagonist; Partial AR agonist
	Megestrol acetate (MGA)	< 0.07 – 25 ng/L (two reports)	PR & GR agonist; GnR, ER & AR antagonist; Partial AR agonist
	Norethindrone (NET)	< 0.04 – 872 ng/L(usually < 16 ng/L)	PR, ER & AR agonist; GnR & ER antagonist



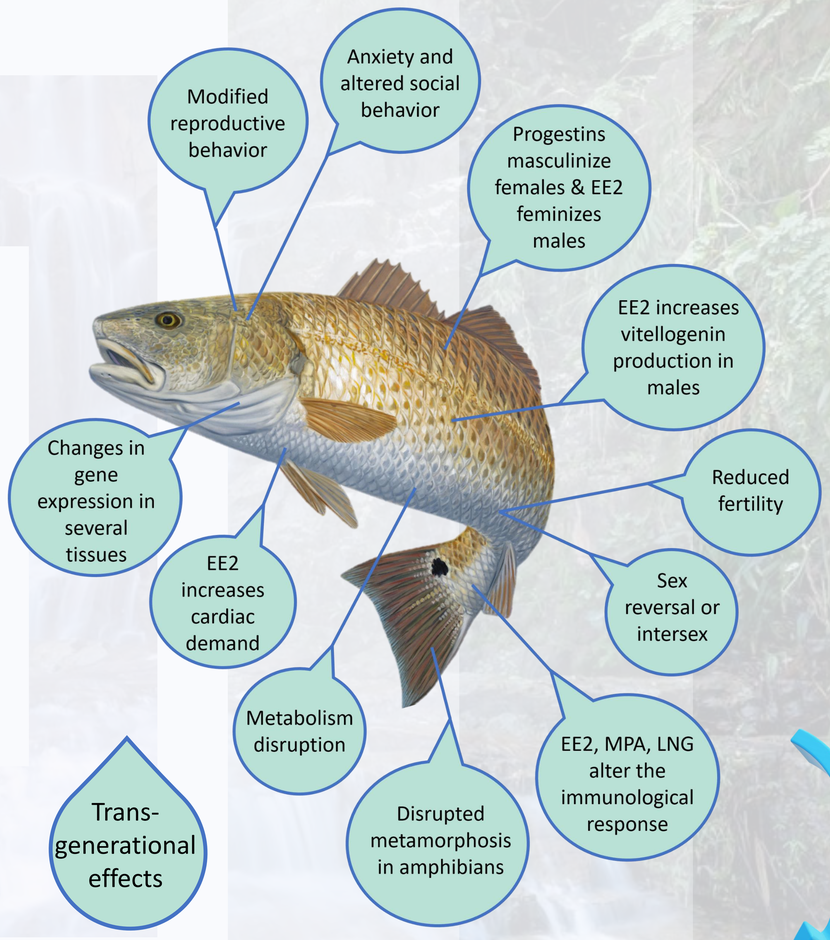
Endocrine disruption on HPG and HPA/HPI axis

EE2
ER agonist

Progestins
PR agonists
GnR antagonists
ER agonists / antagonists
AR agonists / antagonists
GR agonists / antagonists
MR antagonists

Figure 1: HPG and HPA/HPI axes. GnRH: gonadotroping releasing hormone; AVP: arginine vassopressin; CRH: corticotropin releasing hormone; LH: luteinizing hormone; FSH: follicle-stimulating hormone; ACTH: adrenocorticotropic hormone.

Effects on aquatic vertebrates



Effects at the population and ecosystem level

- Altered sexual differentiation causes changes in sex ratio
- Reduced reproductive succesmay lead to population collapse [2]
- High concentrations can reduce survival, accelerating the collapse
- Food webs get resented because of the decrease of some populations through indirect effects [3]
- Because COCs bioaccumulate and probably biomagnify, predation becomes a way of exposure to higher-than-environmental concentrations

Removal from wastewaters

Conventional Activated Sludge systems are not effective in removing OCs an other emerging contaminants. There are more advanced technologies that have proven effective and safe, like activated carbon adsorption combined with ultrafiltration or bioremediation with certain algae, bacteria (e.g., *Rhodococcus rhodochrous*) and fungi. However, large-scale implementation is difficult because of the high costs of these technologies.

Conclusions

Research is needed on effects at the population and ecosystem levels conducted under field or, at least, semi-natural conditions, considering the contaminant mixture actually found in water and considering the bioaccumulation problem, not only concentrations in water. There is also urgency for political and legislative actions to ensure the application of remediation technologies in all WWTPs and to encourage research on the topic.

Materials & Methods. References

Methods for the bibliographic review:
4 books, 129 scientific articles and 4 web pages

References:
[1] Fent, K. (2015). Progestins as endocrine disrupters in aquatic ecosystems: Concentrations, effects and risk assessment. Environment International, 84, 115-130.
[2] Kidd, K. A., Blanchfield, P. J., Mills, K. H., Palace, V. P., Evans, R. E., Lazorchak, J. M., & Flick, R. W. (2007). Collapse of a fish population after exposure to a synthetic estrogen. Proceedings of the National Academy of Sciences of the United States of America, 104(21), 8897-8901.
[3] Kidd, K. A., Paterson, M. J., Rennie, M. D., Podemski, C. L., Findlay, D. L., Blanchfield, P. J., & Liber, K. (2014). Direct and indirect responses of a freshwater food web to a potent synthetic oestrogen. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1656), 20130578.