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Measuring Total Mercury Level in Local Food Fish Bangamary (*Macrodon ancylodon*) in Guyana

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Authors' contributions

This work was done in collaboration between both authors. Both authors contributed to conception of this study. Bheshnandini Lisa Tirbani collected the data. Leanna Kalicharan wrote the first draft of the manuscript and made all subsequent edits. All authors read and approved the final manuscript.

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ABSTRACT

This research conducted in 2019 at the University of Guyana investigated the content of methylmercury in local food fish *Macrodon ancylodon* locally known as Bangamary. A total of 24 samples of *M. ancylodon* was purchased from the Meadow Bank Wharf in Guyana for analysis of total mercury level. Additionally, the size frequency at which mercury concentration is the highest was also evaluated. The results indicated that total mercury concentration in each sample of *M. ancylodon* was less than 0.5 mg/kg. With an average total mercury content of 0.10 mg/kg, adults had the greatest total mercury content, followed by juveniles (0.06 mg/kg) and young (0.02 mg/kg). This may be attributed to the carnivorous diet of *M. ancylodon* and the fact that the fish species is usually captured in the estuarine regions of the Demerara and Essequibo Rivers. These waterways are linked to mining areas in Guyana's interior region that discharge mercury contaminated water, which could be the reason why mercury is bioaccumulating in the tissue of the Bangamary.

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1. INTRODUCTION

A healthy and balanced diet should include fish since they are an excellent source of protein, essential nutrients and are associated with many health benefits [1]. However, fish can bioaccumulate mercury in their muscle tissues [2]. Mercury (Hg) is one of the most toxic elements and occurs in the environment as organic mercury, inorganic mercury (mercuric salts) or elemental or metallic mercury [2,1]. In aquatic environments, inorganic mercury is converted by microorganisms present in sediment to organic mercury in the most common form of methylmercury (MeHg) [2,1].

MeHg is the most hazardous form of mercury found in food and is accumulated in the aquatic food chains of shellfish and fish [2,1]. For most individuals, exposure to methylmercury comes from the ingestion of seafood, as they accumulate high concentrations of MeHg [2,1]. Following ingestion of fish, more than 90% of MeHg [3] is readily absorbed from the gut and is rapidly distributed by the blood to the tissues [2,1]. While mercury may not be a great risk to adults because of their larger body weight, it is harmful to young children and poses a greater risk to pregnant women and their developing fetuses [3]. The European Union (EU), Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) have determined the maximum permitted level of safe consumption of 0.5 µg Hg g^{-1} (ww) in the muscle of most fish species, and 1 µg Hg g^{-1} (ww) in the muscle of some predatory fish species [3,2].

Moreover, the highest concentrations of mercury are typically found in predatory fish species that eat smaller fish and other aquatic life forms [1]. *Macrodon ancylodon* locally known as the Bangamary is a predatory fish species of economic significance in Guyana, as it is exported and locally consumed as it is readily available all year. It is distributed in marine and brackish water in the Wester Atlantic and inhabits muddy or sandy bottoms in coastal waters around 60 m in depth. At maturity, sizes range from 18 to 46 cm [4].

Furthermore, Montaña et al. [2] examined Hg concentrations in fish that constitute important subsistence fisheries from mined and non-mined tributaries in the middle Mazaruni River, Guyana. Their study found that carnivorous and piscivorous fish species had the highest concentration of Hg, and medium– to large–sized bodied fish most consumed by locals exceeded the FAO and WHO criteria. These results ultimately highlight the health concerns for riverine communities in these areas that depend on fish as their main source of protein. The findings of the study also reveal that little is known about the synergy effect of mercury contamination in all components of the aquatic food web and the pathway for inorganic mercury to be converted to organic methylmercury [2].

Further research is needed to determine Hg contamination and impacts of Hg concentrations on fishes and overall aquatic biodiversity. Importantly, how Hg contamination affects human health locally is of top priority. Therefore, the main objective of this research was to evaluate the total mercury content in Bangamary, a locally important food fish, to determine if bioaccumulation is significant. Tissue samples of Bangamary in a range of weights and sizes were obtained from Meadow Bank Wharf. An independent laboratory, Kaizen Environmental Services Inc. Guyana, was commissioned to analyze all tissue samples.

2. MATERIALS AND METHODS

2.1 Sampling Collection

In April 2019, 24 individuals of Bangamary of various size frequencies were bought from vendors at the Meadow Bank Wharf, Guyana. To maintain a typical sample size, eight individuals were collected based on the three size categories: young (less than 15 cm), juvenile (15 – 33 cm), and adult (above 33 cm) [4]. These were put in Zip Loc bags and kept in coolers with ice. The sample was processed at the University of Guyana's Center for Study of Biological Diversity (CSBD) Wet Museum.

2.2 Biological Data

The weight and fork length of every fish were recorded. A digital scale was used to record the weight to the closest 0.1 g, and a measuring tape was used to record the fork length to the nearest 0.1 cm.

2.3 Tissue Sampling

30 grams of muscle tissue were obtained from the fillet section of each fish located between the dorsal fin and the lateral line just beyond the gill cover [5]. Cubes were carved out of the fish tissue to get the samples. To preserve the integrity of the samples for verification, they were put in tiny Zip Loc bags, labeled with a special identifying number, and kept in the freezer [1].

2.4 Test Methodology

The samples were taken to Kaizen Environmental Services Inc. Guyana for mercury analysis. Mercury in Tissue: EPA 3050B and EPA 1631 Revision E. EPA 3050B is the Acid Digestion of Sediments, Sludges and Soil was the procedure used to evaluate the samples for total mercury. The EPA 1631 Revision E is the determination of mercury (Hg) in filtered and unfiltered water by oxidation, purge and trap, desorption, and cold-vapor atomic fluorescence spectrometry [6].

2.5 Data Handling

Microsoft Excel was used to sort the data obtained from Kaizen Environmental Services Inc. Guyana, and then tables and graphs were produced. The mean and standard deviation of fork length, weight, and total mercury content of fish sampled were also calculated using Microsoft Excel. Since statistical analysis was not necessary to achieve the objective, descriptive analyses were conducted.

3. RESULTS AND DISCUSSION

3.1 Concentration of Mercury present in Bangamary

FL (cm) ranged from 17.1 cm to 41.1 cm in young, juvenile, and adult individuals. The mean FL for young is 19.0 cm, juveniles is 30.7 cm, and adults is 38.6 cm (Table 1). The weight for individuals sampled ranged from 30.0 g to 530.0 g, with the mean weight of young being 45.0 g, juveniles being 227.5 g and adults being 470.0 g (Table 1). The total mercury concentration in samples ranged from 0.0200 to 0.2300 mg/kg, with a mean of 0.0238 mg/kg for young, 0.0575 mg/kg for juveniles, and 0.1038 mg/kg for adults (Table 1). As the species' mean FL and weight increased, so did the mean levels of total mercury content (Fig. 1 & Fig. 2).

3.2 Size Frequency and Mercury Concentration

The data indicate that as the maximum FL and weight increase, the maximum total mercury level also increases (Table 2; Fig. 3 & Fig. 4). Total mercury concentration is highest at the adult developmental stage, followed by the juvenile and then the young for both FL and weight (Fig. 3 & Fig. 4).

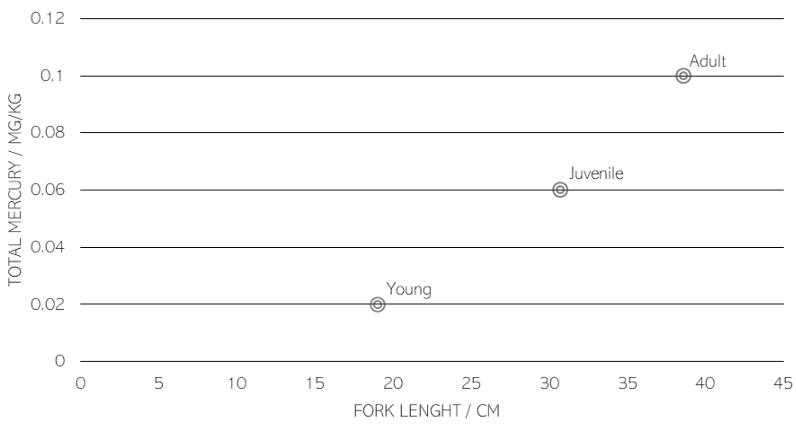

Fig. 1. Mean FL and total mercury content for samples of young, juvenile, and adult fish

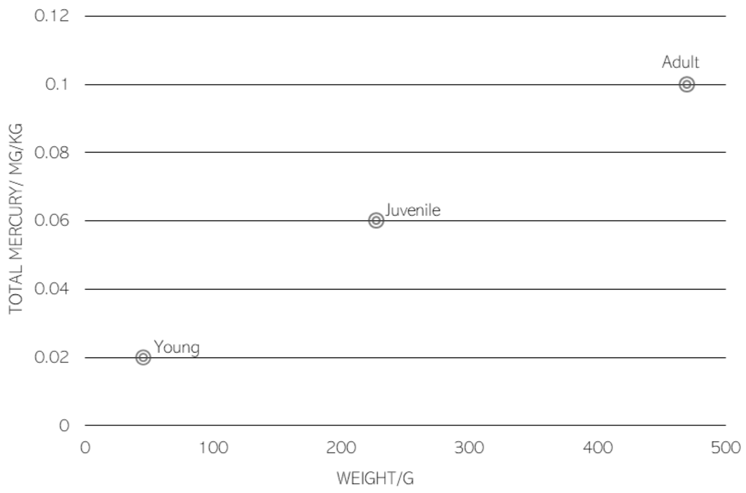

Fig. 2. Mean weight and total mercury content for samples of young, juvenile, and adult fish

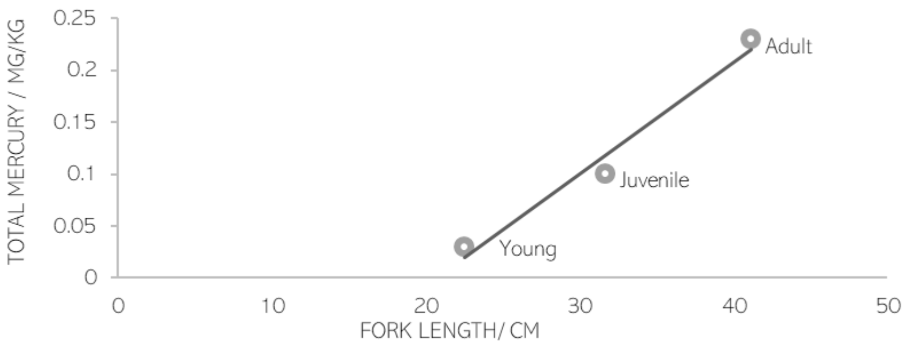

Fig. 3. Maximum FL and total mercury content for samples of young, juvenile, and adult fish

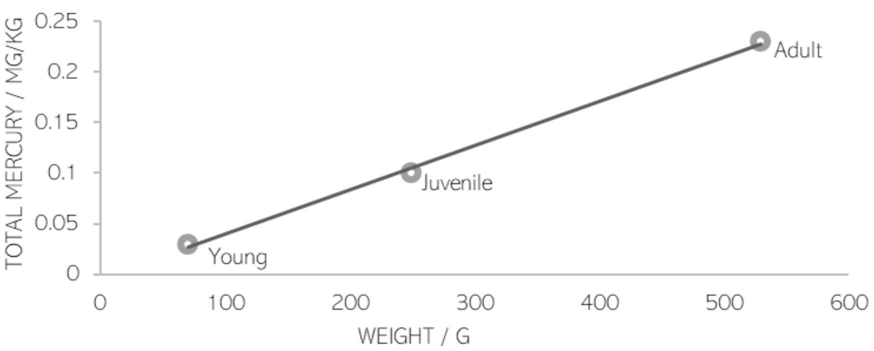

Fig. 4. Maximum weight and total mercury content for samples of young, juvenile, and adult fish

Table 1. Biological Data for the 24 Bangamary Individuals Sampled at the Young, Juvenile and Adult Stage

Developmental Stage of Fish Sampled	Unique Fish ID	FL (cm)	Weight (g)	Total Mercury (mg/kg)
Young	1Y	18.3	50.0	0.0300
	2Y	18.1	40.0	0.0200
	3Y	17.1	30.0	0.0300
	4Y	21.0	60.0	0.0200
	5Y	18.5	40.0	0.0200
	6Y	22.5	70.0	0.0300
	7Y	18.4	40.0	0.0200
	8Y	18.2	30.0	0.0200
Mean		**19.0**	**45.0**	**0.0238**
SD		**(1.8)**	**(14.1)**	**(0.0052)**
Juvenile	1J	31.0	210.0	0.0600
	2J	29.2	200.0	0.0500
	3J	31.5	250.0	0.0600
	4J	29.8	220.0	0.0400
	5J	30.5	220.0	0.0500
	6J	31.2	240.0	0.0600
	7J	31.0	230.0	0.0400
	8J	31.7	250.0	0.1000
Mean		**30.7**	**227.5**	**0.0575**
SD		**(0.9)**	**(18.3)**	**(0.0191)**
Adult	1A	35.1	400.0	0.0800
	2A	39.0	480.0	0.1200
	3A	37.6	440.0	0.0700
	4A	36.7	400.0	0.0700
	5A	40.7	530.0	0.2300
	6A	39.2	500.0	0.0600
	7A	39.5	480.0	0.1400
	8A	41.1	530.0	0.0600
Mean		**38.6**	**470.0**	**0.1038**
SD		**(2.0)**	**(52.1)**	**(0.0588)**

FL = Fork Length, cm = centimeters, g = grams, mg/kg = milligram per kilogram, SD = Standard Deviation

Table 2. Size Frequency Distribution at which total mercury content is lowest and highest for samples of young, juvenile, and adult fish

	Young		**Juvenile**		**Adult**	
	Max.	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
FL (cm)	22.5	17.1	31.7	29.2	41.1	35.1
Weight (g)	70.0	30.0	250.0	200.0	530.0	400.0
Total Mercury (mg/kg)	0.0300	0.0200	0.1000	0.0400	0.2300	0.0800

The results of the mercury analysis showed that the sampled tissues of all stages (young, juvenile, and adult) of Bangamary of various weights and lengths contained MeHg. Fish bioaccumulate MeHg through their diet and through the absorption of water (bioconcentration) [7], which bioaccumulates in the tissue of the fish [2]. This contributes to the rise in total mercury levels from the young to juvenile and to adults as observed from the results obtained. Because adult fish are the largest in terms of size, they would also bioaccumulate the most mercury, followed by juvenile, then young [5].

Bangamary is a carnivorous fish species that feeds on shrimp and smaller fishes [4] and this would be a major contributing factor attributing to the total Hg levels detected, since MeHg bioaccumulates at higher levels in the food web [8]. Additionally, since waterways tend to connect, mercury-contaminated water from mining areas in the interior regions of Guyana, runs through the Demerara and Essequibo Rivers, allowing fish found in these estuaries and coastal waters to bioaccumulate mercury in their tissues [2].

According to the results of this study, none of the samples exceeded the European Commission Decision 93/351 of 19 May 993 (2) which asserts that the mean total mercury content in edible parts of fish products should not exceed 0.5 mg/kg (wet weight) [9]. Consequently, it can be asserted that Bangamary in Guyana is a safe option to consume because total mercury levels in almost all tissue samples were less than 0.15 mg/kg. Because mercury is hazardous and poses serious health risks if it accumulates in humans, it is advised that people consume it only within weekly recommended servings to avoid bioaccumulation [5]. Although small amounts of mercury are ineffective in the body, high amounts over time due to bioaccumulation can lead to major health issues, especially in pregnant women and children [9].

The results of this study only considered a 30 g sample of muscle tissue; thus, care should be exercised to prevent bioaccumulation of mercury in the body since the mercury content of the whole fish would be higher. This study unequivocally shows that when length and weight frequencies increase, total mercury concentrations increase, and that the greatest mercury concentrations were found in adults, followed by juveniles and then young.

It is therefore important that locals consume no more than two to three servings of Bangmary per week according to the EU, FAO, WHO recommendations. This will control the bioaccumulation of mercury in the body and reduce associated risks with mercury poisoning. Furthermore, a more thorough study needs to be conducted which should employ a large sample size for different species to accurately represent the status of mercury concentrations for fish species in Guyana.

4. CONCLUSIONS

All tissue samples from Bangamary contained methylmercury, and adults had the highest amounts of total mercury, followed by juveniles and young. The total mercury level increased with length and weight of fish due to bioaccumulation. The Bangamary as an economically important fish species in Guyana is safe to consume because the total mercury content is less than the 0.5 mg/kg limit for mercury in edible fish tissue.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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