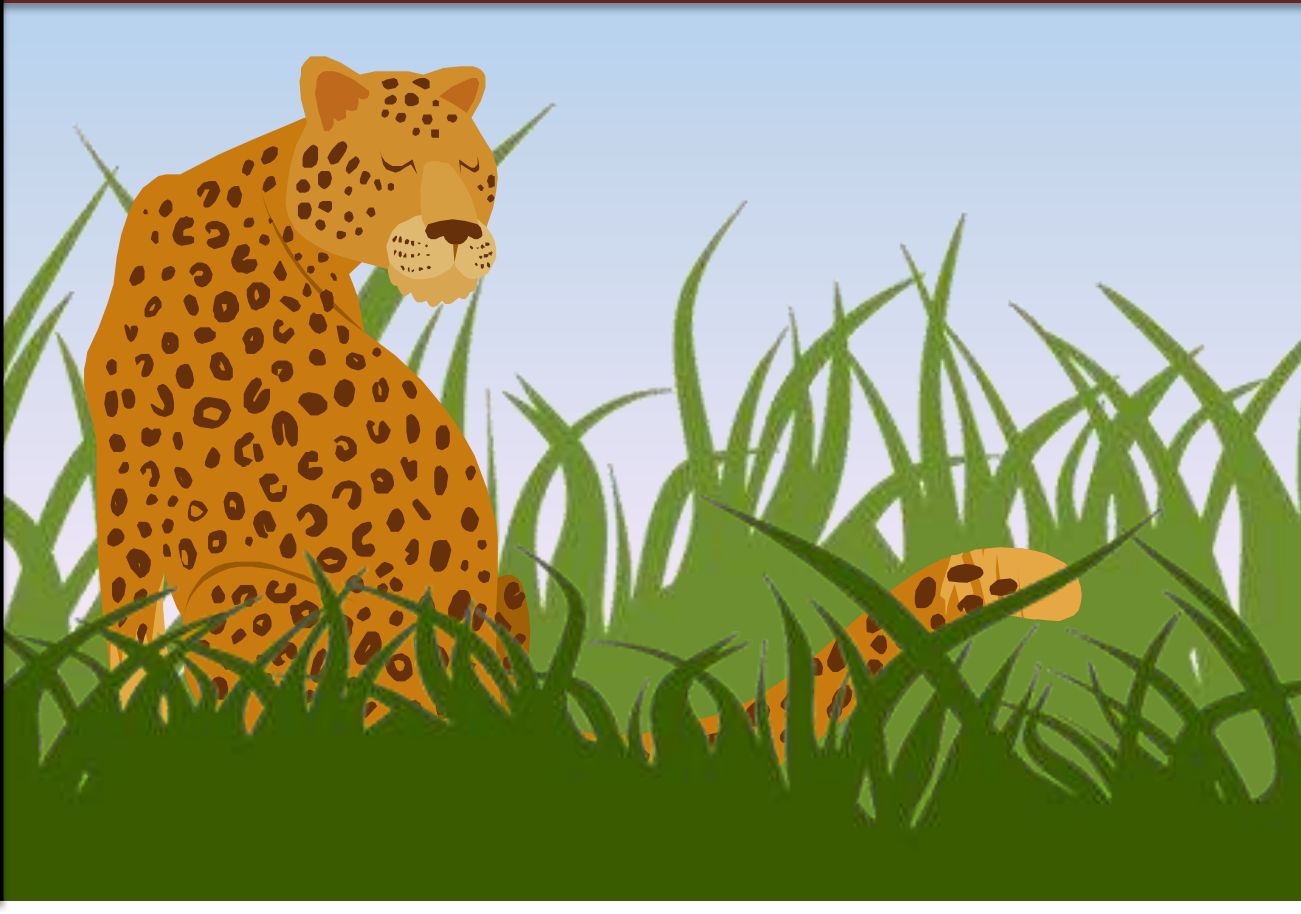
Human, Animal and Ecological Risk of Environmental Chemicals in African Countries

Date: October 22, TUE, 2013
Time: 13:30-15:40
Venue: Lecture Room 3, Graduate School of Veterinary Medicine, Hokkaido University, Japan



This symposium is hosted by JSPS Core-to-Core Program "Establishment of International Toxicology Consortium with 8 African Countries", JSPS Program for Leading Graduate Schools "Fostering Global Leaders in Veterinary Science for contributing to One Health" and Mitsui & Co., Ltd. Environment Fund.

Program

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- 13：30～13：50 Yared B. Yohannes, Hokkaido University, Japan (Ethiopia)
  - *OCPs in fish and bird species from Lake Ziway, Ethiopia: Association with trophic level and human health risk assessment*
- 13：50～14：20 Prof. Nico Smit, North-West University, South Africa
  - *Ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Phongolo River and floodplain, South Africa*
- 14：20～14：50 Prof. Victor Wepener, North West University, South Africa
  - *Application of the Relative Risk Methodology to assess human and ecological risks posed by DDT use in the lower Phongolo River and floodplain.*
- 14：50～15：20 Prof. Johan van Vuren, University of Johannesburg, South Africa
  - *Biomarkers of pollution in fish from the Phongolo River and floodplain where DDT is used for malaria control*
- 15：20～15：40 Dr. John Yabe, University of Zambia, Zambia
  - *Lead poisoning in children from townships in the vicinity of a lead-zinc mine in Kabwe, Zambia*

OCPs in fish species from Lake Ziway, Ethiopia: Association with trophic level and human health risk assessment

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[Introduction]

Organochlorine pesticides (OCPs) have received considerable attention due to their ubiquitous, persistence in ecosystems and can cause detrimental toxic effects. Despite restrictions and bans on the use of them, their usage has continued in many developing countries for agricultural and public health purposes. In aquatic systems, fish are exposed to these environmental pollutants either from water via gills or/and from the diet, and bio-accumulate through the food web. Lake Ziway is located in the Ethiopian rift valley region, which encompasses seven principal lakes. The region is a densely populated area confined with various agricultural activities, coupled with recent establishments of flower farms in the proximity, at which increases claim on the precious fresh water ecosystem resources and threaten the environment. Therefore, OCPs were investigated in five fish species collected from Lake Ziway, Ethiopia to evaluate the bioaccumulation patterns associated with stable isotope ratios ($\delta^{15}N$ and $\delta^{13}C$) and to assess the potential health risk to humans posed through fish consumption.

[Methods]

Samples: Five fish species: *Oreochromis niloticus* (27)*, Tilapia zillii* (19)*, Carp species* (27)*, Clarias gariepinus* (27) *and Barbus intermedius* (5) were caught and dissected. Muscle tissues were taken for chemical analysis.

SIA analysis: After removal of lipid, analysis was done using isotope ratio mass spectrometer equipped with an elemental analyser.

OCPs analysis: Ten gram of muscle tissue homogenized with sodium sulfate was extracted using hexane:acetone 3:1 (*v/v*). Analysis of OCPs was carried out using GC-ECD.

[Results and Discussion]

Stable isotope analysis

Values of $\delta^{13}C$ and $\delta^{15}N$ in all fish species ranged from -16.78‰ to -24.83‰ and 5.25‰ to 10.93‰ respectively. The mean values of $\delta^{15}N$ were significantly high for *B. intermedius* and *C. gariepinus* than *T. zilli, Carp sp*., and *O. niloticus*, indicating a higher trophic position of the first two species in the food chain of the lake. Based on the $\delta^{13}C$ values, the fish species utilized different carbon sources, both with littoral and a pelagic origin. *B. intermedius* and *T. zillii* had wide range of feeding habits from pelagic to littoral food origin, while the other three fish species were utilized food from pelagic carbon sources.

Levels and biomagnification of OCPs

The main OCPs detected in this study were DDTs, HCHs, heptachlor-epoxides and chlordanes (CHLs) with total OCPs concentration ranging from 1.41 to 63.8 ng/g wet weight. DDTs were the predominant pesticides, and might be attributed to the run-off and atmospheric deposition from DDT which is used for agricultural and malaria control activities in the area. DDTs were identified from all fish samples and the metabolite *p,p'*-DDE was accounted for 41% to 82% of the total concentrations of the DDTs.
Correlation between log concentration of OCPs and stable isotopes of nitrogen ($\delta^{15}N$) values confirmed that persistent organic pollutants were biomagnified in Lake Ziway food web. A significant positive ($p<0.001$) relationship were found for DDTs and CHLs.

Human Health Risk Assessment

Since Lake Ziway and its catchment are receive wastes from agriculture and domestic sources, there is concern that OCPs input to the lake pose a risk to human health through fish consumptions. Thus, hazard ratios (HRs) based on 50th centile and 95th centile exposure concentration were assessed by comparing estimated dietary intakes with benchmark concentrations for both noncancer and cancer risks. A hazard ratio that is greater than one indicates that there is potential risk to human health The HRs of noncancer risk for all OCPs was less than one. However, the HR for cancer risk based on the 95th percentile data of HCHs, HPTs and DDTs was greater than one.

[Remarks]

This study supports the followings phenomena:

- DDTs were the main OCs detected, which probably came through the local source near the lake. Maximum levels of OCPs were found in carnivorous fish species as being found at higher trophic positions, which demonstrates the bioaccumulation trend of POPs.

- The hazard ratio (HR) for cancer risk based on the 95th percentile data of HCHs, HPTs and DDTs exceeded the value of 1, suggesting that daily exposure to these compounds yield a life cancer risk greater than 1 in 10^6

Ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Phongolo River and floodplain, South Africa

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Following the construction of the Pongolapoort Dam in the Phongolo River, South Africa in 1974, concerns related to the influence of the resulting changes in water flows into the Phongolo floodplain led to extensive studies. These studies emphasized the importance of the system in the maintenance of social and ecological services of fish communities. Between the early 1980s and mid 1990s the human population increased from 30,000 to 100,000 plus. With an even greater population increase during the last 15 years, the provincial conservation agency, Ezemvelo KZN Wildlife, has expressed their concern regarding the lack of updated studies on the general status of the Phongolo floodplain system. The concern stems from the increased population pressure on the services provided by fish communities and water quality issues related to continued use of pesticides and DDT in malaria vector control. Further, the conservation authorities have never been able to assess the effectiveness of the environmental water flows proposed and thereby fulfill their legislative obligations to establish management and conservation plans for this ecologically sensitive ecosystem. To address these concerns a multidiscipline project was initiated in 2012. The aims of this study were: (1) to conduct an integrated regional scale risk assessment of the lower Phongolo River and Floodplain using the Relative Risk Model to establish and evaluate threats to the sustainable structure and function of the ecosystem; (2) carry out an ecological integrity state assessment of the lower Phongolo River and Floodplains; (3) use fish health and community structures of fish and macroinvertebrates as indicators of ecological health; (4) determine and evaluate the bio-accumulation and biomagnifications of DDT and other relevant organic pollutants and potential impacts thereof in the lower Phongolo River and Floodplain; (5) establish conservation plans for selected major aquatic invertebrate and vertebrate species (macroinvertebrates, fish, amphibians and birds) of the Phongolo River and Floodplain and (6) to (i) evaluate the socio-economic implications associated with the use of fish as an ecosystem service and to (ii) evaluate

the socio-ecological and cultural implications associated with the use of fish as an ecosystem service. For the purpose of this presentation the results dealing with Aims 3 (fish health and fish population structures) will be presented and discussed in terms of its relevance to the biomacnification of DDT in fish (Aim 4) and fish use by local communities (Aim 6).

Application of the relative risk methodology to assess human and ecological risks posed by DDT use in the lower Phongolo River and floodplain.

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The recently established regional scale risk assessment approach for South Africa is being applied to address a range of South African water resource management issues. It is used to evaluate multiple threats associated with multiple sources and stressors to numerous socio-economic and ecological endpoints. Integration of the sources, stressors and endpoints is achieved through developing Bayesian networks (BNs). These BNs are graphical models that use conditional probability distributions to describe cause-effect relationships between the defined ecological driver and responder ecosystem variables. In regional scale risk assessment, BNs are used to represent uncertainty in understanding ecosystem response variability and the influence of uncertainty and variability associated with adaptive management in natural resource management. In this presentation we present the approach developed the conceptual model that represents both ecological and human well-being. Since the risk assessment procedure for the Phongola system is still in its initial stages, the further application of BNs is demonstrated using an example of the Thukela River system in northern Kwa-Zulu-Natal, South Africa.

Biomarkers of pollution in tigerfish (*Hydrocynus vittatus*) in the Phongolo River system

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Tigerfish has a high ecological, economical and social value to South Africans. They are lost through habitat changes caused by water extraction, pollution and obstructions like impoundments and weirs. Tigerfish is therefore a protected species in South Africa and the potential adverse effects of different contaminants present in the aquatic environment through industrial, agricultural en urban activities have to be determined to predict maximum tolerable levels for conservation management. Carefully selected biomarkers are recognised indicators of the levels of pollution that could compromise the health of aquatic organisms. Effects of known concentrations of contaminants on fish physiology and organ function in specific impacted areas can be determined in laboratory and field studies. Tigerfish is a sensitive species and therefore difficult to keep under controlled laboratory conditions for exposure experiments. Effects of water quality on tigerfish can currently be determined from field samples only.

Biomarker values obtained for tigerfish sampled in the Phongolo River system, KwaZulu-Natal provided information on the effects of pollutants e.g. DDE and DDD in the sampling localities on this specie's physiology.

Two groups of biomarkers were analysed. The first group is biomarkers of exposure that consists of Metallotheinins (MT) that responds to metal exposure, acetylcholine esterase (AchE) an indicator of organophosphate and carbamate pesticide exposure and ethoxyresorufin- O-deethylase (EROD) a biomarker of organochlorine. Malondialdehyde (MDA) and protein carbonyl (PC) used to determine antioxidant stress responses as well as cellular energy allocation (CEA) to show changes in energy reserves are biomarkers of effect. Standard techniques were employed for all analyses.

The results obtained on biomarker responses are discussed in view of the importance of the findings to assist in the assessment of tigerfish health. The validity of biomarker responses in toxicity testing as a component of water quality monitoring programmes is

considered. Responses of biomarkers in fish sampled are interpreted to identify similarity in reaction to the contaminants present.

Lead poisoning in children from townships in the vicinity of a lead-zinc mine in Kabwe, Zambia

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Childhood lead (Pb) poisoning is a serious public health concern worldwide. Young children are particularly vulnerable to Pb exposure and eventual poisoning. Blood lead levels (BLLs) > 10 µg/dL in children are considered elevated and at higher BLLs > 60 µg/dl, clinical symptoms of Pb toxicity become visible. BLLs exceeding 100 µg/dL can cause encephalopathy, convulsions, coma and death. It has been recommended that intensive medical management and chelation therapy be initiated at levels ≥ 45 µg/dL. In Africa, major sources of childhood Pb poisoning include Pb mining and smelting. In Kabwe, the capital of Zambia's Central Province, extensive Pb contamination of township soils in the vicinity of a Pb-Zn mine has been reported and poses a serious health risk to children in these townships.

However, no studies have been done to investigate BLLs in children exposed to Pb pollution. Therefore, this study investigated BBLs in children (n = 246), under the age of 7 years, in townships around the Pb-Zn mine in Kabwe and to identify children with BLLs that require medical intervention. Almost all of the sampled children had BLLs exceeding 10 µg/dL. Children in these areas could be at serious risk of Pb toxicity as 18% of the sampled children in Chowa, 57% (Kasanda) and 25% (Makululu) had BLLs exceeding 65 µg/dL; the threshold widely considered to result in Pb toxicity. A total of 8 children had BLLs exceeding 150 µg/dL. These levels were markedly high, especially that concentrations of up to 427 µg/dL were recorded. Therefore, it is recommended that medical intervention be commenced in the children with BLL exceeding 45 µg/dL and other interventions to reduce Pb exposure in the affected townships

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