ISSN: 1412-033X
E-ISSN: 2085-4722

BIODIVERSITAS

Journal of Biological Diversity

Volume 21 - Number 6 - June 2020

Front cover: *Rhyothemis phyllis* (Sulzer, 1776)
(PHOTO: WILLIAM CHO)

Published monthly **PRINTED IN INDONESIA**

ISSN: 1412-033X E-ISSN: 2085-4722

BIODIVERSITAS

Journal of Biological Diversity

Volume 21 – Number 6 – June 2020

ISSN/E-ISSN:
1412-033X (printed edition), 2085-4722 (electronic)

PUBLISHER:
The Society for Indonesian Biodiversity

CO-PUBLISHER:
Department of Biology, Faculty of Mathematics and Natural Sciences, Sebelas Maret University, Surakarta

ADDRESS:
Jl. Ir. Sutami 36A Surakarta 57126. Tel. +62-271-7994097, Tel. & Fax.: +62-271-663375, email: editors@smujo.id

ONLINE:
biodiversitas.mipa.uns.ac.id; smujo.id/biodiv

Society for Indonesia Biodiversity

Sebelas Maret University Surakarta

Published by Smujo International for The Society for Indonesian Biodiversity and Sebelas Maret University Surakarta

GUIDANCE FOR AUTHORS

Aims and Scope *Biodiversitas, Journal of Biological Diversity* or abbreviated as *Biodiversitas* encourages submission of manuscripts dealing with all biodiversity aspects of plants, animals and microbes at the level of the gene, species, and ecosystem as well as ethnobiology.

Article types The journal seeks original full-length research papers, reviews, and short communication. Manuscript of original research should be written in no more than 8,000 words (including tables and picture), or proportional with articles in this publication number. Review articles will be accommodated, while, short communication should be written at least 2,000 words, except for pre-study.

Submission The journal only accepts online submission, through open journal system (**https://smujo.id/biodiv/about/submissions**) or email to the editors at **unsjournals@gmail.com**. Submitted manuscripts should be the original works of the author(s). The manuscript must be accompanied by a cover letter containing the article title, the first name and last name of all the authors, a paragraph describing the claimed novelty of the findings versus current knowledge. Submission of a manuscript implies that the submitted work has not been published before (except as part of a thesis or report, or abstract); and is not being considered for publication elsewhere. When a manuscript written by a group, all authors should read and approve the final version of the submitted manuscript and its revision; and agree the submission of manuscripts for this journal. All authors should have made substantial contributions to the concept and design of the research, acquisition of the data and its analysis; drafting of the manuscript and correcting of the revision. All authors must be responsible for the quality, accuracy, and ethics of the work.

Ethics Author(s) must obedient to the law and/or ethics in treating the object of research and pay attention to the legality of material sources and intellectual property rights.

Copyright If and when the manuscript is accepted for publication, the author(s) still hold the copyright and retain publishing rights without restrictions. Authors or others are allowed to multiply article as long as not for commercial purposes. For the new invention, authors are suggested to manage its patent before published.

Open access The journal is committed to free-open access that does not charge readers or their institutions for access. Readers are entitled to read, download, copy, distribute, print, search, or link to the full texts of articles, as long as not for commercial purposes. The license type is CC-BY-NC-SA.

Acceptance The only articles written in English (U.S. English) are accepted for publication. Manuscripts will be reviewed by editors and invited reviewers(double blind review) according to their disciplines. Authors will generally be notified of acceptance, rejection, or need for revision within 1 to 2 months of receipt. The manuscript is rejected if the content does not in line with the journal scope, does not meet the standard quality, inappropriate format, complicated grammar, dishonesty (i.e. plagiarism, duplicate publications, fabrication of data, citations manipulation, etc.), or ignoring correspondence in three months. The primary criteria for publication are scientific quality and biodiversity significance. **Uncorrected proofs** will be sent to the corresponding author by email as *.doc* or *.docx* files for checking and correcting of typographical errors. To avoid delay in publication, corrected proofs should be returned in 7 days. The accepted papers will be published online in a chronological order at any time, but printed in the early of each month (12 times).

A charge Starting on January 1, 2019, publishing costs waiver is granted to authors of graduate students from **Least Developed Countries**, who first publish the manuscript in this journal. However, other authors are charged USD 250 (IDR 3,500,000). Additional charges may be billed for language editing, USD 75-150 (IDR 1,000,000-2,000,000).

Reprints The sample journal reprint is only available by special request. Additional copies may be purchased when ordering by sending back the uncorrected proofs by email.

Manuscript preparation Manuscript is typed on A4 (210x297 mm^2) paper size, **in a single column**, single space, 10-point (10 pt) Times New Roman font. The margin text is 3 cm from the top, 2 cm from the bottom, and 1.8 cm from the left and right. Smaller lettering size can be applied in presenting table and figure (9 pt). Word processing program or additional software can be used, however, it must be PC compatible and Microsoft Word based (*.doc* or *.rtf*; **not *.docx***). **Scientific names** of species (incl. subspecies, variety, etc.) should be written in italic, except for italic sentence. Scientific name (genera, species, author), and cultivar or strain should be mentioned completely for the first time mentioning it in the body text, especially for taxonomic manuscripts. Name of genera can be shortened after first mentioning, except generating confusion. Name of the author can be eliminated after first mentioning. For example, *Rhizopus oryzae* L. UICC 524, hereinafter can be written as *R. oryzae* UICC 524. Using trivial name should be avoided, otherwise generating confusion. **Biochemical and chemical nomenclature** should follow the order of the IUPAC - IUB. For DNA sequence, it is better used Courier New font. Symbols of standard chemical and abbreviation of chemistry name can be applied for common and clear used, for example, completely written butilic hydroxyl toluene (BHT) to be BHT hereinafter. **Metric measurement** use IS denomination, usage other system should follow the value of equivalent with the denomination of IS first mentioning. Abbreviations set of, like g, mg, mL, etc. do not follow by dot. Minus index (m^{-2}, L^{-1}, h^{-1}) suggested to be used, except in things like "per-plant" or "per-plot". **Equation of mathematics** does not always can be written down in one column with text, in that case can be written separately. **Number** one to ten are expressed with words, except if it relates to measurement, while values above them written in number, except in early sentence. The fraction should be expressed in decimal. In the text, it should be used "%" rather than "percent". Avoid expressing ideas with complicated sentence and verbiage, and used efficient and effective sentence.

Title of the article should be written in compact, clear, and informative sentence, preferably not more than 20 words. Name of author(s) should be completely written. **Name and institution** address should also be completely written with street name and number (location), postal code, telephone number, facsimile number, and email address. Manuscript written by a group, author for correspondence along with address is required. First page of the manuscript is used for writing above information.

Abstract should not be more than 200 words. **Keywords** is about five words, covering scientific and local name (if any), research theme, and special methods which used; and sorted from A to Z. All important **abbreviations** must be defined at their first mention. **Running title** is about five words. **Introduction** is about 400-600 words, covering the background and aims of the research. **Materials and Methods** should emphasize on the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences, however, for manuscript with long discussion should be divided into subtitles. Thorough discussion represents the causal effect mainly explains for why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences. **Concluding** sentence should be given at the end of the discussion. **Acknowledgments** are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

Figures and Tables of maximum of three pages should be clearly presented. Title of a picture is written down below the picture, while title of a table is written above the table. Colored figures can only be accepted if the information in the manuscript can lose without those images; chart is preferred to use black and white images. Author could consign any picture or photo for the front cover, although it does not print in the manuscript. All images property of others should be mentioned source. **There is no appendix**, all data or data analysis are incorporated into Results and Discussions. For broad data, it can be displayed on the website as a supplement.

References Author-year citations are required. In the text give the authors name followed by the year of publication and arrange from oldest to newest and from A to Z. In citing an article written by two authors, both of them should be mentioned, however, for three and more authors only the first author is mentioned followed by et al., for example: Saharjo and Nurhayati (2006) or (Boonkerd 2003a, b, c; Sugiyarto 2004; El-Bana and Nijs 2005; Balagadde et al. 2008; Webb et al. 2008). Extent citation as shown with word "*cit*" should be avoided. Reference to unpublished data and personal communication should not appear in the list but should be cited in the text only (e.g., Rifai MA 2007, pers. com. (personal communication); Setyawan AD 2007, unpublished data). In the reference list, the references should be listed in an alphabetical order (better, if only 20 for research papers). Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php). The following examples are for guidance.

Journal:

Saharjo BH, Nurhayati AD. 2006. Domination and composition structure change at hemic peat natural regeneration following burning; a case study in Pelalawan, Riau Province. Biodiversitas 7: 154-158.

Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds) Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta***.** 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.) Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from internet:

Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic *Escherichia coli* predator-prey ecosystem. Mol Syst Biol 4: 187. www.molecularsystemsbiology.com

BIODIVERSITAS
Volume 21, Number 6, June 2020
Pages: 2566-2575

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d210629

Effect of the administration of probiotic *Bacillus* NP5 in the rearing media on water quality, growth, and disease resistance of African catfish (*Clarias gariepinus*)

ACHMAD NOERKHAERIN PUTRA[1,2,♥], MAS BAYU SYAMSUNARNO[1], WIDIA NINGRUM[1], JUMYANAH[1], MUSTAHAL[1]

[1]Department of Fisheries, Faculty of Agriculture, Universitas Sultan Ageng Tirtayasa. Jl. Raya Jakarta Km. 4, Pakupatan, Serang 42121, Banten, Indonesia. Tel.: +62-254-280330, Fax.: +62-254-281254. ♥email: Putra.achmadnp@untirta.ac.id

[2]Indonesia-Center of Excellence for Food Security, Universitas Sultan Ageng Tirtayasa. Jl. Raya Jakarta Km. 4, Pakupatan, Serang 42121, Banten, Indonesia

Manuscript received: 29 February 2020. Revision accepted: 15 May 2020.

Abstract. *Putra AN, Syamsunarno MB, Ningrum W, Jumyanah, Mustahal. 2020. Effect of the administration of probiotic* Bacillus *NP5 in the rearing media on water quality, growth, and disease resistance of African catfish (*Clarias gariepinus*). Biodiversitas 21: 2566-2575.* The purpose of this study was to investigate the effect of administration of the probiotic *Bacillus* NP5 in rearing media on water quality, growth, and disease resistance of African catfish. The study consisted of three different concentrations of probiotic *Bacillus* NP5 - C: control, A: probiotic *Bacillus* NP5 of 1 x 10^9 CFU/mL, and B: probiotic *Bacillus* NP5 of 1 x 10^{10} CFU/mL, on the rearing media of African catfish for 45 days. Based on the results, the lowest significant ammonia ($P < 0.05$) was found in treatment A (1.91 ± 0.17 mg/L), then followed by B (2.12 ± 0.14 mg/L) while the highest was in the control (2.36 ± 0.19 mg/L). Treatment A also had a better immune response compared to other treatments shown with the highest significant number of leukocytes at 6.69 ± 0.17 x 10^4 cells/mm^3 and phagocyte activity at 65.19 ± 0.04%. Furthermore, treatment A significantly resulted in the best specific growth rate and feed conversion ratio (2.02 ± 0.07%.day^{-1}, 1.05 ± 0.07, respectively). The administration of probiotic *Bacillus* NP5 of 1 x 10^9 CFU/mL in rearing media significantly improved the ammonia value, growth, and resistance of African catfish to *Aeromonas hydrophila* infection.

Keywords: *Bacillus* NP5, *Clarias gariepinus*, disease-resistant, probiotic, water quality

INTRODUCTION

Clarias gariepinus, commonly known as African catfish, is a species of fish widely cultivated in Indonesia (Ngaddi et al. 2019; Iswanto et al. 2019; Nasrulloh et al. 2019) with the production of over 19 thousand tons in 2017 (Ministry of Marine Affairs and Fisheries of the Republic of Indonesia 2019). Based on a report released by FAO in 2018, various intensive fish culture systems have been carried out which help in meeting up for the increasing demands for fish. In intensive culture systems, fish are more easily stressed because fish are reared in high density (Cerezuela et al. 2012; Giri et al. 2014) and many accumulations of organic matter originating from leftover feed and feces (Ren et al. 2019). Also, a study conducted by Widanarni et al. (2010) revealed that the accumulation of organic waste generally in this system with high fish density and feed inputs. Similarly, Avnimelech and Ritvo (2003) reported that 75-80% of the feed is excreted into the water in the form of ammonia, considering the fact that fish only assimilate 20-25% in their body. The presence of ammonia in water further increase fish's susceptibility to bacterial infection and could lead to mass death at concentration > 0.2 mg/L (Boyd and Mcnevin 2014). Also, research by Wang et al. (2008), showed that lack of quality water is a major cause of mass death in intensive fish culture. Zhang et al. (2016) and Garcia-Mendoza et al. (2019) also reported that the health status of fish and shrimp depends on water quality. Poor water quality directly influences fish metabolism, such as decreased growth, stress, increasing the general mortality, and also thereby leading to the spread of disease outbreaks (Xiong et al. 2016). In addition, disease control in intensive aquaculture is a current issue that has ultimately affect the economy of the country (Nandi et al. 2017). Hence, creating a friendly environment in terms of providing quality water to prevent disease attacks (Ramadhani et al. 2019; Amin et al. 2019).

According to Gomez-Gil et al. (2000) and Kuebutornye et al. (2019), the probiotic is an environmentally friendly method with improved water quality, thereby increasing fish immunity against pathogenic attacks. In clear terms, probiotic is an additional living microbe which could benefit its host by improving microbial balance in the digestive tract (Makled et al. 2019; Zhao et al. 2019; Darafsh et al. 2019; Arani et al. 2019; Valipour et al. 2019), increasing feed use or nutritional value, as well as the host response to disease through improved water quality (Verschure et al. 2000). Also, Devaraja et al. (2013) reported that the provision of probiotics helped in improving the quality of water in vannamei shrimp ponds through the mechanism of bioremediation. Based on research conducted by Dawood et al. (2018), bioremediation is the process of decomposing harmful

organic wastes in waters using microorganisms. The application of probiotics in various aquaculture systems has been reported to increase water quality through bioremediation of organic waste in water, thereby reducing the growth of pathogenic bacteria (Nimrat et al. 2012; Devaraja et al. 2013; Zorriehzahra et al. 2016; Chumpol et al. 2017; Elsabagh et al. 2018). The methods of providing probiotic in either rearing media (Kewcharoen and Srisapoome 2019; Zhang et al. 2019; Xie et al. 2019) or feed (Jang et al. 2019; Yang et al. 2019; Tachibana et al. 2019; Tsai et al. 2019) have been found to minimize the occurrence of pathogen attacks and water quality degradation.

Similarly, the results of previous studies showed that applying probiotic *Bacillus* NP5 could increase the growth and activity of proteolytic, lipolytic, and amylolytic enzymes of African catfish (Putra and Romdhonah 2019). According to Putra and Widanarni (2015), the probiotic *Bacillus* NP5 is usually isolated from the digestive tract of tilapia which has passed the stages of the probiotic selection process. The research conducted by Tamamdusturi et al. (2016) found that the addition of probiotic *Bacillus* NP5 in the feed could increase the growth and immune response of *Pangasianodon hypophthalmus* catfish against *A. hydrophila* infection. Other positive applications of this bacteria in the diet have been found to improve growth performance in tilapia fish (Utami et al. 2015; Putra et al. 2015; Agung et al. 2015), vannamei shrimp (Widanarni et al. 2014) and improve the immune response of the shrimp against white spot syndrome virus (WSSV) attacks (Febrianti et al. 2016). However, no research has shown the role of probiotic *Bacillus* NP5 in the rearing media of fish culture. Therefore, this study aimed to investigate the effect of the administration of the probiotic *Bacillus* NP5 on water quality, growth, and disease resistance of African catfish in the rearing media.

MATERIALS AND METHODS

Culture of probiotic *Bacillus* NP5

Isolates of the probiotic *Bacillus* NP5 were obtained from the Laboratory of Fish Health, Bogor Agricultural University. A total of 250 mL of TSB (Tryptic soy broth) media was prepared and isolate of *Bacillus* NP5 bacterium was inoculated on it and incubated for 18 hours at 29°C (Putra and Romdhonah 2019). Next, the freshly harvested culture was centrifuged at a speed of 1000 g for 10 minutes. Then probiotics were diluted serially by adding Phosphate Buffered Saline (PBS) based on different treatments (Nurhayati et al. 2015), after which these diluted samples were given to the catfish through the rearing media.

Experimental design

This study was conducted at Wet Laboratory, Department of Fisheries, Faculty of Agriculture, University of Sultan Ageng Tirtayasa. The African catfish used were the seeds from the Baros Fish Seed Center (BBI Baros), Serang Regency, Banten. Each fish with an average weight of 8.06 ± 0.06 g were reared for 45 days using a round tank with a diameter of 71 cm and a height of 53.5 cm involving 20 fish/tank. The fish acclimation was carried out for 5 days before to the rearing process. Experimental fish were fed the commercial feed with a protein content of 30% and fed to fish three times a day (08: 00, 12: 00, 16: 00 Western Indonesia Time) up to satiation. In addition, the water purification and replacement processes were not carried out during rearing. The study design was the completely randomized design consisting of three treatments with different concentrations of the probiotics on the rearing media and three replications, namely:

C: control

A: probiotic *Bacillus* NP5 of 1 x 10^9 CFU/mL

B: probiotic *Bacillus* NP5 of 1 x 10^{10} CFU/mL

The challenge test

The pathogenic bacteria used, *A. hydrophila*, was obtained from the Laboratory of Fish Health, IPB University. Then, Koch's postulate was carried out to increase its virulence. Furthermore, *A. hydrophila* was inoculated in 50 mL TSB media and then incubated at 20 °C for 24 hours. The bacterial culture was subsequently centrifuged at 1000 g for 10 minutes and then diluted to a density of 10^7 CFU/mL through the addition of PBS. The pathogenic bacterium was then injected into catfish intramuscularly (Putra and Widanarni 2015) at a dose of 10^7 CFU/mL. The wound formed due to this was scratched on the TSA media using the quadrant scratch method.

Subsequently, Lethal Doses 50% (LD_{50}) was performed to obtain the amount of the bacteria used in the challenge test. LD_{50} is the pathogen needed to kill 50% of the total catfish population. In addition, the pathogenic bacterium was inoculated on 100 mL TSB media, then incubated at 20 °C for 24 hours. Further, the bacterial culture was centrifuged at 1000 g for 10 minutes to obtain fresh samples and then given the catfish rearing media with 3 different doses - 10^5 CFU/mL, 10^6 CFU/mL, and 10^7 CFU/mL. After 10 days of observation, the test results showed that the treatment with a dose of 10^6 CFU/mL had a survival rate of 55%. Hence, the sample with a dose of 10^6 CFU/mL was used in the challenge test.

The challenge test was carried out after 30 days of rearing period with the addition of probiotic *Bacillus* NP5 in the rearing media. The *A. hydrophila* isolate was inoculated on 200 mL TSB media and then cultured on a water bath shaker at 29°C for 24 hours. Furthermore, the bacterial culture was centrifuged at a speed of 1000 g for 10 minutes after which the fresh culture was further diluted using PBS to a density of 10^6 CFU/mL and given to catfish rearing media.

Water quality parameters

The water quality sampling was carried out on days 0, 10, 20, 30, 34, 38 and 45 which involved the measurements of temperature and Dissolved Oxygen (DO) with the use of a DO meter with a brand of Luxtron DO550, and pH using a pH meter with a type of luxtron 208, in-situ manner. The ammonia measurements were carried out at the Laboratory

of Aquaculture, Department of Fisheries, Faculty of Agriculture, University of Sultan Ageng Tirtayasa. A sample of 100 mL of water was taken from each container and measured using a spectrophotometer AMV01 through the Phenate standard method following with APHA (1988).

Growth parameters

The growth sampling was carried out on Day 30 before the challenge test and at the end of the culture or after the challenge test (Day 45). The fish were weighed and counted at the beginning and end of the rearing process to calculate the value of the Specific Growth Rate (SGR) and Survival Rate (SR). The amount of both the initial and final feeds were weighed to obtain the value of total feed consumption (FI) and Feed Conversion Ratio (FCR). Calculations of SGR, SR, FI, and FCR were in accordance with Huisman (1987) as follows:

SGR (% day^{-1}) = ((Ln Bt - Ln Bo)/P) x 100

SR (%) = (Et/Eo) x 100

FI (g) = Ft-Fo

FCR = FI/(Bt + Bd-Bo)

Note: Bt: t-th biomass of fish, Bo: initial biomass of fish, Et: t-th number of fish, P: time (days), Eo: initial number of fish, Ft: t-th amount of feed, Fo: the initial amount of feed, Bd: biomass of dead fish.

Hematological parameters

A total of 3 fish from each treatment was selected and blood samples were taken on days 0, 30 (before the challenge test) and 45 (after the challenge test), with a syringe already containing anti-coagulant, 0.1 mL of 3.8% Na citrate. Furthermore, blood profile consisting of hematocrit and hemoglobin levels, total erythrocytes and leukocytes, and phagocytic activity were calculated with the aid of a microscope. Determination of hematocrit levels and phagocytic activity were in accordance with Anderson and Siwicki (1995) method, hemoglobin levels were measured through the Sahli method in Wedemeyer and Yasutake (1977), and the total erythrocytes and leukocytes were following Blaxhall and Daisley (1973) method.

Histopathology

Histology was carried out to evaluate the level of organ damage due to pathogen attacks based on the method described by Wada et al. (2011). Its preparation was made at the Histopathology Laboratory, Fish and Environmental Disease Examination Station (LP2IL), Serang, Banten Province. At the end of the culturing period, 3 catfish were taken from each treatment for histological observation. This was carried out on the gills, kidneys, and liver, then fixed using a 10% phosphate-buffered formalin solution and 5% ethylenediaminetetraacetic acid (EDTA). The histology preparation was then stained with hematoxylin and eosin (H&E) and Gram stains.

Data analysis

The growth data and hematological parameters obtained at the end of rearing were analyzed using Analysis of Variance (ANOVA) and for those with differences were subjected to Duncan multiple range tests with a 95% confidence interval (Duncan 1995). In addition, the results of histological observations were analyzed descriptively.

RESULTS AND DISCUSSION

Water quality

The value of water quality in African catfish rearing is shown in Table 1. It shows that there was no significant difference (P> 0.05) of ammonia value in catfish rearing media before (H0, H10, H20, and H30) and after challenge tests (H34, H38). The difference in ammonic value occurred on day 45, and the lowest significant ammonia value (P <0.05) was in treatment A, which was 1.91 ± 0.17 mg/L, then treatment B was 2.12 ± 0.14 mg/L and the highest ammonia value was found in the control treatment, which was at 2.36 ± 0.19 M. Furthermore, the addition of probiotics in African catfish rearing had no effect (P <0.05) on the parameters of temperature, DO and pH. The values of the temperature range in the catfish rearing from day 0 to 45 ranged between 28.0 and 29.0 ^{o}C and the DO ranged between 5.1 and 6.9 mg/L, while the range of the pH was 6.7-7.0.

Growth

The effect of the addition of the three different dosages of the probiotic *Bacillus* NP5 on the growth performance of African catfish is presented in Table 2. The results showed that the highest significant African catfish biomass on the 30th day (P <0.05) was found in treatments A and B (346.00 ± 7.30 g, and 334.17 ± 12.28 g, respectively), while the lowest biomass was in the control treatment at 251.43 ± 10.73 g. The amount of feed consumption and survival rate of African catfish on the 30th day also did not differ (P> 0.05) among the treatments. The highest significant SGR and FCR values on the 30th day (P <0.05) were found in the treatments with the addition of probiotics compared with the control. The highest significant FCR value (P <0.05) on the 30th day was also found in the probiotic treatments compared with the control. In a period of 30-45 days or after the challenge test, the highest final significant biomass value of catfish (P <0.05) was found in treatment A (398.97 ± 12.12 g), then followed by B (369.57 ± 11.23 g) while the lowest was found in the control treatment (270.37 ± 5.90 g). The highest significant FCR value (P <0.05) was found in the control treatment compared with those with probiotic. The results of the survival rates were found, where the highest was found in the treatments with probiotics (A = 89.82 ± 0.30% and B = 83.07 ± 7.56%) compared with the SR from the control, which was 50.96 ± 6.50%. In the overall time period, day 0 to 45, the highest significant biomass and SGR value (P <0.05) was found in treatment A, then followed by B before the control. The SGR value obtained for treatment A was 2.02 ± 0.07% day^{-1}, while the values for control and treatment B were 1.15 ± 0.05% day^{-1} and 1.85 ± 0.07% day^{-1}, respectively. However, the highest significant FCR value (P <0.05) was found in the control treatment, while the lowest found in treatment A. Furthermore, the addition of probiotics in the rearing media had a significant effect (P

<0.05) on the survival rate of African catfish. Based on the results, the highest SR value was obtained in the treatments with probiotics supplementation.

Hematological parameters

The results showing the hematological parameters such as the values of erythrocytes, leukocytes, hemoglobin, hematocrit, and phagocyte activity, are shown in Table 3. Based on Table 3, the values did not differ among the treatments on day 0. However, there were highest significant values (P <0.05) of erythrocytes, hematocrit and phagocyte activity on day 30 found in the treatment with the probiotic supplementation, and it was more in A compared with B. Then on day 45, after the challenge test, the highest significant values of erythrocytes, leukocytes and phagocyte activity (P <0.05) were found in treatments A and B. However, the highest significant value (P <0.05) of the leukocyte was found in treatment A at 6.69 ± 0.17 x 10^4 cells/mm^3 compared with B at 6.46 ± 0.06 x 10^4 cells/mm^3 and control at 5.08 ± 0.07 x 10^4 cells/mm^3. The same trend occurred for phagocyte activity where the highest significant value (P <0.05) was found in treatment A at 65.19 ± 0.04% compared with the control and treatment B at 32.21 ± 0.18% and 44.20 ± 0.17%, respectively.

Histopathology

Histopathology is a microscopic search of disease in an organism, however, a histopathological observation involves obtaining information in the form of an organ/tissue change pictures. The histopathology results after the challenge test on the gills, liver, and kidneys of catfish are presented in Figures 1, 2, and 3.

Table 1. Water quality values of African catfish (*C. gariepinus*) cultured with the administration of different probiotics in the rearing media

Parameter	Treatment*			Range	Quality standards
	Control	A	B		
Ammonia (mg/L)					
H0	0.01±0.01	0.01±0.02	0.01±0.01	0.01-0.02	
H10	0.29±0.44	0.04±0.04	0.05±0.08	0.01-0.79	
H20	0.68±0.09	0.65±0.12	0.66±0.11	0.24-0.75	
H30	1.65±0.23	1.34±0.28	1.30±0.21	1.20-1.91	<2.5 mg/L**
H34	1.85±0.09	1.52±0.19	1.60±0.23	1.35-1.95	
H38	2.05±0.17	1.75±0.32	1.92±0.10	1.41-2.17	
H45	2.36±0.19[b]	1.91±0.17[a]	2.12±0.14[ab]	1.75-2.44	
Temperature (°C)					
H0	28.00±0.00	28.00±0.00	28.00±0.00	28.0-28.0	
H10	28.77±0.29	28.77±0.12	28.80±0.10	28.0-28.9	
H20	28.43±0.21	28.83±0.06	28.87±0.06	28.2-28.9	
H30	28.53±0.35	28.93±0.06	28.87±0.06	28.2-29.0	26-32 °C**
H34	28.80±0.10	28.77±0.21	28.83±0.21	28.6-29.0	
H38	28.93±0.06	28.93±0.06	29.00±0.00	28.9-29.0	
H45	29.00±0.00	28.70±0.26	28.87±0.15	28.5-29.0	
DO (mg/L)					
H0	6.40±0.01	6.41±0.01	6.40±0.01	6.40-6.41	
H10	6.43±0.38	6.57±0.49	6.83±0.21	6.00-6.90	
H20	6.20±0.26	6.03±0.06	6.07±0.06	6.00-6.50	> 3 mg/L**
H30	6.03±0.06	6.17±0.16	6.00±0.00	6.00-6.50	
H34	6.20±0.17	6.13±0.21	6.05±0.35	6.10-6.50	
H38	6.17±0.25	6.23±0.29	6.27±0.32	6.00-6.60	
H45	5.23±0.35	5.27±0.36	5.26±0.12	5.10-6.10	
pH					
H0	7.00±0.00	7.00±0.00	7.00±0.00	7.00-7.00	
H10	7.00±0.00	7.00±0.00	7.00±0.00	7.00-7.00	
H20	6.90±0.00	6.90±0.00	6.90±0.00	6.90-6.90	6-9**
H30	6.90±0.00	6.80±0.00	6.90±0.00	6.80-6.90	
H34	6.90±0.00	6.90±0.00	6.90±0.00	6.90-6.90	
H38	6.74±0.00	6.73±0.06	6.70±0.00	6.70-6.80	
H45	6.80±0.00	6.80±0.00	6.70±0.00	6.70-6.80	

Note: * The same superscript letter in the same row shows the effect of probiotic *Bacillus* NP5 that are not different (P>0.05) on the water quality values of catfish rearing. ** Bhatnagar A & Devi P. 2013

Table 2. Growth performance values of African catfish (*C. gariepinus*) cultured with the administration of different probiotics in the rearing media

Day/parameter**	Treatment*		
	Control	A	B
0-30 days (before the challenge test)			
Initial biomass (g)	160.80±0.40	160.53±0.23	160.73±0.31
Final biomass (g)	251.43±10.73^{a}	346.00±7.30^{b}	334.17±12.28^{b}
Feed intake (g)	193.30±14.39	185.87±5.13	188.03±6.93
SGR (%.day^{-1})	1.49±0.14^{a}	2.56±0.08^{b}	2.44±0.13^{b}
FCR	2.14±0.13^{b}	1.00±0.14^{a}	1.09±0.07^{a}
SR (%)	98.33±2.89	98.33±2.89	98.33±2.89
30-45 days (after the challenge test)			
Initial biomass (g)	251.43±10.73^{a}	346.00±7.30^{b}	334.17±12.28^{b}
Final biomass (g)	270.37±5.90^{a}	398.97±12.12^{c}	369.57±11.23^{b}
Feed intake (g)	65.57±2.29	63.07±2.36	62.47±2.67
SGR (%.day^{-1})	0.49±0.14^{a}	0.95±0.15^{ab}	0.67±0.16^{ab}
FCR	3.61±0.84^{b}	1.22±0.23^{a}	1.84±0.53^{a}
SR (%)	50.96±6.50^{a}	89.82±0.30^{b}	83.07±7.56^{b}
0-45 days			
Initial biomass (g)	160.80±0.40	160.53±0.23	160.73±0.31
Final biomass (g)	270.37±5.90^{a}	398.97±12.12^{c}	369.57±11.23^{b}
Feed intake (g)	258.87±16.11	248.93±6.90	250.50±6.25
SGR (%.day^{-1})	1.15±0.05^{a}	2.02±0.07^{c}	1.85±0.07^{b}
FCR	2.36±0.07^{c}	1.05±0.07^{a}	1.20±0.04^{b}
SR (%)	50.00±5.00^{a}	88.33±2.89^{b}	81.67±7.64^{b}

Note: *The same superscript letter in the same row shows the effect of probiotic *Bacillus* NP5 that are not different (P> 0.05) on the growth of catfish. ** SGR (Specific Growth Rate), FCR (Feed Conversion Ratio), SR (Survival Rate)

Table 3. The value of blood profiles in of African catfish (*C. gariepinus*) cultured with the administration of different probiotics in the rearing media

Day/parameter	Treatment*		
	Control	A	B
0 day			
Erythrocytes (x 10^{6} cell/mm^{3})	2.81±0.05	2.72±0.14	2.81±0.02
Leukocytes (x 10^{4} cell/mm^{3})	1.28±0.08	1.42±0.04	1.26±0.14
Hemoglobin (g%)	5.79±0.28	6.09±0.51	5.87±0.53
Hematocrit (%)	16.19±0.03	15.79±0.74	16.10±0.15
Phagocyte activity (%)	28.31±0.06	28.44±0.05	28.30±0.07
30 days (before the challenge test)			
Erythrocytes (x 10^{6} cell/mm^{3})	1.31±0.03^{a}	3.62±0.08^{c}	1.57±0.04^{b}
Leukocytes (x 10^{4} cell/mm^{3})	5.05±0.04^{b}	7.14±0.10^{c}	4.44±0.29^{a}
Hemoglobin (g%)	5.86±0.31^{a}	7.03±0.66^{b}	5.57±0.16^{a}
Hematocrit (%)	14.77±0.21^{b}	15.93±0.36^{c}	11.82±0.21^{b}
Phagocyte activity (%)	35.42±0.03^{a}	93.19±0.06^{c}	55.28±0.08^{b}
45 days (after the challenge test)			
Erythrocytes (x 10^{6} cell/mm^{3})	1.42±0.04^{a}	2.67±0.10^{c}	2.48±0.08^{b}
Leukocytes (x 10^{4} cell/mm^{3})	5.08±0.07^{a}	6.69±0.17^{c}	6.46±0.06^{b}
Hemoglobin (g%)	5.58±0.39^{a}	7.26±0.99^{ab}	6.03±0.49^{b}
Hematocrit (%)	8.48±0.33	8.20±0.23	8.14±0.13
Phagocyte activity (%)	32.21±0.18^{a}	65.19±0.04^{c}	44.20±0.17^{b}

Note: *The same superscript letter in the same row shows the effect of the probiotic *Bacillus* NP5 that are not different (P> 0.05) on the blood profiles of catfish.

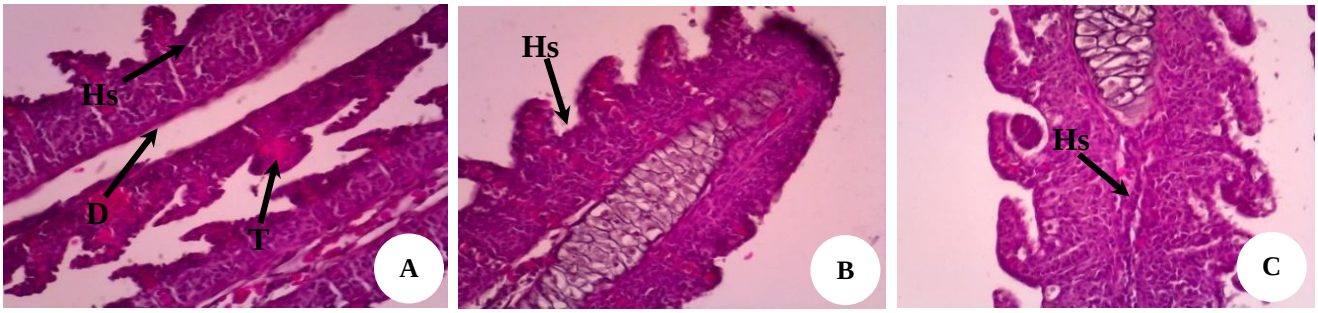

Figure 1. Histopathology of the gill of African catfish (*C. gariepinus*). (Magnification of 400x). The control (C) treatment shows the condition of histological changes in the form of hyperplasia (Hs), desquamation (D), and telangiectasia (T). Treatment A and B show the condition of histological changes in the form of hyperplasia (Hs)

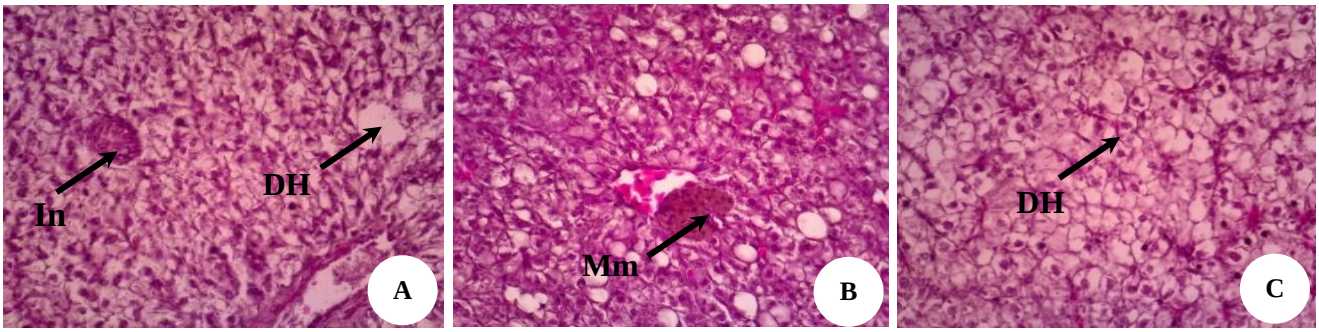

Figure 2. Histopathology of the liver of African catfish (*C. gariepinus*) (400x magnification). The control (C) treatment shows the condition of histological changes in the form of hydropic degeneration (DH) and inflammation infiltration (In). Treatment A shows the condition of histological changes in the form of melanomacrophage (Mm) and treatment B shows the conditions of histological changes in the form of hydropic degeneration (DH).

Discussion

Ammonia is derived from leftover feed and feces of fish (Randall and Tsui 2002) or the decomposition of organic matter by microorganisms (Kir et al. 2016). The effect of *Bacillus* NP5 as a probiotic on African catfish rearing media is presented in Table 1. The results showed that the ammonia value increased as the day progresses and the ammonia value in probiotic treatment was better than the control. This result might be related to the role of probiotic in nitrification and denitrification process in the fish water culture. Boyd and Gross (1998) reported that probiotic application increased nitrification and denitrification of organic matter in the water. The addition of *Bacillus* probiotic was reported to decrease the value of ammonia and nitrite in white shrimp rearing (Nimrat et al. 2012). Zokaeifar et al. (2014) noted that the administration of *B. subtilis* of 10^8 CFU/mL in the water could reduce concentration of ammonia, nitrite, and nitrate of shrimp culture. The best ammonia value on the 45th day was found in treatment A. Based on these results, the treatment of the rearing media with *Bacillus* NP5 of 1 x 10^9 CFU/mL, could reduce the amount of ammonia dissolved in it. Similarly, Banerjee and Ray (2017) stated that the application of probiotics could eliminate ammonia and nitrite through nitrification in the fish environment. This is in line with the research conducted by Yang et al. (2011), which stated that the *Bacillus* sp. could convert ammonia to nitrogen under aerobic conditions. A similar result was reported in the previous study that the total ammonia in the rearing media of fish or shrimp, was lower in the one treated with probiotic compared with the control (Banerjee et al. 2010; Nimrat et al. 2011; Devaraja et al. 2013; Mahmud et al. 2016). In addition, the low ammonia in treatment A was believed to be related to the FCR value in this treatment. The results showed that the lowest significant FCR value was found in this treatment. This might be due to good water quality in this treatment so that the value of FCR increases. According to Kir et al. (2019), good water quality is an important factor for fish growth in any aquaculture system, and ammonia is one of the toxic compounds which decreases the quality of water used in fish rearing. This supports the statement of NRC (2011) that low feed conversion values are indications that the feeds were used optimally.

Temperature and pH are factors that affect the activity of bacteria to oxidase ammonium in the water (Esoy et al. 1998; Hastuti 2011). The results also showed that there were no significant differences in temperature and pH among the treatments. This indicates that the ammonia value obtained in this study not related to temperature and pH. Based on the research conducted by Bhatnagar and Devi (2013), the temperature and pH obtained in this research are still within the range needed in catfish rearing. Similar results were also reported by Abdul-El-Atta et al.

(2019) that the addition of *Lactobacillus plantarum* has no effect on temperature, dissolved oxygen, and pH of tilapia rearing media. Gupta et al. (2016) also stated that the application of *B. coagulans* had no effect on the temperature, pH, and DO values of freshwater prawn rearing media. The similar result was observed in the research conducted by Nimrat et al. (2012) on white shrimp (*Litopenaeus vannamei*), Madani et al. (2018) on white shrimp and Elsabagh (2018) on tilapia, that the provision of probiotics did not affect on the temperature of the fish rearing media. Zhou et al. (2009) also reported that the addition of probiotic *B. coagulans* SC8168 had no effect on the pH of larvae shrimp (*Penaeus vannamei*) rearing media.

The results on growth performance and feed conversion showed a significant (P <0.05) increase with the addition of *Bacillus* NP5 in African catfish rearing media for all periods. This is believed to be due to the role of probiotics in converting ammonia in African catfish rearing media, leading to optimal growth. The better growth performance in the treatments with probiotics is believed to be related not only to the environmental conditions but also to the health status (Xiong et al. 2016; Chumpol et al. 2017). Furthermore, the results of this research showed that the amount of feed consumption was not significant (P> 0.05) among the treatments for the entire period. These corroborate the results of previous research which stated that the addition of probiotics to rearing media and feed did not affect fish appetite or feed palatability (Nargesi et al. 2019). There was no significant difference (P> 0.05) in the survival rate at the initial period (0-30 days). However, the survival rate in the treatment with probiotic was higher compared with the control after the challenge test period with *A. hydrophila* (30-45 days). This is an indication that probiotic *Bacillus* NP5 could improve the immune system of African catfish thereby making it more resistant to bacterial attacks. According to Dawood et al. (2018) and Zorriehzahra et al. (2016), the mechanism of action of probiotics in converting suppressing the growth of pathogenic bacteria is due to its ability to inhibit the colonization of these bacteria by producing bacteriostatic compounds such as bacteriocins, hydrogen peroxide, proteases, and lysozyme. Probiotics increase the immune response through physiological modulation (Adel et al. 2017). Al-Hisnawati et al. (2019) also reported that the administration of *Pediococcus acidilactici* MA18/5M as probiotic can modulate the microbiota and increase the innate immune response of rainbow trout. Similar results were reported in several studies that the addition of probiotics increased the survival rate and immune response of fish after challenge test, such as in juvenile white shrimp, *L. vannamei* against *Vibrio harveyi* infection (Zokaeifar et al. 2014), freshwater prawn infected with *Vibrio harveyi* (Gupta et al. 2016), Pacific white shrimp against *V. harveyi* (Hamsah et al. 2019) and *V. parahaemolyticus* (Kewcharoen and Srisapoome 2019), hybrid grouper infected by *V. harveyi* (Li et al. 2019), tilapia infected by *Streptococcus agalactiae* (Zhu et al. 2019), Japanese eel against *A. hydrophila* (Park et al. 2019).

The hematological parameters are used to detect physiological changes in fish bodies due to pathogen attack (Al-dohail et al. 2009). In this research, the value of erythrocytes, leukocytes, and phagocyte activity significantly (P <0.05) increased in the treatments with probiotics after *A. hydrophila* infection (45 days). This indicates that catfish in rearing media with probiotics have a better immune response. This result is thought to be related to the role of probiotics in the modulation of innate immune responses. Probiotic can increase innate immune systems such as neutrophils (Hoseinifar et al. 2018), monocytes (Aly et al. 2008), macrophage (Kumar et al. 2008), and leucocytes (Korkea-aho et al. 2012). It corroborates the results of previous research that the addition of probiotic *Bacillus* NP5 could increase the value of erythrocytes, leukocytes, and phagocytic activity in tilapia infected with *Streptococcus algalactiae* (Agung et al. 2015) and *P. hypopthalmus* infected with *A. hydrophila* (Tamamdusturi et al. 2016). The results showed that the value of erythrocytes after the challenge test decreased for all treatments. This is due to *A. hydrophila* infection which produced both exotoxin and endotoxin enzymes leading to the lysis of red blood cells (Zhang et al. 2014). These results are consistent with Agung et al. (2015) who reported that pathogen infection caused a decrease in erythrocyte values in tilapia.

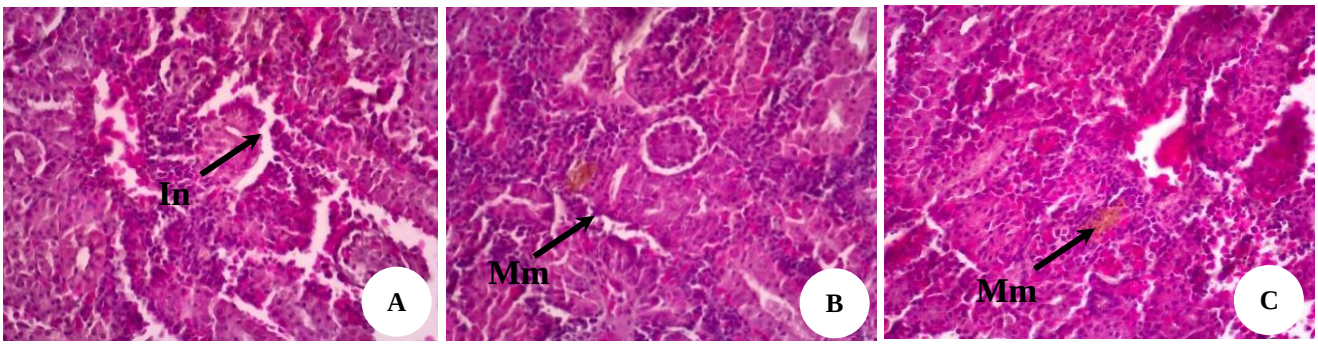

Figure 3. Histopathology of the kidney of African catfish (*C. gariepinus*) (400x magnification). The control (C) treatment shows the condition of histological changes in the form of inflammatory cell infiltration (In). Treatment A and treatment B show the condition of histological changes in the form of melanomacrophage (Mm)

According to Uribe et al. (2011), leukocytes are part of the body defense system which is nonspecific. The results showed that at the end of the rearing period, treatment A had the highest significant ($P < 0.05$) leukocytes among the treatments. These indicate that African catfish with probiotic *Bacillus* NP5 of 1 x 10^9 CFU/mL have a better body defense mechanism against pathogen attacks. Similar results were obtained by da Paixão et al. (2017) who reported that the addition of commercial probiotics *B. subtilis* and *Saccharomyces cerevisiae* increased leukocyte values after infection with *Streptococcus agalactiae*. Furthermore, the value of phagocytic activity was higher in the treatments with probiotics. According to Balcazar et al. (2006), phagocytic activity is an inflammatory response which serves as initial resistance before the production of antibody.

Furthermore, the results showed there was damage to the African catfish gill tissue after infection with *A. hydrophila*. This is shown by the tissue changes in the form of hyperplasia in all gills of African catfish in the treatments. Laith and Najiah (2013) stated that the symptoms of *A. hydrophila* attacks are limp fish, decreased appetite, necrosis, and hypertrophy of the skin, hyperplasia and infiltration of leukocytes in the gills, inflammation in the kidneys, liver, and spleen. In addition to hyperplasia, desquamation and telangiectation occur in the gills of African catfish in the control. This telangeactasis occurs in the gills of fish in poor water quality, attacked by pathogens, as well as with accumulation of metabolic and chemical pollutants (Robert 2001). The histology results of the liver showed more histological changes in the control. These changes include hydropic degeneration and inflammation infiltration. However, there was melanomacrophage in treatment A while B had hydropic degeneration. Inflammatory cell infiltration and melanomacrophage occur in the kidneys of African catfish infected with *A. hydrophila*. According to Mokhtar (2017), hydropic degeneration, melanomacrophages, and inflammatory infiltration are all indications of tissue damage due to pathogen infection. The degree of damage to all probiotic treatments only occurs focally. This is believed to be due to the effect of the probiotics in rearing media which only reduces the number of *A. hydrophila* without causing severe organ damage.

Based on the results, it could be concluded that the addition of probiotic *Bacillus* NP5 on rearing media significantly improved the growth performance, survival rates, and resistance of African catfish to *A. hydrophila* infection. The degree of tissue damage due to *A. hydrophila* infection in the treatments with probiotics supplementation was smaller compared with that of the control. Also, the probiotic of 1 x 10^9 CFU/mL (A) significantly resulted in the best SGR and FCR at 2.02 ± 0.07% day^{-1} and 1.05 ± 0.07 respectively. Similarly, the highest number of leukocytes at 6.69 ± 0.17 x 10^4 cells/mm^3 and phagocyte activity at 65.19 ± 0.04% were found in treatment A. Furthermore, the addition of probiotics of 1 x 10^9 CFU/mL resulted in the lowest ammonia value at 1.91 ± 0.17 mg/L. However, the administration of probiotics did not affect the temperature, DO and pH values of the African catfish rearing media.

ACKNOWLEDGEMENTS

We would like to thank Histopathology Laboratory of LP2IL, Serang-Indonesia for the guidance in histology preparation. We also thank Baros Fish Seed Center (BBI Baros), Serang Regency, Banten for providing African catfish in the present study.

REFERENCES

Abdul-El-Atta ME, Abdel-Tawwab M, Abdel-Rezek N, Abdelhakim TMN. 2019. Effects of dietary probiotic *Lactobacillus plantarum* and whey protein concentrate on the productive parameters, immunity response, and susceptibility of Nile tilapia, *Oreochromis niloticus* (L), to *Aeromonas sobria* infection. Aquac Nutr 25: 1367-1377.

Adel M, Yeganeh S, Dawood MAO, Safari R, Radhakrishnan S. 2017. Effect of *Pediococcus pentosaceus* supplementation on growth performance, intestinal microflora and disease resistance of white shrimp, *Litopenaeus vannamei*. Aquac Nutr 23: 1401-1409.

Al-Dohail MA, Hashim R, Aliyu-Paiko M. 2009. Effects of the probiotic, *Lactobacillus acidophilus*, on the growth performance, haematology parameters and immunoglobulin concentration in African Catfish (*Clarias gariepinus*, Burchell 1822) fingerling. Aquac Res 40: 1642–1652.

Al-Hisnawati A, Rodiles A, Rawling MD, Catex M, Waines P, Gioacchini G, Carnevalli O, Merrifiled DL. 2019. Dietary probiotic *Pediococcus acidilactici* MA18/5M modulates the intestinal microbiota and stimulates intestinal immunity in rainbow trout (*Oncorhynchus mykiss*). J World Aquac Soc 50: 1133-1151.

Aly SM, Ahmed YA-G, Ghareeb AA-A, Mohamed MF. 2008. Studies on *Bacillus subtilis* and *Lactobacillus acidophilus*, as potential probiotics, on the immune response and resistance of Tilapia nilotica (*Oreochromis niloticus*) to challenge infections. Fish Shellfish Immunol 25: 128-136.

Agung AL, Widananrni, Yuhana M. 2015. Application of microencapsulated probiotic *Bacillus* NP5 and prebiotic mannan oligosaccharide (MOS) to prevent Streptococcosis on tilapia *Oreochromis niloticus*. Res J Microbiol 10: 571–581.

Amin M, Bolch CJS, Adams MB, Burke CM. 2019. Growth enhancement of tropical abalone, *Haliotis asinina* L, through probiotic supplementation. Aquac Int 28: 463-475.

Anderson DP, Siwicki AK. 1995. Basic hematology and serology for fish health program. Proceeding of the second symposium on disease in Asian aquaculture, October 25-29, 1995.

Arani MM, Salati AP, Safari O, Keynanshokooh. 2019. Dietary supplementation effects of *Pediococcus acidilactici* as probiotics on growth performance, digestive enzyme activities and immunity response in zebrafish (*Danio rerio*). Aquac Nutr 25: 854-861.

APHA. 1998. Standard methods for the examination of the water and wastewater (22nd ed.). American public health association. Washington DC., USA.

Avnimelech Y, Ritvo G. 2003.Shrimp and fish pond soils: processes and management. Aquaculture 220: 549-567.

Balcazar JL, Blas ID, Ruiz-Zarzuela I, Cunningham D, Vendrell D, Múzquiz JL. 2006. The role of probiotics in aquaculture. Vet Microbiol 114: 173–186.

Banerjee S, Khatoon H, Shariff M, Yusoff F Md. 2010. Enhancement of *Penaeus monodon* shrimp postlarvae growth and survival without water exchange using marine *Bacillus pumilus* and periphytic microorganism. Fish Sci 76: 481-487.

Banerjee G, Ray AK. 2017. The advancement of probiotics research and its application in fish farming industries. Res Vet Sci 115: 66-77.

Bhatnagar A, Devi P. 2013. Water quality guidelines for the management of pond fish culture. Int J Environ Sci 3: 1980-2009.

Blaxhall PC, Daisley KW. 1973. Routine hematological methods for use with fish blood. J Fish Biol 5: 771-781.

Boyd CE, Gross A. 1998. Use of probiotic for improving soil and water quality in aquaculture ponds. In: Flegel TW (eds) Advances in shrimp biotechnology. National center for genetic engineering and biotechnology, Bangkok 101-105.

Boyd CE, Mcnevin AA. 2014. Aquaculture resource Use, and the environment. Wiley Blackwell, Canada. 377 pp.

Cerezuela R, Guardiola FA, Gonzales P, Meseguer J, Esteban MA. 2012. Effects of dietary *Bacillus subtilis*, *Tetraselmis chuii*, and *Phaeodactylum tricornutum*, singularly or in combination, on the immune response and disease resistance of sea bream (*Sparus aurata* L.) Fish Shellfish Immunol 33: 342-349.

Chumpol S, Kantachote D, Nitoda T, Kanzaki H. 2017. The roles of probiotic purple nonsulfur bacteria to control water quality and prevent acute hepatopancreatic necrosis disease (AHPND) for enhancement growth with higher survival in white shrimp (*Litopenaeus vannamei*) during cultivation. Aquaculture 473: 327-336.

Dawood MAO, Koshio S, Abdel-Daim MM, Doan HV. 2018. Probiotic application for sustainable aquaculture. Rev Aquac 11: 1-8.

Darafsh F, Soltani M, Abdolhay HA, Mehrejan MS. 2019. Improvement of growth performance, digestive enzymes and body composition of Persian sturgeon (*Acipenser persicus*) following feeding on probiotics: *Bacillus licheniformis*, *Bacillus subtilis* and *Saccharomyces cerevisiae*. Aquac Res 51: 957-964.

da Paixão AEM, dos Santos JC, Pinto MS, Pereira DSP, de Oliveira Ramos CEC, Cerqueira RB, da Silva RF. 2017. Effect of commercial probiotics (*Bacillus subtilis* and *Saccharomyces cerevisiae*) on growth performance, body composition, hematology parameters, and disease resistance against *Streptococcus agalactiae* in tambaqui (*Colossoma macropomum*). Aquac Int 25(6): 2035-2045.

Devaraja T, Banerjee S, Yusoff F, Shariff M, Khatoon H. 2013. A holistic approach for selection of *Bacillus* spp. as a bioremediator for shrimp postlarvae culture. Turk J Biol 37: 92-100.

Duncan DB. 1955. Multiple range and multiple 'F' tests. Biometrics 11: 1-42.

Elsabagh M, Mohamed R, Moustafa EM, Hamza A, Farrag F, Decamp O, Dawood MAO, Eltholth M. 2018. Assessing the impact *Bacillus* strains mixture probiotic on water quality, growth performance, blood profile and intestinal morphology of Nile-Tilapia, *Oreochromis niloticus*. Aquac Nutr 24: 1613-1622.

Esoy A, Odegaard H, Bentzen G. 1998. The effect of sulphide and organic matter on the nitrification activity in biofilm process. Water Sci Technol 37: 115-122.

Febrianti D, Yuhana M, Widanarni. 2016. Dietary symbiotic microcapsule influence the immune responses, growth performance and microbial population to white spot syndrome virus in pacific white shrimp (*Litopenaeus vannamei*). J Fish Aquat Sci 11 : 28-42.

Food and Agriculture Organization of the United Nations (FAO). 2018. The state of world fisheries and aquaculture: opportunities and challenges. Roma: FAO. 223 pp.

Garcia-mendoza, Caceres-Martinez, Vaquez-Yeomans, Cruz-Flores. 2019. Bacteriological water quality of recirculating aquatic system for maintenance of yellowtail amberjack *Seriola lalandi*. J World Aquac Soc 50: 934-953.

Giri SS, Sen SS, Sukumaran V. 2012. Effect of dietary supplementation of potential probiotic *Pseudomonas aeruginosa* VSG-2 on the innate immunity and disease resistance of tropical freshwater fish, *Labeo rohita*. Fish Shellfish Immunol 32: 1135-1140.

Gomez-Gil B, Roque A, Turnbull JF. 2000. The use and selection of probiotic bacteria for use in the culture of larval aquatic organisms. Aquaculture 191: 259-270.

Gupta A, Verma G, Gupta P. 2016. Growth performance, feed utilization, digestive enzyme activity, innate immunity and protection against *Vibrio harveyi* of freshwater prawn, *Macrobrachium rosenbergii* fed diets supplemented with *Bacillus coagulans*. Aquac Int 24: 1379-1392.

Hamsah H, Widanarni, Alimuddin, YUhana M, Junior MZ, Hidayatulloh D. 2019. Immune response and resistance of Pacific white shrimp larvae administered probiotic, prebiotic, and symbiotic larvae trough thebio-encapsulation of *Artemia* sp. Aquac Int 27: 567-580.

Hastuti YP. 2011. Nitrification and denitrification in pond. Jurnal Akuakultur Indonesia 10: 89-98. [Indonesian]

Hoseinifar SH, Sun Y-Z, Wang A, Zhou Z. 2018. Probiotics as means of disease control in aquaculture, a review of current knowledge and future perspectives. Front Microbiol 9: Article 2429.

Huisman EA. 1987. Principles of fish production. Department of Fish Culture and Fisheries, Wageningen Agriculture University, Wageningen, Netherland.

Iswanto B, Suprapto R, Imron. 2019. Establishing a base population of individual selection for low maintenance requirements in terms of dietary protein level in the African catfish (*Clarias gariepinus*). Indon Aquac J 14: 23-29.

Jang JW, Lee JM, Hasan MT, Lee B-J, Lim SG, Kong I-S. 2019. Effects probiotic supplementation of a plant-based protein diet on intestinal microbial diversity, digestive enzyme activity, intestinal structure, and immunity in olive flounder (*Paralichthys olivaceus*). Fish Shellfish Immunol 92: 719-727.

Kewcharoen W, Srisapoome P. 2019. Probiotic effects of *Bacillus* spp. from Pacific white shrimp (*Litopenaeus vannamei*) on water quality and shrimp growth, immune responses, and resistance to *Vibrio parahaemolyticus* (AHPND strains). Fish Shellfish Immunol 94: 175-189.

Kir M, Topuz M, Sunar MC, Topuz H. 2016. Acute toxicity of ammonia in Meagre (*Argyrosomus regius Asso*, 1801) at different temperatures. Aquac Res 47: 3593-3598.

Kir M, Sunar MC, Gok MG. 2019. Acute ammonia toxicity and the interactive effects of ammonia and salinity on the standard metabolism of European sea bass (*Dicentrarchus labrax*). Aquaculture 511: 734273.

Korkea-aho TL, Papadopoulou A, Heikkinen J, Wright AV, Adams A, Austin B, Thomson KD. 2012. *Pseudomonas* M162 confers protection against rainbow trout fry syndrome by stimulating immunity. J Appl Microbiol 113: 24-35.

Kuebutornye FKA, Abarike ED, Lu Y. 2019. A review on the application of *Bacillus* as probiotics in aquaculture. Fish Shellfish Immunol 87: 820-828.

Kumar R, Mukherjee SC, Ranjan R, Nayak SK. 2008. Enhances innate immune parameters in *Labeo rohita* (Ham.) following oral administration of *Bacillus subtilis*. Fish Shellfish Immunol 24: 168-172.

Laith AR, Najiah M. 2013. *A. hydrophila*: antimicrobial susceptibility and histopathology of isolates from diseased catfish, *Clarias gariepinus* (Burcell). Aquac Res Dev 5: 1-7.

Li J, Wu Z-B, Zhang Z, Zha J-W, Qu S-Y, Qi X-Z, Wang G-X. 2019. Effects of potential probiotic *Bacillus velezensis* K2 on growth, immunity, and resistance to *Vibrio harveyi* infection of hybrid grouper (*Epinephelus lanceolatus* x *E. fuscoguttatus*). Fish Shellfish Immunol 93: 1047-1055.

Madani NSH, Adorian TJ, Farsani HG, Hoseinifar SH. 2018. The effects of dietary probiotic Bacilli (*Bacillus subtilis* and *Bacillus licheniformis*) on growth performance, feed efficiency, body composition, and immune parameters of white leg shrimp (*Litopenaeus vannamei*) postlarvae. Aquac Res 49: 1926-1933.

Mahmud S, Ali ML, Alam MA, Rahman M, Jorgensen NOG. 2016. Effect of probiotic and sand filtration treatments on water quality and growth of tilapia (*Oreochromis niloticus*) and pangas (*Pangasianodon hypophthalmus*) in earthen ponds of southern Bangladesh. J Appl Aquac 28 (3): 199-212.

Makled SO, Hamdan AM, El-Sayed A-F. 2019. Effect of dietary supplementation of a marine thermotolerant bacterium, *Bacillus paralicheniformis* SO-1, on growth performance and immune responses of Nile tilapia, *Oreochromis niloticus*. Aquac Nutr 25: 817-827.

Ministry of Marine Affairs and Fisheries of the Republic Indonesia. 2019. Kelautan dan perikanan dalam angka. Retrieved from https: //kkp.go.id/setjen/satudata/artikel/9669-kelautan-dan-perikanan-dalam-angka-2018-telah-terbit. [Indonesian]

Mokhtar DM. 2017. Fish histology from cells to organs. Apple Academic Press, Canada. 239pp.

Nandi A, Banerjee G, Dan SK, Ghosh K, Ray AK. 2017. Probiotic efficiency of *Bacillus* sp. in *Labeo rohita* challenged by *Aeromonas hydrophila*: assessment of stress profile, haetomato-biochemical parameters and immune responses. Aquac Res 48: 4334-4345.

National Research Council [NRC]. 2011. Nutrient requirements of fish and shrimp. In: The National Academies Press, Washington, DC. 376pp.

Nasrulloh H, Nababab YI, Yanti DH, Hardiantho D, Nuryati S, Zairin M, Ekasari J, Alimudin. 2019. Identification and expression analysis of c-

type and g-type lysozymes genes after *Aeromonas hydrophila* infection in African catfish. Jurnal Akuakultur Indonesia 18: 110-119. [Indonesian]

Nargesi EA, Falahatkar B, Sajjadi MM. 2020. Dietary supplementation of probiotic and influence on feed efficiency, growth parameters and reproductive performance in female rainbow trout (*Oncorhynchus mykiss*) broodstock. Aquac Nutr 26: 98-108.

Ngaddi A, Jusadi D, Wasjan, Supriyono E. 2019. Evaluation of monosodium glutamate supplementation on physiological response, growth performance, and feed utilization in North African catfish *Clarias gariepinus* (Burchell, 1822). Jurnal Ikhtiologi Indonesia 19: 337-348. [Indonesian]

Nimrat S, Boonthai T, Vuthiphandchai V. 2011. Effects of probiotic forms, compositions of and mode of probiotic administration on rearing of Pacific white shrimp (*Litopenaeus vannamei*) larvae and postlarvae. Anim Feed Sci Technol 169: 244-258.

Nimrat S, Suksawat S, Boonthai T, Vuthiphandchai V. 2012. Potential *Bacillus* probiotics enhance bacterial numbers, water quality and growth during early development of white shrimp (*Litopenaeus vannamei*). Vet Microbiol 159: 443-450.

Nurhayati D, Yuhana M. 2015. Dietary synbiotic influence on the growth performances and immune responses to co-infection with infectious myonecrosis virus and *Vibrio harveyi* in *Litopenaeus vannamei*. J Fish Aquat Sci 10(1): 13.

Park Y, Kim H, Won S, Hamidoghli A, Hasan MT, Kong I-S, Bai SC. 2019. Effects of two dietary probiotics (*Bacillus subtilis* or *Licheniformis*) with two prebiotics (mannan or fructo oligosaccharide) in Japanese eel, *Anguilla japonica*. Aquac Nutr 26: 316-327.

Putra AN, Widanarni. 2015. Screening of amylolytic bacteria as candidates of probiotics in tilapia *Oreochromis* sp.. Res J Microbiol 10: 1–13.

Putra AN, Widanarni, Utomo NBP. 2015. Growth performance of tilapia (*Oreochromis niloticus*) fed with probiotic, prebiotic and synbiotic in diet. Pak J Nutr 14: 263–268.

Putra AN, Romdhonah Y. 2019. Effects of dietary *Bacillus* NP5 and sweet potato extract on growth and digestive enzyme activity of dumbo catfish, *Clarias* sp.. Jurnal Akuakultur Indonesia 18: 80-88. [Indonesian]

Ramadhani DK, Widanarni, Sukenda. 2019. Microencapsulation of probiotic and its applications with prebiotic in Pacific white shrimp larvae through *Artemia* sp. Jurnal Akuakulture Indonesia 18: 130-140. [Indonesian]

Randall DJ, Tsui TKN. 2002. Ammonia toxicity in fish. Mar Pollut Bull 45: 17-23.

Ren Y, Guo G, Zhou S, Li C. 2019. Water quality and nitrogen budget in turbot *Scophthalmus maximus* culture system supplemented with lactic acid bacteria. Aquac Res 50: 2743-2750.

Roberts RJ. 2001. Fish pathology. Edisi III. Saunders, W.B. London. Edinburgh, Philadelphia, St. Louis, Sydney, Toronto, 472 pp.

Tachibana L, Telli GS, Dias DC, Goncalves GS, Ishikawa CM, Cavalcante RB, Natori MM, Hamed SB, Ranzani-Paiva MJT. 2020. Effect of feeding strategy of probiotic *Enterococcus faecium* on growth performance, hematologic, biochemical parameters and non-specific immune response of Nile tilapia. Aquac Rep 16: 100277.

Tamamdusturi R, Widanarn, Yuhana M. 2016. Administration of microencapsulated probiotic *Bacillus* sp. NP5 and prebiotic mannan oligosaccharide for prevention of *Aeromonas hydrophila* infection on *Pangasianodon hypophthalmus*. J Fish Aquat Sci 11: 67–76.

Tsai C-T, Chi C-C, Liu C-H. 2019. The growth and apparent digestibility of white shrimp, *Litopenaeus* vannamei, are increased with the probiotic, *Bacillus* subtilis. Aquac Res 50: 1475-1481.

Uribe C, Folch H, Enriquez R, Moran G. 2011. Innate and adaptive immunity in teleost fish: A review. Vet Med 56: 486-503.

Utami DAS, Widanarni, Suprayudi MA. 2015. Quality of dried *Bacillus* NP5 and its effect on growth performance of tilapia *Oreochromis niloticus*. Pak J Biol Sci 18: 88–93.

Valipour A, Nedaei S, Noori A, Khanipour AA, Hoseinifar SH. 2019. Dietary *Lactobacillus plantarun affected* some immune parameters, air-exposure stress response, intestinal microbiota, digestive enzyme activity and performance of narrow clawed crayfish (*Astacus leptodactylus*, Eschscholtz). Aquaculture 504: 121-130.

Verschure L, Rombaut G, Sorgeloos P, Verstrate W. 2000. Probiotic bacteria as biological control agents in aquaculture. Microbiol Mol Biol Rev 64: 655-671.

Wada S, Atami H, Kurata O, Hatai K, Kasuya K, Watanabe Y, Fukuda H. 2011. Histopathology of gill lesions of ayu *Plecoglossus altivelis* clinically diagnosed with '*Boke'* Disease. Fish Pathol 46: 59-61.

Wang Y-B, Tian Z-Q, Yao J-T, Li W-F. 2008. Effect of probiotics, *Enterococcus faecium*, on tilapia (*Oreochromis niloticus*) growth performance and immune response. Aquaculture 277: 203-207.

Wedemeyer GA, Yasutake. 1977. Clinical methods for the assessment on the effect of environmental stress on fish health. US: U.S Fish and Wildlife service. 89p.

Widanarni, Yuniasari D, Sukenda, Ekasari J. 2010. Nursery culture performance of *Litopenaeus vannamei* with probiotics addition and different C/N ration under laboratory condition. Hayati J Biosci 17: 115-119.

Widanarni, Yuhana M, Muhamad A. 2014. *Bacillus* NP5 improves growth performance and resistance against infectious myonecrosis virus in white shrimp *Litopenaeus vannamei*. Ilmu Kelautan 19: 211–218. [Indonesian]

Xie J-J, Liu Q-Q, Liao S, Fang H-H, Yin P, Xie S-W, Tian L-X, Liu Y-J, Niu J. 2019. Effects of dietary mixed probiotics, on growth, non-specific immunity, intestinal morphology and microbiota of juvenile pacific white shrimp, *Litopenaeus vannamei*. Fish Shellfish Immunol 90: 456-465.

Xiong J, Dai W, Li L. 2016. Advances, challenges, and direction in shrimp disease control: the guidelines from an ecological perspective. Appl Microbiol Biotechnol 100: 6947-6954.

Yang XP, Wang SM, Zhang DW, and Zhou LX. 2011. Isolation and nitrogen removal characteristics of an aerobic heterotrophic nitrifying–denitrifying bacterium, *Bacillus subtilis* A1. Bioresour Technol 102 : 854-862.

Yang G, Cao H, Jiang W, Hu B, Jian S, Wen C, Kajbaf K, Kumar V, Tao Z, Peng M. 2019. Dietary supplementation of *Bacillus cereus* as probiotics in Pengze crucian carp (*Carassius auratus* var. Pengeze): Effects on growth performance, fillet quality, serum biochemical parameters and intestinal histology. Aquac Res 50: 2207-2217.

Zhang X, Yang W, Wu H, Gong X, Li A. 2014. Multilocus sequence typing revealed a clonal lineage of *Aeromonas hydrophila* caused motile *Aeromonas septicemia* outbreaks in pond-cultured cyprinid fish in an epidemic area in central China. Aquaculture 432: 1-6.

Zhang H, Sun Z, Liu B, Xuan Y, Jiang M, Pan Y, Zhang Y, Gong Y, Lu D, Kumar D, Hu X, Cao G, Xue R, Gong C. 2016. Dynamic changes of microbial communities in *Litopenaeus vannamei* culture and the effects of environmental factors. Aquaculture 455: 97-108.

Zhang Z, Yang Z, Zheng G, Lin Q, Zhuo X, Zhang G. 2019. Effect of addition of sucrose and probiotics on whiteleg shrimp *Litopenaeus vannamei* postlarvae performance, water quality, and microbial community. North Am J Aquac 82: 45-53.

Zhao C, Zhu J, Hu J, Dong X, Sun L, Zhang X, Miao S. 2019. Effects of dietary *Bacillus pumilus* on growth performance, innate immunity and digestive enzymes of giant freshwater prawns (*Macrobarachium rosenbergii*). Aquac Nutr 25: 712-720.

Zhou X-X, Wang Y-B, Li W-F. 2009. Effect of probiotic on larvae shrimp (*Penaeus vannamei*) based on water quality, survival rate, and digestive enzyme activities. Aquaculture 287: 349-353.

Zhu C, Yu L, Liu W, Jiang M, He S, Yi G, Wen H, Liang X. 2019. Dietary supplementation with *Bacillus subtilis* LT3-1 enhances the growth, immunity and disease resistance against *Streptococcus agalactiae* infection in genetically improved farmed tilapia, *Oreochromis niloticus*. Aquac Nutr 25: 1241-1249.

Zokaeifar H, Babaei N, Saad CR, Kamarudin MS, Sijam K, Balcazar JL. 2014. Administration of *Bacillus subtilis* strains n the rearing water enhances the water quality, growth performance, immune response, and resistance against *Vibrio harveyi* infection in juvenile white shrimp, *Litopenaeus vannamei*. Fish Shellfish Immunol 36: 68-74.

Zorriehzahra MJ, Delshad ST, Adel M, Tiwari R, Karthik K, Dharma K. Lazado CC. 2016. Probiotics as beneficial microbes in aquaculture: an update on their multiple modes of action: a review. Vet Q 36: 228-241.

(https://smujo.id/biodiv/issue/view/262)

Vol. 21 No. 6 (2020)

Full Issue

Front Cover (https://smujo.id/biodiv/issue/view/262/119)

Articles

Parasitism disruption by ants of Anagyrus lopezi (Hymenoptera: Encyrtidae), parasitoid of cassava mealybug (https://smujo.id/biodiv/article/view/5626)

MUHAMMAD ZAINAL FANANI, AUNU RAUF, NINA MARYANA, ALI NURMANSYAH, DADAN HINDAYANA

PDF (https://smujo.id/biodiv/article/view/5626/3899)

Biodiversity of nekton in Batangtoru River and its tributaries in North Sumatra, Indonesia (https://smujo.id/biodiv/article/view/5685)

DESRITA, AHMAD MUHTADI, RUSDI LEIDONALD, RINA D'RITA SIBAGARIANG, NURFADILLAH

PDF (https://smujo.id/biodiv/article/view/5685/3900)

Species identification of stranded seaweeds on eastern seashores of Thailand and utilization as a sole carbon source for single cell oils synthesized by oleaginous yeasts (https://smujo.id/biodiv/article/view/5862)

AIYA CHANTARASIRI

PDF (https://smujo.id/biodiv/article/view/5862/3901)

The diversity in nutritional profile of farmed edible bird's nests from several regions in Indonesia (https://smujo.id/biodiv/article/view/5716)

LINA ELFITA, IETJE WIENTARSIH, DONDIN SAJUTHI, INDRA BACHTIAR, HUDA SHALAHUDIN DARUSMAN

PDF (https://smujo.id/biodiv/article/view/5716/3903)

Estimation of aboveground biomass using aerial photogrammetry from unmanned aerial vehicle in teak (Tectona grandis) plantation in Thailand (https://smujo.id/biodiv/article/view/5657)

SASIWIMOL RINNAMANG, KAMPANART SIRIRUEANG, SORAVIS SUPAVETCH, PONTHEP MEUNPONG

PDF (https://smujo.id/biodiv/article/view/5657/3904)

Phytochemical screening and biological activities of pakoba (Syzygium luzonense) stem bark ethanol extract (https://smujo.id/biodiv/article/view/5712)

MARIO WALEAN, ROSTINA MELPIN, MERVINA RONDONUWU, KINZIE FELICIANO PINONTOAN, HENDRA PRATAMA MALIANGKAY, MELI ASTRIANI

PDF (https://smujo.id/biodiv/article/view/5712/3905)

Comparative study of larvicidal activity of commercial essential oils from aromatic rosemary, vanilla, and spearmint against the mosquito Aedes aegypti (https://smujo.id/biodiv/article/view/5703)

SEDTHAPONG LAOJUN, TANAWAT CHAIPHONGPACHARA

PDF (https://smujo.id/biodiv/article/view/5703/3906)

Microsatellite polymorphism for molecular characterization of pomelo (Citrus maxima) accessions from Indonesia (https://smujo.id/biodiv/article/view/5774)

RATNA SUSANDARINI, SITI SUBANDIYAH, BUDI S. DARYONO, RUGAYAH

PDF (https://smujo.id/biodiv/article/view/5774/3907)

Short Communication: The lifecycle of Neocaridina denticulata and N. palmata in aquariums (https://smujo.id/biodiv/article/view/4975)

HANAN HASSAN ALSHEIKH MAHMOUD, MOH. HUSEIN SASTRANEGARA, ENDANG SRIMURNI KUSMINTARSIH

PDF (https://smujo.id/biodiv/article/view/4975/3908)

Rapid assessment of lichen diversity in Baliem Valley, Jayawijaya, Papua, Indonesia (https://smujo.id/biodiv/article/view/5410)

SUHARNO, LINUS Y. CHRYSTOMO, PUGUH SUJARTA, ROSYE H.R. TANJUNG

PDF (https://smujo.id/biodiv/article/view/5410/3909)

Trichoderma virens-Tv4 enhances growth promoter and plant defense-related enzymes of mungbean (Vigna radiata) against soil-borne pathogen Rhizoctonia solani (https://smujo.id/biodiv/article/view/5340)

ALFI INAYATI, LILIEK SULISTYOWATI, LUQMAN QURATA AINI, ERIYANTO YUSNAWAN

PDF (https://smujo.id/biodiv/article/view/5340/3910)

Investigation of biochemical characters and antioxidant properties of different winged bean (Psophocarpus tetragonolobus) genotypes grown in Indonesia (https://smujo.id/biodiv/article/view/5539)

JANSON CALVINDI, MUHAMAD SYUKUR, WARAS NURCHOLIS

PDF (https://smujo.id/biodiv/article/view/5539/3911)

Short Communication: A note on the new record of the amphibian fauna in Pulau Tinggi, Malaysia (https://smujo.id/biodiv/article/view/4869)

NG YIN HUI, EHWAN NGADI, BADRUL MUNIR MD-ZAIN, ZAINAL MD-ZAIRI, MUHAMMAD ABU BAKAR ABDUL-LATIFF

PDF (https://smujo.id/biodiv/article/view/4869/3912)

Protein profile, amino acids and taurine composition of sea slug

(Paromoionchis tumidus) from Sumenep sea waters, Madura, Indonesia (https://smujo.id/biodiv/article/view/5795)

HAFILUDIN, SRI ANDAYANI, HARTATI KARTIKANINGSIH, MUHAMAD FIRDAUS

PDF (https://smujo.id/biodiv/article/view/5795/3913)

Therapeutic potentials of n-hexane extracts of the three medicinal mushrooms regarding their anti-colon cancer, antioxidant, and hypocholesterolemic capabilities (https://smujo.id/biodiv/article/view/5934)

GHOSON M. DABA, WAILL A. ELKHATEEB, ASMAA NEGM EL-DEIN, EMAN F. AHMED, ALI MOHAMED EL HAGRASSI, WALID FAYAD, TING-CHI WEN

PDF (https://smujo.id/biodiv/article/view/5934/3914)

Checklist and estimation of total number of phytoplankton species in Pari, Tidung, and Payung Islands, Indonesia (https://smujo.id/biodiv/article/view/4827)

ARIEF RACHMAN

PDF (https://smujo.id/biodiv/article/view/4827/3915)

Short Communication; Medicinal plants in Ubud Monkey Forest in Bali, Indonesia: Diversity, distribution, traditional use and tourism attractiveness (https://smujo.id/biodiv/article/view/4894)

NYOMAN WIJANA, PUTU INDAH RAHMAWATI

PDF (https://smujo.id/biodiv/article/view/4894/3916)

Short Communication: Polymorphism of Fumarate Hydratase 1 (FUM1) gene associated with nitrogen uptake in oil palm (Elaeis guineensis) (https://smujo.id/biodiv/article/view/5422)

SIGIT DWI MARYANTO, ZULFIKAR ACHMAD TANJUNG, WIDYARTINI MADE SUDANIA, ANDREE SUNANJAYA KUSNANDAR, ROBERDI, PUJIANTO, CONDRO UTOMO, TONY LIWANG

PDF (https://smujo.id/biodiv/article/view/5422/3917)

Diversity of bird species in the coffee agroforestry landscape: Case study in the Pangalengan Sub-district, Bandung District, West Java, Indonesia (https://smujo.id/biodiv/article/view/5290)

SUSANTI WITHANINGSIH, PARIKESIT, RIZKA FATHARANI ALHAM

PDF (https://smujo.id/biodiv/article/view/5290/3918)

Morphological and molecular characterization of Termitomyces (Lyophyllaceae, Agaricales) in Thailand (https://smujo.id/biodiv/article/view/5418)

NICHAREE JANNUAL, MINGKWAN NIPITWATTANAPHON, SASITORN HASIN, THARNRAT KAEWGRAJANG

PDF (https://smujo.id/biodiv/article/view/5418/3919)

Genetic patterns of the corals Euphyllia glabrescens and Lobophyllia corymbosa across the Indonesian Archipelago (https://smujo.id/biodiv/article/view/5520)

JAMALUDDIN JOMPA, WIDYASTUTI UMAR, SYAFYUDDIN YUSUF, ASMI CITRA MALINA AR. TASSAKKA, GINO V. LIMMON, RAHMI, AMANDA PRICELLA PUTRI, HALWI, HARTATI TAMTI, ABIGAIL MARY MOORE

PDF (https://smujo.id/biodiv/article/view/5520/3920)

Prevalence of Salmonella spp. in fresh fish and shrimp in Semarang's Traditional Markets (Indonesia) through Polymerase Chain Reaction (https://smujo.id/biodiv/article/view/5650)

ULFAH AMALIA, Y. S. DARMANTO

PDF (https://smujo.id/biodiv/article/view/5650/3921)

Bifidobacterium from infant stool: the diversity and potential screening (https://smujo.id/biodiv/article/view/5873)

DYAH FITRI KUSHARYATI, HENDRO PRAMONO, DINI RYANDINI, TSANI ABU MANSHUR, MEILANY ARIATI DEWI, KHUSNUL KHATIMAH, ANWAR ROVIK

PDF (https://smujo.id/biodiv/article/view/5873/3922)

The very low genetic variability on Aceh Tamiang's (Indonesia) population of Painted Terrapin (Batagur borneoensis) inferred by cytochrome oxidase I (CO I) and D-loop (control region) (https://smujo.id/biodiv/article/view/5592)

JOKO GUNTORO, WIRDATETI, AWAL RIYANTO

PDF (https://smujo.id/biodiv/article/view/5592/3923)

Identification of compounds isolated from a methanolic extract of Acanthus ilicifolius leaves and evaluation of their antifungal and antioxidant activity (https://smujo.id/biodiv/article/view/5649)

DWI ANDRIANI, SYAMSULINA REVIANTI, WIDYASRI PRANANINGRUM

PDF (https://smujo.id/biodiv/article/view/5649/3924)

Vegetation and ecoregion analysis at Sipirok Botanic Gardens, South Tapanuli, North Sumatra, Indonesia (https://smujo.id/biodiv/article/view/5988)

MUSTAID SIREGAR, DANANG W. PURNOMO, HARTUTININGSIH M-SIREGAR, JOKO RIDHO WITONO

PDF (https://smujo.id/biodiv/article/view/5988/3926)

Cultural and ecological significance of Odonata (Insecta) to the T'boli of Lake Sebu, Mindanao, Philippines (https://smujo.id/biodiv/article/view/5212)

RIZALYN B. CUDERA, BRANDO C. RAZON, KENETTE JEAN I. MILLONDAGA

PDF (https://smujo.id/biodiv/article/view/5212/3928)

Drought-induced production of reactive oxygen species and antioxidants activity of four local upland rice cultivars in Central Sulawesi, Indonesia (https://smujo.id/biodiv/article/view/5563)

RUSLAN BOY, DIDIK INDRADEWA, EKA TARWACA SUSILA PUTRA, BUDIASTUTI KURNIASIH

PDF (https://smujo.id/biodiv/article/view/5563/3929)

Effect of the administration of probiotic Bacillus NP5 in the rearing media on water quality, growth, and disease resistance of African catfish (Clarias gariepinus) (https://smujo.id/biodiv/article/view/5565)

ACHMAD NOERKHAERIN PUTRA, MAS BAYU SYAMSUNARNO, WIDIA NINGRUM, JUMYANAH, MUSTAHAL

PDF (https://smujo.id/biodiv/article/view/5565/3930)

Family structure of F5 soybeans lines derived from soybean varieties with the main differences on seed size and maturity traits (https://smujo.id/biodiv/article/view/5504)

HERU KUSWANTORO, RINA ARTARI, RUDI ISWANTO, HILYATUL IMANI

PDF (https://smujo.id/biodiv/article/view/5504/3933)

Traditional ecological knowledge of the bird traders on bird species bird naming, and bird market chain: A case study in bird market Pasty Yogyakarta, Indonesia (https://smujo.id/biodiv/article/view/5809)

JOHAN ISKANDAR, BUDIAWATI S. ISKANDAR, DEDE MULYANTO, RACHMAN LATIF ALFIAN, RUHYAT PARTASASMITA

PDF (https://smujo.id/biodiv/article/view/5809/3935)

The structure, composition, and threatened plants in The Kinarum Protected Forest, South Kalimantan, Indonesia (https://smujo.id/biodiv/article/view/5854)

DODO, SYAMSUL HIDAYAT

PDF (https://smujo.id/biodiv/article/view/5854/3934)

Morphological characteristics and morphometrics of Stingless Bees (Hymenoptera: Meliponini) in Yogyakarta, Indonesia (https://smujo.id/biodiv/article/view/4940)

MANAP TRIANTO, HARI PURWANTO

PDF (https://smujo.id/biodiv/article/view/4940/3936)

The Distribution of bird communities in University of Lampung, Indonesia (https://smujo.id/biodiv/article/view/5636)

DIAN ISWANDARU, N. NOVRIYANTI, IRWAN SUKRI BANUWA, SUGENG P. HARIANTO

PDF (https://smujo.id/biodiv/article/view/5636/3937)

Genetic variability assessment in bread wheat (Triticum aestivum) grown in Algeria using microsatellites SSR markers (https://smujo.id/biodiv/article/view/5777)

KARIMA KARA, MALIKA RACHED-KANOUNI, SAMAH MNASRI, HICHEM KHAMMAR, M'BAREK BEN NACEUR

PDF (https://smujo.id/biodiv/article/view/5777/3938)

Ethnozoology of the ritual and magic of the To Bada Ethnic Group in the Lore Lindu Biosphere Reserve, Central Sulawesi, Indonesia (https://smujo.id/biodiv/article/view/5601)

ENY YUNIATI, SERAFINAH INDRIYANI, JATI BATORO, Y. PURWANTO

PDF (https://smujo.id/biodiv/article/view/5601/3941)

The density and diversity of plant-parasitic nematodes associated with maize rhizosphere in Malakaji Highland, South Sulawesi, Indonesia

(https://smujo.id/biodiv/article/view/5672)

HISHAR MIRSAM, AMRAN MUIS, NURNINA NONCI

PDF (https://smujo.id/biodiv/article/view/5672/3942)

Short Communication: The presence of extended-spectrum beta-lactamase (ESBL) producing Escherichia coli on layer chicken farms in Blitar Area, Indonesia (https://smujo.id/biodiv/article/view/5278)

FRESHINTA JELLIA WIBISONO, BAMBANG SUMIARTO, TRI UNTARI, MUSTOFA HELMI EFFENDI, DIAN AYU PERMATASARI, ADIANA MUTAMSARI WITANINGRUM

PDF (https://smujo.id/biodiv/article/view/5278/3943)

Growth optimization of Saccharomyces cerevisiae and Rhizopus oligosporus during fermentation to produce tempeh with high β-glucan content (https://smujo.id/biodiv/article/view/5614)

SAMSUL RIZAL, MURHADI, MARIA ERNA KUSTYAWATI, UDIN HASANUDIN

PDF (https://smujo.id/biodiv/article/view/5614/3944)

Structure and composition of trees in Mount Tilu Nature Reserve, West Java, Indonesia (https://smujo.id/biodiv/article/view/5688)

TRI CAHYANTO, MUHAMMAD EFENDI, DIAN MUHAMAD RAMDAN

PDF (https://smujo.id/biodiv/article/view/5688/3945)

Molecular identification of endophytic fungi from torch ginger (Etlingera elatior) antagonist to phytopathogenic fungi (https://smujo.id/biodiv/article/view/5434)

ANISA LUTFIA, ERMAN MUNIR, YURNALIZA YURNALIZA

PDF (https://smujo.id/biodiv/article/view/5434/3948)

The diversity of entomopathogenic fungi collected from leaves and rhizospheres of rice implementing integrated pest management (https://smujo.id/biodiv/article/view/5683)

AMINUDIN AFANDHI, ELYKA PUTRI PERTIWI, DICKY PREJEKI PURBA, TITA WIDJAYANTI, AMIN SETYO LEKSONO

PDF (https://smujo.id/biodiv/article/view/5683/3949)

Genotypic diversity assessment of some durum wheat (Triticum durum)

genotypes using RAPD analysis (https://smujo.id/biodiv/article/view/5684)

RATIBA BOUSBA, SARA GUERAICHE, MALIKA RACHED KANOUNI, RABAH BOUNAR, ABDELHAMID DJEKOUNE, HICHEM KHAMMAR, YKHLEF NADIA

PDF (https://smujo.id/biodiv/article/view/5684/3950)

Population genetic structure of Asiatic Hard Clam (Meretrix meretrix) in Thailand based on Cytochrome Oxidase subunit I gene sequence (https://smujo.id/biodiv/article/view/5820)

VERAKIAT SUPMEE, PRADIT SANGTHONG, APIRAK SONGRAK, JUTHAMAS SUPPAPAN

PDF (https://smujo.id/biodiv/article/view/5820/3951)

Environmental efficiency of rice production in Vietnam: An application of SBM-DEA with undesirable output (https://smujo.id/biodiv/article/view/5910)

TRUC-LINH LE

PDF (https://smujo.id/biodiv/article/view/5910/3952)

Short Communication: Effect of urban greening and land use on air pollution in Chelyabinsk, Russia (https://smujo.id/biodiv/article/view/5369)

TATYANA G. KRUPNOVA, OLGA V. RAKOVA, ANNA L. PLAKSINA, SVETLANA V. GAVRILKINA, EVGENY O. BARANOV, ANTON D. ABRAMYAN

PDF (https://smujo.id/biodiv/article/view/5369/3953)

Determining relevant petiole anatomy characters to delimit Eupolypods I families (https://smujo.id/biodiv/article/view/5739)

JEANETTE MARA P. TAN, INOCENCIO E. BUOT, JR.

PDF (https://smujo.id/biodiv/article/view/5739/3954)

Potential antagonistic rhizobacteria to control Colletotrichum scovillei, the cause of anthracnose disease in chili pepper (https://smujo.id/biodiv/article/view/5773)

DEWA NGURAH SUPRAPTA, ANAK AGUNG KETUT DARMADI, KHAMDAN KHALIMI

PDF (https://smujo.id/biodiv/article/view/5773/3957)

Molecular identification of bacteria isolated from culture medium of rotifer fed on fishery waste diet (https://smujo.id/biodiv/article/view/5778)

AMINA BELGUIDOUM, TAKIA LOGRADA, MESSAOUD RAMDANI

PDF (https://smujo.id/biodiv/article/view/5849/3964)

Root detection by resistivity imaging and physiological activity with the dead-end trench on three clones of cocoa (Theobroma cacao) (https://smujo.id/biodiv/article/view/5144)

CANGGIH NAILIL MAGHFIROH, EKA TARWACA SUSILA PUTRA, ENDANG SRI DEWI HS

PDF (https://smujo.id/biodiv/article/view/5144/3969)

Plant diversity and composition at three Imperata grasslands in Bogor, Katingan, and Kupang, Indonesia (https://smujo.id/biodiv/article/view/5581)

DIDI USMADI, JOKO RIDHO WITONO, RENI LESTARI, DIDIK WIDYATMOKO, MAHAT MAGANDHI, IYAN ROBIANSYAH, ARIEF NOOR RACHMADIYANTO, DANANG WAHYU PURNOMO, RIZMOON NURUL ZULKARNAEN, REZA RAMDAN RIVAI, HENDRA HELMANTO, ANGGA YUDAPUTRA, FRISCA DAMAYANTI

PDF (https://smujo.id/biodiv/article/view/5581/3970)

The growth of three teak (Tectona grandis) clones and its effect on wood properties (https://smujo.id/biodiv/article/view/5722)

GUDIWIDAYANTO SAPTO PUTRO, SRI NUGROHO MARSOEM, JOKO SULISTYO, SURYO HARDIWINOTO

PDF (https://smujo.id/biodiv/article/view/5722/3971)

Short Communication: Detection of bioactive compounds in essential oil from lemongrass cultivated in Ngantang, Malang, East Java, Indonesia (https://smujo.id/biodiv/article/view/5771)

ENDANG SRI HARTATIE, INDAH PRIHARTINI, WAHYU WIDODO, AHMAD WAHYUDI

PDF (https://smujo.id/biodiv/article/view/5771/3972)

Antibacterial activity of CaO from blood cockle shells (Anadara granosa) calcination against Escherichia coli (https://smujo.id/biodiv/article/view/5656)

AMANDA FIRZA RUSDARYANTI, ULFAH AMALIA, SLAMET SUHARTO

PDF (https://smujo.id/biodiv/article/view/5656/3973)

Soil properties and sulfur-oxidizing bacterial diversity in response to

different planting patterns of shallot (Allium ascalonicum) (https://smujo.id/biodiv/article/view/5666)

MUHAMMAD JUWANDA, SAKHIDIN, SAPARSO, KHARISUN

PDF (https://smujo.id/biodiv/article/view/5666/3978)

Evaluation of physical and chemical characteristics of sixty peanut germplasm (https://smujo.id/biodiv/article/view/5709)

ERLIANA GINTING, NOVITA NUGRAHAENI

PDF (https://smujo.id/biodiv/article/view/5709/3979)

Structural variability of Aleppo pine stands in two forests in northeastern Algeria (https://smujo.id/biodiv/article/view/5861)

MALIKA RACHED-KANOUNI; INSAF HANI, RATIBA BOUSBA, AMINA BELDJAZIA, HICHEM KHAMMAR

PDF (https://smujo.id/biodiv/article/view/5861/3980)

Genetic characterization based on the D-loop MtDNA and the TSPY genes of the Dwarf Siamang (Hylobates klossii) of Mentawai Island, Indonesia (https://smujo.id/biodiv/article/view/5058)

RIZKA HASANAH, UUS SAEPULOH, DYAH PERWITASARI-FARAJALLAH, WALBERTO SINAGA, YOHANA TRI HASTUTI, DONDIN SAJUTHI

PDF (https://smujo.id/biodiv/article/view/5058/3983)

Trophic level and position of Pterygoplichthys pardalis in Ciliwung River (Jakarta, Indonesia) ecosystem based on the gut content analysis (https://smujo.id/biodiv/article/view/5754)

DEWI ELFIDASARI, FAHMA WIJAYANTI, AFIFATUS SHOLIHAH

PDF (https://smujo.id/biodiv/article/view/5754/3984)

Information

For Readers (https://smujo.id/biodiv/information/readers)

For Authors (https://smujo.id/biodiv/information/authors)

For Librarians (https://smujo.id/biodiv/information/librarians)

Usage Statistics Information

We log anonymous usage statistics. Please read the privacy information (https://smujo.id/biodiv/usageStats/privacyInformation) for details.

Journals List

Biodiversitas Journal of Biological Diversity (https://smujo.id/biodiv)

Nusantara Bioscience (https://smujo.id/nb)

Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia (https://smujo.id/psnmbi)

Asian Journal of Agriculture (https://smujo.id/aja)

Asian Journal of Ethnobiology (https://smujo.id/aje)

Asian Journal of Forestry (https://smujo.id/ajf)

Biofarmasi Journal of Natural Product Biochemistry (https://smujo.id/jnpb)

Bioteknologi Biotechnological Studies (https://smujo.id/bbs)

Bonorowo Wetlands (https://smujo.id/bw)

Cell Biology and Development (https://smujo.id/cbd)

Ocean Life (https://smujo.id/ol)

Tropical Drylands (https://smujo.id/td)

Reviewers List

Reviewers (https://smujo.id/biodiv/reviewers/index)

Visitor Statistics

Statistics (https://smujo.id/info/stats)

(https://info.flagcounter.com/JKar)

(https://www.scopus.com/sourceid/21100332431)

(http://doaj.org/toc/3eda1e70aa014e1e8bd1fc367b4df956)

(http://scholar.google.co.id/citations?hl=id&user=rae-lrEAAAAJ)

(http://search.crossref.org/?q=biodiversitas&type=Journal)

(https://academic.microsoft.com/#/detail/2738269101)