ผลของอะบาเม็กตินต่อการเปลี่ยนแปลงของโลหิตวิทยา และการเปลี่ยนแปลงเนื้อเยื่อในปลาดุกลูกผสม

Adverse Effects of Abamectin on Hematological Profile and Histological Alterations of Hybrid Catfish (*Clarias macrocephalus x C. gariepinus*)

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บทคัดย่อ

ศึกษาผลกระทบเชิงลบของอะบาเม็กตินที่ระดับความเข้มข้น 5 ไมโครลิตรต่อลิตร เมื่อปลาดุกลูกผสมได้รับสัมผัสเป็นเวลา 0, 5, 10, 15 และ 20 วัน โดยตรวจสอบจากค่าโลหิตวิทยาและการเปลี่ยนแปลงเนื้อเยื่อ พบว่าระยะเวลาที่ได้รับสัมผัสมีอิทธิพลต่อองค์ประกอบของเปอร์เซ็นต์ของฮีโมโกลบิน จำนวนเม็ดเลือดแดงและจำนวนเม็ดเลือดขาวที่นับได้ โดยค่าเปอร์เซ็นต์ของฮีโมโกลบินและจำนวนของเม็ดเลือดแดงจะลดลงอย่างมีนัยสำคัญทางสถิติที่ระดับความเชื่อมั่น 95% ($p<0.05$) เมื่อปลาดุกลูกผสมได้รับสัมผัสกับอะบาเม็กตินเป็นเวลา 15 และ 20 วัน เมื่อเปรียบเทียบกับกลุ่มควบคุม และยิ่งไปกว่านั้นเมื่อได้รับสัมผัสเป็นเวลานานมากขึ้นจะส่งผลต่อการเพิ่มของจำนวนเม็ดเลือดขาว ซึ่งเม็ดเลือดขาวที่พบจะมี 3 ชนิดคือ ลิมโฟไซท์ โมโนไซท์ และนิวโทรฟิล การเปลี่ยนแปลงของเนื้อเยื่อที่เกิดขึ้นในเซลล์เหงือก ตับ ลำไส้ และไตนั้นจะขึ้นอยู่กับระยะเวลาที่ได้รับสัมผัส โดยการเปลี่ยนแปลงรูปร่างและเกิดการตายพบได้ที่บริเวณซี่เหงือก ลำไส้เกิดการเพิ่มจำนวนของก๊อบเลทเซลล์และเกิดแผล ส่วนในเซลล์ตับพบการตายของเซลล์ ยิ่งไปกว่านั้นพบการเปลี่ยนแปลงรูปร่างของเซลล์ท่อไตและเกิดการตาย สรุปได้ว่าปลาดุกลูกผสมสามารถนำมาใช้ประโยชน์ในการประเมินถึงระดับความเป็นพิษของอะบาเม็กตินในสิ่งแวดล้อมทางน้ำได้โดยศึกษาการเปลี่ยนแปลงของโลหิตวิทยาและการเปลี่ยนแปลงเนื้อเยื่อ

คำสำคัญ : อะบาเม็กติน โลหิตวิทยา ปลาดุกลูกผสม ลิวโคไซท์ ความเป็นพิษ

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Abstract

The study was designed to investigate the adverse effects of abamectin concentration of 5 µl L^{-1} for 0, 5, 10, 15 and 20 days on the hematological profile and histological alterations of hybrid catfish (*Clarias macrocephalus* x *C.gariepinus*). It was found that the exposure time influenced the content of hemoglobin concentration percentage (Hb gm (%)), red blood cell (RBC), and white blood cell (WBC) counts. The percentage of Hb and RBC count significantly decreased ($p<0.05$) after juvenile hybrid catfish exposed to abamectin for 15 and 20 days compared to the control group. Furthermore, an increasing in exposure time resulted in the significant increase ($p<0.05$) of WBC count. The leukocyte was found only 3 types: lymphocyte, monocyte and neutrophil. Histological alterations in gill, intestine, liver and kidney illustrated the changes of tissue depending on the time of exposure. There were deformation of secondary lamellae and necrosis of gills. The intestine showed increasing of goblet cells and lesion, and the liver illustrated necrosis of hepatocytes. In addition, necrosis of the tubular cell and glomerulus deformation were found in kidney. In conclusion, hybrid catfish could be useful to evaluate the toxicity of abamectin contaminated in aquatic environment by studying its hematological profile and histological alterations.

Keywords : abamectin, hematology, hybrid catfish, leukocyte, toxicity

Introduction

The use of pesticide is an obligation of modern agriculture to obtain the yield in accordance with the need of ever increasing population, particularly in the developing countries (Ali *et al*., 2014; Ghaffar *et al*., 2014). Pesticides provide an important role in enhancing cereal production so they are generally found in aquatic habitats i.e. ponds, rivers and streams at varying concentrations. They are dispersed to these habitats via overspray, drift, atmospheric transport, agricultural and residential runoff, individual misuse, and improper disposal (Hasan *et al*., 2015).

Abamectin, recognized as avermectin B1a, is normally used as pesticide and anti-helminthic medicine for animals. It is produced as the product of *Streptomyces avermitilis* via naturally occurring fermentation, and is a mixture of homologues B1a and B1b. Besides, it contains a minimum of 80% B1a and a maximum of 20% B1b (El-Said, 2007). Abamectin is very active against insects and animal parasites. Generally, it is highly lipophilic and dissolved in most organic solvents, but poorly soluble in water (Roth *et al*., 1993). Despite low toxicity in mammals, it is extremely toxic in fish. The LC50 values of abamectin at 96 h in rainbow trout and bluegill sunfish at 96 h are consecutively 3.2 ppb and 9.6 ppb (Jenčič *et al*., 2006). And, it can pass the blood/brain barrier and then cause toxic effects in fish (El-Said, 2007). The nervous system is the main target being interacted with the glutamate-gated chloride channels and GABA (c-amino butyric acid)-gated chloride channels. This generates strong chloride influx,

resulting in disrupted neural signal transmission (Martin, 1997). Its action is not only specific to parasitic arthropods and nematodes but also probably affective on other organisms in the environment. Many methods were now applied to study the effect of pesticide on aquatic organisms. For the example, Raina and Sachar (2014) studied on hematological parameter in *Labeo boga* after exposed to pesticide in carbamate group and El-Said (2007) also investigated the effect of abamectin on tilapia (*Oreochromis niloticus*) by measuring biochemical constituents and osmoregulation. Moreover, Jenčič *et al.* (2006) reported that histological alterations can be used to assess the effect of abamectin on rainbow trout (*Oncorhynchus mykiss*) which caused some alterations such as degenerative changes in brain and kidney. In Thailand, the study on the effect of abamectin has been very few. Thus, this study was performed to fulfill that gap for understanding the impact of abamectin on hematological profile and histological alterations of hybrid catfish (*C. macrocephalus* x *C. gariepinus*), which is an economically important freshwater fish. Furthermore, the results of this study could be used as fundamental knowledge for assessing the negative effect of abamectin on other fishes and beneficially applied to water quality management.

Methods

1. Animals husbandry

Adult specimens of hybrid catfish were collected from the Suriyan farm in Surin province. The fishes were then acclimatized for 14 days. The average weight of catfish was 150±25.2 g and the length was 25±3.2 cm that they were 45 days of age. They were placed in a 500 L of plastic tank with water being exchanged every day. In this period, the abamectin concentration was constantly kept. Normally, they were fed twice a day but the feeding was stopped for 3 days before experiment. The experiment was performed triplicate. In an experiment, 50 catfishes were used and randomly sampled to do hematological analysis and study histological alterations for evaluating the toxicity of abamectin. Prior the experiment, the Median lethal concentration (LC 50) of abamectin was identified by using Mini tab program at 0, 24, 48, 72 and 96 h in the concentration of 0, 2.5, 5, 7.5, 10, 12.5 and 15 µl L^{-1}. After that, three concentration of abamectin (1.8% WV EC purchased from Sevenagro company, Thailand) was selected to use i.e. 5, 10 and 15 µl L^{-1} and then compared with a control group through the course of the experimental period. After the experiment finished, all of the hybrid catfish was terminated and burned in an incinerator to reduce environmental contamination.

2. Hematological analysis

After acclimation, the hybrid catfish was lain unconsciously by using 80 ppm of clove oil. Next, 0.5 ml of blood was taken directly by cardiac puncture with the help of heparinized needles using ethylenediaminetetraacetic acid (EDTA) as an anticoagulant at the 0, 5, 10, 15, 20 days. Sample of blood (about 100 µl, from each fish) was subjected to routine hematological analysis. This analysis was performed immediately after blood sampling and each parameter in all samples was measured. Red Blood Cell (RBC) and White Blood Cell (WBC) counts were

determined with a haemocytometer with improved Neubauer counting chamber as described by Blaxhall and Diasley (1973). Hemoglobin concentration (Hb gm (%)) estimates were determined as described by Wedemeyer and Yasutake (1977). Differential leukocyte counts were based on the analysis of blood smear. Blood smear was prepared, stained with May- Grünwald -Giemsa solution and fixed with balsam and cover glass. Identification of various blood cells (differential leukocyte count) was done in each smear (100 leukocyte were viewed) and analyzed under the light compound microscope (Primo Star, ZEISS) and photographed by digital camera (Nikon coolpix S 5100).

Experimental data were statistically analyzed by means of analysis of variance (ANOVA). Significance was set at $p<0.05$. All analyses were performed using Statistical Package for the Social Science for Windows (SPSS) software.

3. Histological alterations

After acclimation, the fishes (n=5) from each group was immersed in 80 ppm of clove oil. Then, there were sacrificed and their organs, i.e. liver, kidney, intestine and gill tissues, were collected carefully from both controls (Figure 1A) and treated groups (Figure 1B). Both tissues were then fixed in Bouin fixative solution for 48 h. Fixed tissues were washed with 50% ethanol and dehydrated further through 60% and 90% absolute ethanol and cleared in xylene. The tissues were then embedded in paraffin wax and sections of 6 µm were obtained on rotary microtome. The sections were then stained with Mayer's hematoxylin and eosin (H & E) to observe the architecture of liver, kidney, intestine and gills of both control and treated group. Stained slides were observed under compound microscope and then photographed and assessed.

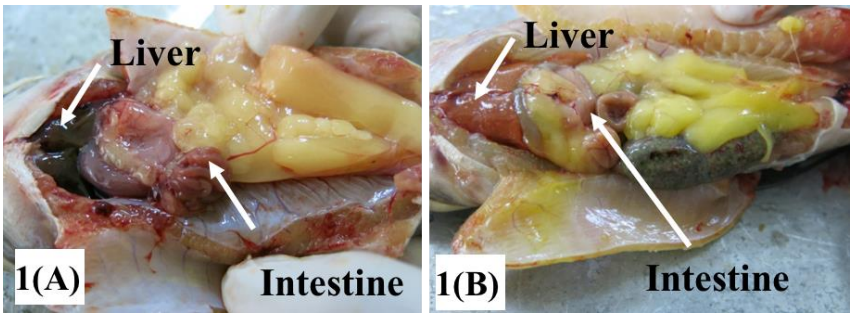

Figure 1 Internal organs of non-exposed hybrid catfish (1A) and abamectin exposed hybrid catfish (1B)

Results

In this study, the effect of abamectin on hybrid catfish was evaluated. Studied fishes were exposed to abamectin at the concentration of 0, 5, 10, and 15 µl L^{-1} for 0, 5, 10, 15, and 20 days. Prior experiment, the LC 50 of abamectin was identified as 11.81, 9.17, 8.40 and 8.08 ml L^{-1} at 24, 48, 72 and 96 h, respectively. Moreover, it was found 100 % mortality of the catfish exposed to abamectin at the concentration of 10 and 15 µl L^{-1} for 24 h. Thus, there was only one concentration being selected in this study that was 5 µl L^{-1} because the catfish survived in this concentration. This condition is classified as chronic exposure as found in the real condition. We found that Hb gm (%) and RBC count decreased with an increasing in exposure time. The content of Hb gm (%) and RBC count after 15 and 20 days of exposure significantly differed ($p<0.05$) from the content after 0, 5, and 10 days of exposure (Table 1). For WBC count, it significantly increased with an increasing in exposure time ($p<0.05$). The content of WBC count in 0, 5, 10, 15, and 20 days after exposure were 59.07±1.05, 67.17±0.76, 76.9±0.62, and 86.2±1.08 ($10^3/mm^3$), respectively.

Table 1 Effect of abamectin on hematological parameters of hybrid catfish from individual fish. Data are means ± standard error of mean (n=5). Data were subjected to ANOVA followed by Duncan's multiple-range test. Different letters denote statistically significant ($p<0.05$).

Parameters	Exposure period (days)				
	0	5	10	15	20
Hb gm (%)	9.29±0.18^a	8.97±0.07^a	8.51±0.10^a	7.74±0.56^b	7.4±0.15^b
RBC ($10^6/mm^3$)	2.74±0.05^a	2.18±0.06^a	1.99±0.02^a	1.83±0.06^b	1.75±0.05^b
WBC ($10^3/mm^3$)	53±2.00^a	59.07±1.05^b	67.17±0.76^c	76.9±0.62^d	86.2±1.08^e

After the type of leukocyte was identified, we found only 3 types: monocyte (Figure 2A), lymphocyte (Figure 2B), and neutrophil (Figure 2C). Percentage of lymphocyte expression decreased with an increasing in exposure time while the content of monocyte and neutrophil increased in the same time. Figure 3 shows the expression of hybrid catfish after 0, 5, 10, 15, and 20 days of exposure. For lymphocyte, the expression percentage decreased from 91.7 ± 1.5 % to 67.3±2.5 % after 20 days of exposure. At 10, 15 and 20 days, the content showed significant difference ($p<0.05$) compared to the control group. For monocyte, it contrastingly increased from 2.0±1.0 % to 8.0±1.0 % after 20 days of exposure. Moreover, the groups exposed for 10, 15 and 20 illustrated significant difference ($p<0.05$) compared to the control group. For neutrophil, its content in the fish exposed for 20 days was 3.5 times higher than that of 0 day of exposure ranging 7±1.0 % to 24.7±3.1 % (Figure 3). It was found significant difference ($p<0.05$) only in the group of catfish exposed for 15 and 20 days.

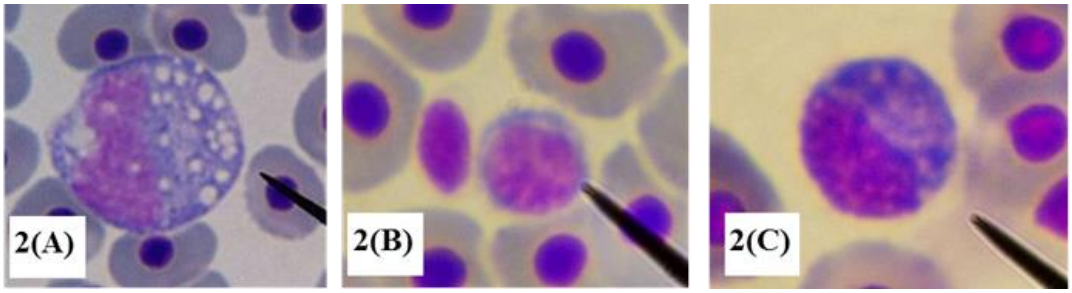

Figure 2 Morphological images of 3 types of leukocytes: monocyte (2A), lymphocyte (2B) and neutrophil (2C) in hybrid catfish after exposed to abamectin.

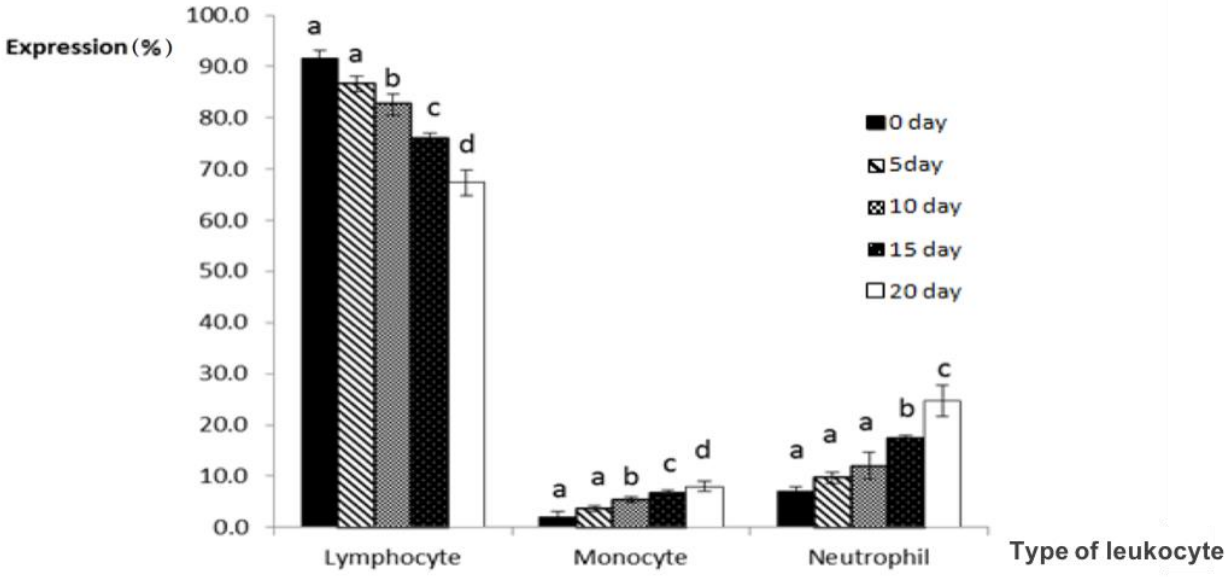

Figure 3 The expression of 3 types of leukocyte in blood of hybrid catfish from individual fish after exposed to abamectin at the concentration of 5 µl L^{-1} for 0, 5, 10, 15 and 20 day. Data are means ± standard error of mean (n=5) and the data were subjected to ANOVA followed by Duncan's multiple-range test. Different letters denote statistical significance ($p<0.05$) as compared to the control group.

Histological alterations in gill, intestine, liver and kidney showed that the changes depended on time of exposure. In non-exposed fish (Figure 4A), its gills were in normal condition which composed of normal gill filament, primary and secondary gill lamellae. After 5 days of exposure, it was found some alterations showing gill lifting

lamellae (data not shown). The alterations increased with an increasing in exposure time and the deformation of secondary lamellae and cell necrosis was found after 20 days of exposure (Figure 4B).

In addition, it was found histological alteration in intestine of exposed fish after 10 days of exposure (data not shown) while it was in normal condition in non-exposed fish and the fish which exposed for 5 days. Figure 5A shows the normal condition; there was no deviation from normal histological structure, the vascular structures and epithelial cells. However, the most alterations in increasing of goblet cell and lesion, was found in hybrid catfish exposed to abamectin for 20 days (Figure 5B).

In the liver of non-exposed hybrid catfish, it showed no histological alterations (Figure 6A). The hepatocyte was normal with foamy cytoplasm and no vascular changes observed. Contrastingly, it was observed in moderate degree of changes including vacuolation and cellular swelling in some places after 5 and 10 days of exposure (data not shown). And, it was found the most serious alteration being necrosis of hepatocytes after 20 days of exposure (Figure 6B).

For the kidney, Figure 7A showed the normal condition. It was found some alterations after 5 days of exposure (data not shown) and observed the most serious alterations which were necrosis of the tubular and deformation of glomerulus after 20 days of exposure (Figure 7B).

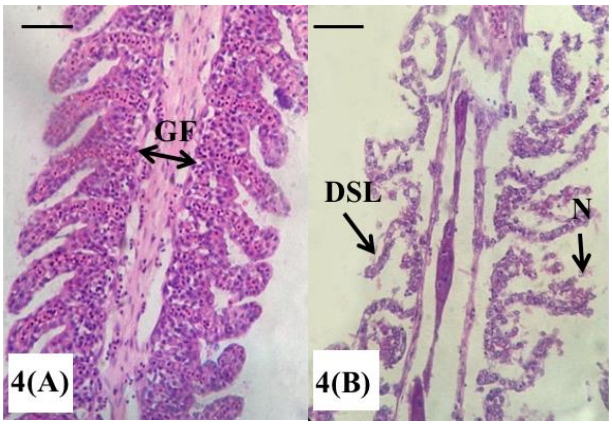

Figure 4 Photomicrograph of normal gill (4A) and the alteration in fish exposed to abamectin at the concentration of 5 µl L^{-1} for 20 days (4B); where, GF: Gill filament, DSL: Damaged secondary lamellae, N: Necrosis, scale bar corresponding to 25 µm (H & E stain, 40X)

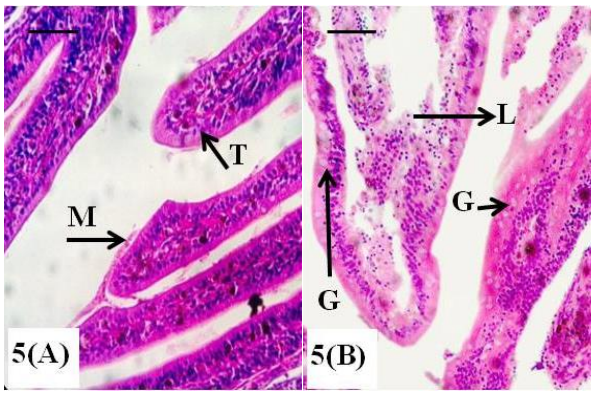

Figure 5 Photomicrograph of normal intestine (5A) and the alteration in fish exposed to abamectin at the concentration of 5 µl L^{-1} for 20 days (5B); where, M: Microvilli, T: Tall cylindrical, G: Goblet cell, L: Lesion, scale bar corresponding to 25 µm (H & E stain, 40X)

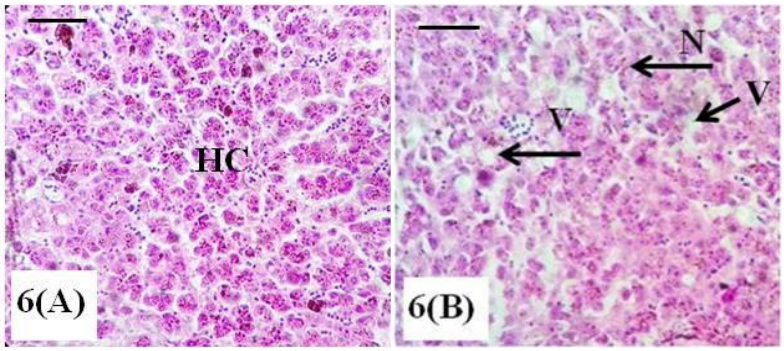

Figure 6 Photomicrograph of normal liver (6A) the alterations in fish exposed to abamectin at the concentration of 5 µl L^{-1} for 20 days (6B); where, HC: Hepatocyte , V: Vacuolation, N: Necrosis of hepatocytes, scale bar coresponding to 25 µm (H & E stain, 40X)

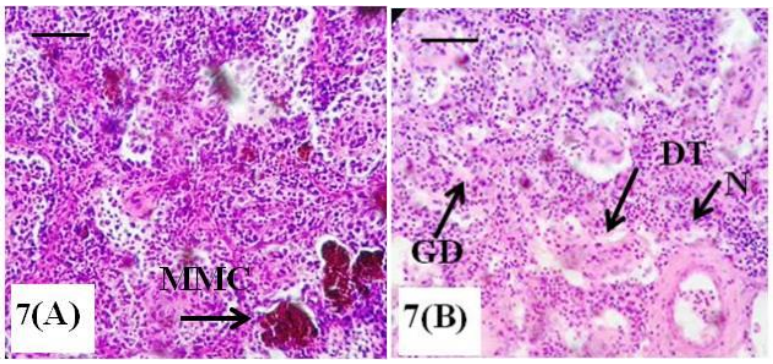

Figure 7 Photomicrograph of normal kidney (7A) the alteration in fish exposed to abamectin at the concentration of 5 µl L^{-1} for 20 days (7B); where, MMC: Melanomacrophage center, DT: Deformed of the tubular, N: Necrosis of tubular, GD: Glomerulus deformed, scale bar corresponding to 25 µm (H & E stain, 40X)

Discussions

Hematological profile study and histology are the normal methods used to study adverse effects in many toxicants. Additionally, the alterations in blood parameters illustrate the stress of fish exposed to different toxicants such as heavy metal, biocides, pesticides, rodenticides or insecticides (Singh *et al*., 2008). After studying the hematological profile, the results illustrated that Hb gm (%) and RBC count decreased with an increasing in exposure time, whereas WBC count increased in the same condition. The results in agreement with a research of Singh *et al*. (2008) that studied a freshwater fish, *Channa punctatus*, exposed to copper. They found that condition of exposed fish is occurred owning stress condition causing blood cell injury and disrupted hemoglobin synthesis. Moreover, it was found the reduction in hemoglobin content in exposed fish which might be caused by the inhibition effect of the toxic substance on the enzyme system playing the important role in synthesis of hemoglobin (Pamila *et al*., 1991). For the increasing in WBC count, this research illustrated that this phenomenon may relate to the damage caused by the infection in body tissue that serves physical stress and leukemia. Many cases showed that red blood cell morphology is recorded (Singh *et al*., 2008) that it is also found in our study. In addition, Raina and Sachar (2014) reported that an increasing in WBC count indicated the higher toxic level. Thus, industrial and agricultural effluent should be properly treated before releasing to the aquatic ecosystem where xenobiotics can cause a harmful effect on aquatic organisms.

After leukocytes were identified and counted, it was found only 3 types: lymphocyte, monocyte and neutrophil, while basophil and eosinophil were not found. This finding differed from the research of Affonson *et al.* (2014) studied and identified 4 types of leukocytes in catfish (*Hoplosternum littorale*) after exposed to sulphate. This difference may be because to there was only 100 blood cells being smeared and studied. In general, basophil and eosinophil had very low expression percentage thus it requires more cells to studied and identified. However, types and amount of leukocyte found in this study is in agreement with found in carp fish (*Cyprinus carpio*) which exposed to 2- phenoxythanol and etomidate and showing 3 types of leukocyte: monocyte, lymphocyte and neutrophil.

Lymphocyte, which is most common leukocyte found in the blood of many fishes, account approximately 85% of the total leukocyte cells (Groff and Zinkl, 1999). Various studies showed an interest in the leukocytes of teleost fishes due to their morphology and absolute values. Their studies illustrated a plenty of morphological aspects in many types of leukocyte (Vázquez and Guerrero, 2007). Monocytes have been called hemoblasts and macrophages (Barber *et al*., 1981), while some authors could not find monocytes (Hrubec *et al*., 2000). There have been quite few morphological studies on fish monocytes, mostly by light microscopy (Hrubec *et al*., 2000) and electronic microscopy Valenzeula *et al.* (2003). In this study, leukocyte found was lymphocyte which was a small and round shape having basophilic cytoplasm and the nucleus round. Monocytes were round shape having basophilic and sometimes vacuolated cytoplasm. The nucleus was normally eccentric and occasionally horseshoe-

shaped, whereas neutrophil was large and round with the cytoplasm, which contained fine neutrophilic granules and nucleus in small and had rod shape and was occasionally segmented. This finding is in agreement with the researches of Taraves-dias and Barcellos (2005) and Vázquez and Guerrero (2007) who studied in Armored catfish (*Hoplosternum littorate*) and in *Cichlasoma dimerus*, respectively.

Recently, physiological and histopathological biomarkers have been widely used to quantify pollutant and its effect on the exposed organism. Generally, biomarkers only response to the pollutant in biological available form. Their expression is the result of integral effects of multiple stressors and elucidates mechanisms of action (Yancheva *et al*., 2016). Teleost, kidneys, gills, and intestines play the role in excretion mechanism, and balance the homeostasis of the body fluids (Hinton *et al*., 1992; Yancheva *et al*., 2016) as well as produce urine which acts as an excretory route for the metabolites derived from xenobiotics. Kidney can also excrete various metabolized nitrogen-containing waste products such as ammonia and creatinine. In fish or higher vertebrates, its function relates to electrolyte and water balance and maintenance of a stable internal environment (Cengiz, 2006; Yancheva *et al*., 2016). Many studies such as Thophon *et al*. (2003), Florez- Lopes and Thomas (2011) and Thanomsit *et al*.(2016) performed by utilizing the fish's gills as a monitoring tool for studying the toxicity of many pollutants in laboratory tests. The histological changes found in exposed fish had an adverse effect at tissue level. In hybrid catfish exposed to abamectin, the deformation of gill lamellae and necrosis was found, in accordance with the study of El-Said (2007) in gill of *Oreochromis niloticus* observed under the light microscope.

Osman *et al.* (2010) suggested that gills are close in contact to the external environment and also sensitive to the alteration in water quality, that they are a primary target organ of various contaminants. The damages of cell noticed in the gills such as epithelium proliferation and necrosis can disturb gas exchange and ionic regulation. The observed edematous alteration in gill filaments may be caused by an increasing in capillary permeability. The defense mechanisms expression can be observed by various alterations such as a fusion of some secondary lamellae resulting in an increase of the distance between external environment and blood. Thus, they play as a barrier to the entrance of contaminants. These lesions have been recently reported in many researches in some fish species exposing to different pollutants. Moreover, Thanomsit (2016) recommended that histological changes in the gill of Asian sea bass after exposed to abamectin strongly depend on toxicant concentration and exposure time. The alterations in gills were epithelial lifting and partial fusion of lamellae. Besides, Mohamed (2009) found that liver is the target organ because of supplying blood to the whole body, which makes it risk to toxicant exposure. Additionally, the liver is a primary organ which has been studying for toxic effects of different xenobiotics because of its toxicant bioaccumulation. The hepatocytes are found in blood capillaries that they are classified as sinusoids forming a cord-like structure known as hepatic cell cords. The lumen of sinusoids produces and contains erythrocytes. The venous blood passes through the liver from intestine via hepatic portal veins and branches and then into sinusoids. They are contacted to reticuloendothelial cells, being encapsulated by hepatocytes (Yancheva

et al.,2016).This study found vacuolation and necrosis of hepatocytes while there is the change of microvilli. This finding is in agreement with the study of Hasan *et al*. (2015), who studied the alterations in Grass carp (*Ctenopharyngodon idella*) after exposed to endosulfan. Moreover, some alterations such as vacuolation, blood congestion, and enlargement of sinusoid and necrosis of hepatocyte in the liver of the Asian sea bass exposed to abamectin (Thanomsit, 2016). And, increased goblet cells eerw found in the intestine. Generally, goblet cell is indicated as highly polarized secretory cells playing an important role in protection mechanism in intestine. In the stimulated conditions, it produces mucin MUC2-containing granules and releases into the lumen,that hydrate and construct structural basis for the mucus gel layer contacting to the intestinal epithelium. This layer illustrates an important role in physiological process in the gut with lubricating the intestinal surface, limiting the passage of luminal molecules into the mucosa, and being a dynamic defensive barrier to pathogens (Hasan *et al*., 2015). In fish, its kidney receives the largest proportion of post branchial blood, as well as renal lesions can be used as an appropriate indicator for environmental pollution (Yancheva *et al*., 2016). Hinton *et al*. (1992), Oliveira Ribeiro *et al*. (2015) and Thanomsit (2016) showed that the effects of pollutants on fish kidneys can be studied in other species and they found that the damage severity depends on fish species having different sensitivity to substances in the aquatic environment. These can also be found in the gills and liver. Normally, the alterations found in fish's kidney after the fishes expose to the contamination are tubule degeneration: cloudy swelling and hyaline droplets, and alteration in the corpuscle: dilation of capillaries in the glomerulus and reduction of Bowman's space. After they expose to toxic agents such pesticides, their kidney showed histological alterations at the level of tubular epithelium and glomerulus (Thophon *et al.,* 2003; Thanomsit, 2016). In 2007, El-Said (2007) reported that it was found vacuolar degenerated renal tubules in kidney of *O. niloticus* after exposed to abamectin for 14 days that is in agreement with the founding in this study. In this study, deformation of tubular and glomerulus and necrosis were also observed in kidney of exposed hybrid catfish.

Conclusions

In this study, it was found that abamectin can cause the adverse effects on hematological profile and histological alterations in liver, kidney, gill, and intestine of hybrid catfish after exposed at the concentration of 5 μl L^{-1} from 5 to 20 days. The tested fish was chronic exposed to the lower concentration as same as in the natural waters. Thus, the results can be used as fundamental data to assess abamectin exposure of hybrid catfish in aquatic environment.

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