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Assessment of the health status of wild fish inhabiting a cotton basin heavily impacted by pesticides in Benin (West Africa)

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HIGHLIGHTS

- Getting bioindicator species of pollutant in the aquatic ecosystem of beninese cotton basin.
- Obtaining biomarkers to characterize the estrogenic effects of pesticides.
- The pesticide effects are among the cause of the disappearance of certain species of fish in the cotton basin.

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ABSTRACT

To determine the impact of agricultural pesticides used in cotton cultivation on the health status of fish living in a Beninese cotton basin, we compared the reproductive and hepatic systems of fish sampled from rivers located in both contaminated and pristine conditions. Different types of biomarkers, including biometric indices (a condition factor K, a gonadosomatic index GSI, and a hepatosomatic index HSI), plasma levels of sex steroids (11-ketotestosterone 11-KT, testosterone T and estradiol-17β E2) and the histopathology of the gonads and liver, were investigated for two different trophic levels of the following two fish species: the Guinean tilapia *Tilapia guineensis* and the African catfish *Clarias gariepinus*. The fish were captured during both the rainy season (when there is heavy use of pesticides on cotton fields) and the dry season from one site, in Pendjari River (reference site), which is located outside the cotton-producing basin, and from three other sites on the Alibori River within the cotton-producing basin. Comparing fish that were sampled from contaminated (high levels of endosulfan, heptachlor and DDT and metabolites) and reference sites, the results clearly indicated that agricultural pesticides significantly decreased K and GSI while they increased HSI, regardless of the season, species and sex of the fish. These pesticides also induced a decrease in the plasma levels of 11-KT and T and increased those of E2. The histopathology of the testes revealed, in both species, a high rate of testicular oocytes, up to 50% in the African catfish, downstream of the Alibori River, which indicated estrogenic effects from the pesticides. The disruption of male spermatogenesis primarily included necrosis, fibrosis and the presence of foam cells in the lobular lumen. The histopathology of the ovaries revealed high levels of pre-ovulatory follicular atresia, impaired oogenesis, a decrease in the oocyte vitellogenic diameter and other lesions, such as fibrosis, vacuolation and melano-macrophagic centers. The histopathology of the liver revealed the presence of necrosis, hypertrophic hepatocytes, foci of vacuolation, glycogen depletion and hemosiderin. An assessment of the general health of the fish indicated that all of the sampled fish from the polluted sites were in poorer health compared with those from the reference site but that the African catfish appeared much more affected than the Guinean tilapia, regardless of the sex and season. In conclusion, the overall results indicated that agricultural pesticides significantly impair the endocrine regulation of fish living in the Beninese cotton basin and that this would most likely be one of the causes of the severe damage observed in the liver and gonads and the reduced health condition.

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1. Introduction

An increasing number of widely used chemicals are reported to possess endocrine activity that is capable of affecting the reproduction of

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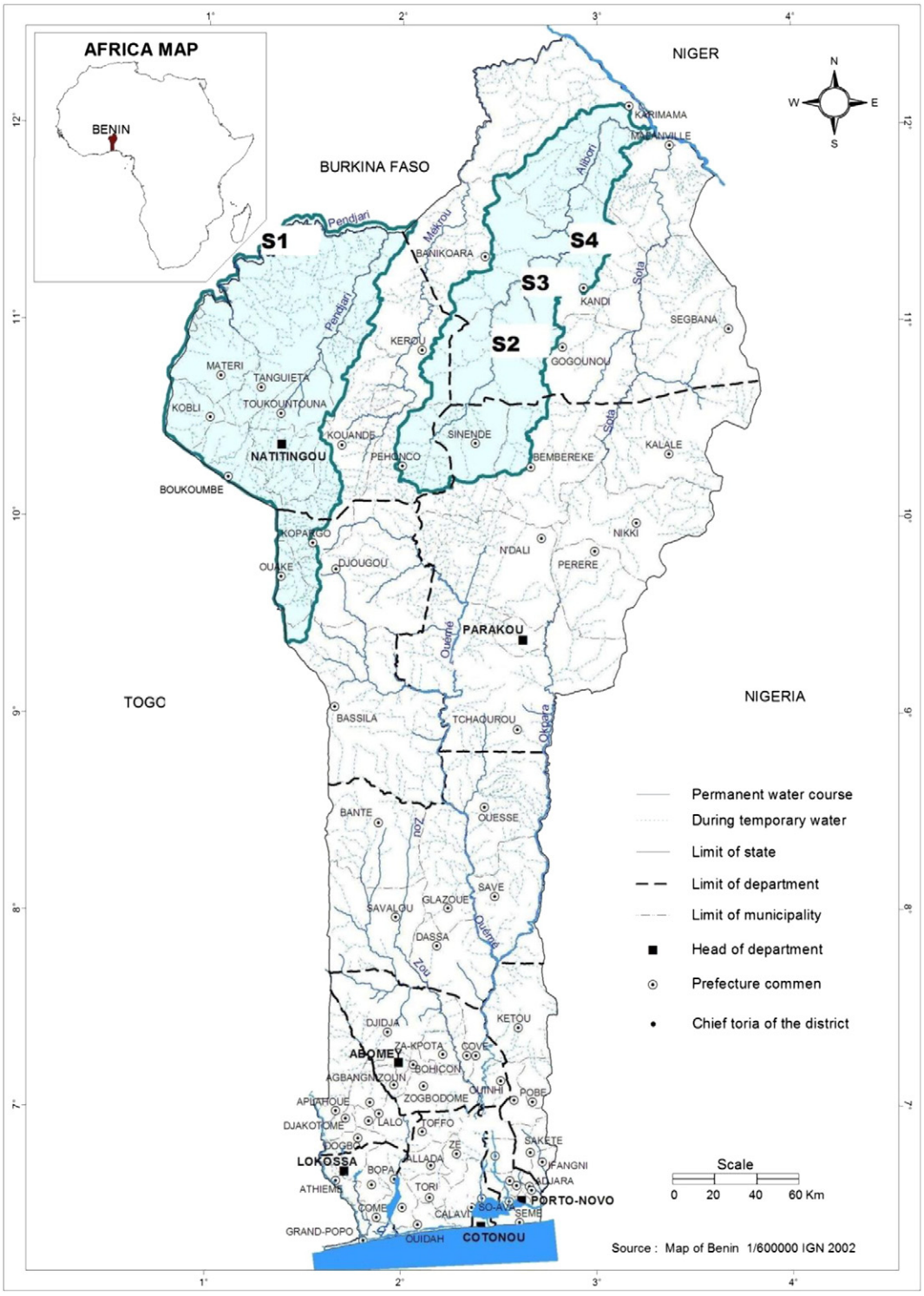

Fig. 1. Hydrographic map of Benin showing the study sites (S1: reference site on the Pendjari River, S2–S4: contaminated sites on the Alibori River).

wildlife populations (Rotchell and Ostrander, 2003). Among these chemicals, there are various types of agricultural pesticides that are applied in large quantities on field crops to ward against plant pests. Several studies have shown that only 0.1% of the applied pesticides reached the target pests (Primentel and Levitain, 1986; Grébil et al., 2001). Aquatic ecosystems are generally the final destination of pesticides used in agricultural production (Gillium, 2007; Chao et al., 2009). Other studies (Purdom et al., 1994; Gimeno et al., 1996; Barse et al., 2007; Micheletti et al., 2007; Singh and Singh, 2007; Mckinlay et al., 2008; Palma et al., 2008, 2009a and b) have reported on the interactions of certain pesticides on the hypothalamic–pituitary–gonadal axis, demonstrating that these pollutants behave as endocrine disruptors that potentially alter fish reproduction and growth.

Among West African countries, Benin (Fig. 1) is known as the main producer of cotton. Large quantities of pesticides belonging to different chemical families (e.g., organochlorines, organophosphates, pyrethroids, neonicotinoids) have been and are still widely used, legally or not, by cotton producers (e.g., DDT, lindane, heptachlor, endrin,

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